ULTRA-DEEPWATER RESEARCH AT DOE:

PROTECTING OUR ENVIRONMENT THROUGH RISK ASSESSMENT AND SPILL PREVENTION

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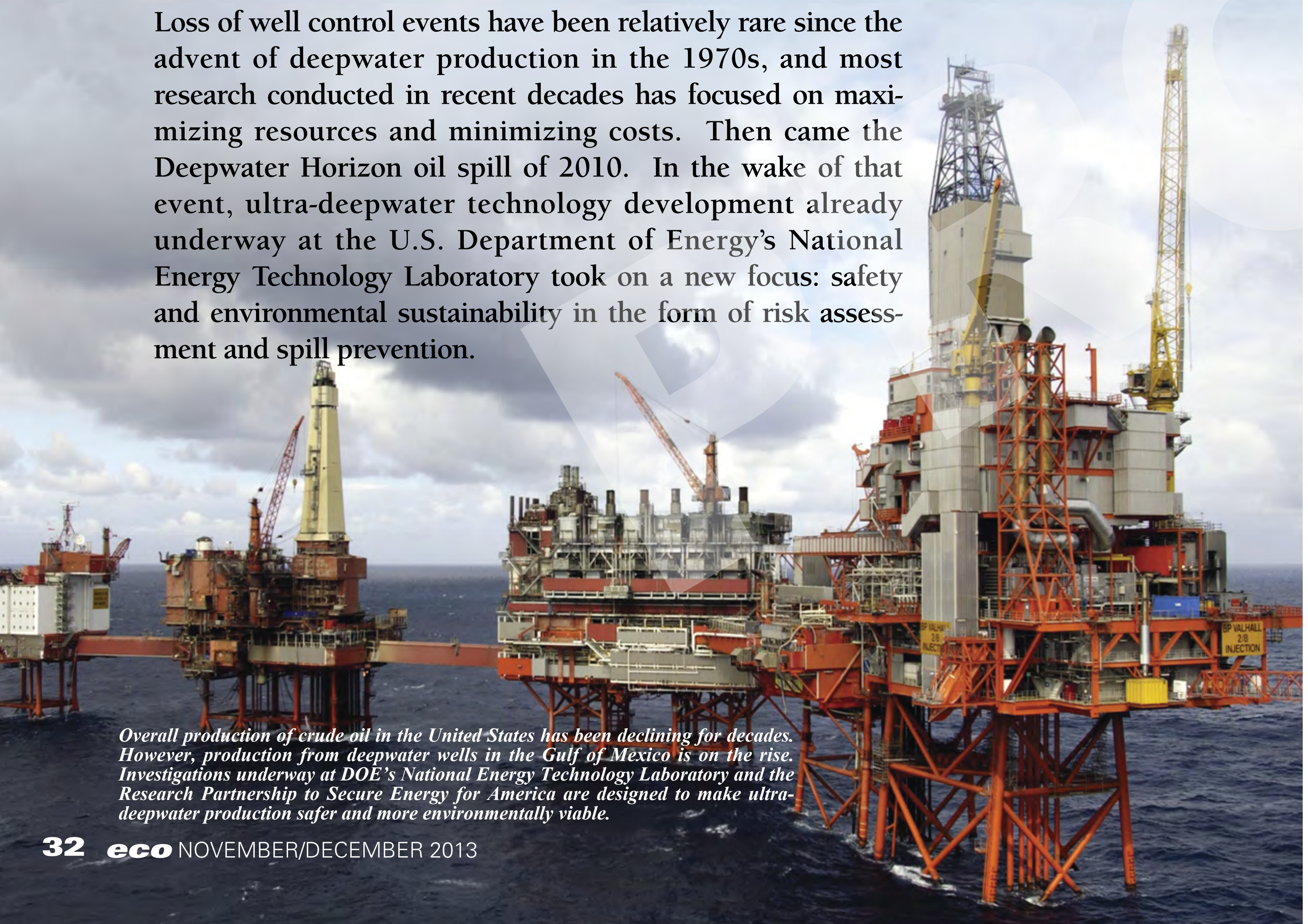
The construction of wells for deepwater and ultra-deepwater offshore oil and gas production is on the rise, and operators continue to push the boundaries of water and subsurface depths. The world's deepest floating oil platform, Shell's Perdido in the Gulf of Mexico, plunges 8,000 feet into the water—650 stories, or six and a half times the height of the Empire State building. In 2016, Shell plans to go to 9,500 feet.

Loss of well control events have been relatively rare since the advent of deepwater production in the 1970s, and most research conducted in recent decades has focused on maximizing resources and minimizing costs. Then came the Deepwater Horizon oil spill of 2010. In the wake of that event, ultra-deepwater technology development already underway at the U.S. Department of Energy's National Energy Technology Laboratory took on a new focus: safety and environmental sustainability in the form of risk assessment and spill prevention.



Overall production of crude oil in the United States has been declining for decades. However, production from deepwater wells in the Gulf of Mexico is on the rise. Investigations underway at DOE's National Energy Technology Laboratory and the Research Partnership to Secure Energy for America are designed to make ultra-deepwater production safer and more environmentally viable.

Federal Investment in Safety and Environmental Protection

The deepwater continental shelf is one of the last remaining areas where undiscovered oil and natural gas resources remain. Due to the extreme conditions of the deepwater environment, the complex architecture employed to develop these resources reflects some of the oil and gas exploration and production industry's most advanced engineering accomplishments.

Yet, as made starkly evident by Deepwater Horizon, exploration and production in the remote, high-risk regions of the world's offshore areas still pose significant operational challenges and distinct environmental and societal concerns. For the safety of rig workers and the protection of marine ecosystems, extensive research is conducted by the U.S. Department of Energy (DOE), its agencies, and its partners under the Energy Policy Act of 2005. The goal is to develop technologies that will better enable operators to deal with geologic uncertainties and develop best practices to minimize risk and ensure that spills are prevented.

This effort is part of DOE's Ultra-deepwater and Unconventional Natural Gas and Other Petroleum Resources Program, an 8-year, $50 million-dollar-per-year public-private research partnership. The program is overseen by DOE-NETL, managed by DOE's Office of Fossil Energy, and supported by the Research Partnership to Secure Energy for America, or RPSEA, a non-profit research consortium selected by DOE-NETL to administer contracted activities under the program.

It is clearly essential to the United States that we minimize risks associated with ultra-deepwater oil recovery. This can be accomplished through such advances as new facility and platform designs, materials with greater performance limits, new riser designs and inspection criteria, and improved understanding of the metocean forces and human factors at play in ultra-deepwater operations.

The work being conducted by the National Energy Technology Laboratory (NETL) and the Research Partnership to Secure Energy for America (RPSEA) is pursuing these advances to help safely move oil discoveries in the Gulf of Mexico and other national waters to production.

Research Focus

Long-standing research indicates that cementing is a primary factor contributing to loss of zonal isolation in the Gulf of Mexico where cement types and placement practices vary. To address this issue, DOE research teams are working to improve casing cement jobs and better understand the physical, chemical, and temporal integrity of formation, cement, and casing barriers. They are working to minimize other risks, as well, by more accurately predicting hurricane intensity, designing improved subsea system monitors, and more effectively assessing corrosion and other operational criteria to improve the reliability of subsea equipment.

Offshore architecture is another area of focus for the ultra-deepwater program, including technology development related to surface facilities, subsea equipment, pipelines, and the tools and systems used to operate and maintain them. By conducting research to enhance operational safety, improve cost effectiveness, and extend system capabilities, resources can be developed with a smaller environmental footprint.

Finally, as hydrocarbon mixtures move from extremely deep rock formations to complicated subsea piping systems and into surface facilities, they undergo extreme variations in temperature and pressure—a unique challenge to equipment designers. DOE-NETL and DOE-RPSEA are carrying out research to enhance industry's understanding of ultra-deepwater production processes and help ensure these systems operate safely and effectively.

Program Results

DOE's Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Program was launched in 2007, and resulting technologies are already emerging and being made available through market and other channels. DOE-NETL has also developed tools that cut across the DOE natural gas and oil research portfolio and support efforts by other agencies in this critical area. Let's examine some of the successes this program has launched.

The Marlin System autonomously inspects structures up to 1,000 feet below the surface. Two vehicles are available for lease from Lockheed Martin. Photo credit: Lockheed Martin.

Marlin® Autonomous Underwater Vehicle System

Under the DOE-RPSEA portfolio, Lockheed Martin developed the Marlin® Autonomous Underwater Vehicle System. Marlin allows operators above the surface to remotely conduct preventative structural and bottom-debris surveys and pipeline inspections safely, quickly, efficiently and economically.

Equipped with advanced sensors, specialty navigation capabilities and 3D imaging sonar, the AUV quickly generates accurate, high-resolution, 3D geo-referenced models that provide a clear view of subsea structures. The Marlin can sprint up to four knots, cruise for as many as 18 hours and dive 1,000 feet beneath the surface (original prototype; Lockheed Martin is now designing a model for 10,000 to 12,000-foot diving depths). At 10 feet in length, it deftly maneuvers around underwater structures and operates in tight spaces. Marlin performs inspections more quickly and with fewer personnel than tethered devices, delivering high-fidelity information in hours versus days. If this capability had been available in 2010, the ocean floor wreckage around the Deepwater Horizon spill could have been mapped on a single day.

Extended-Range Ensemble Forecasting in the Gulf of Mexico

Currently underway through DOE-RPSEA is the development of an extended range (~60 days) ocean forecasting system for the Gulf of Mexico. The system generates probabilistic forecasts by perturbing the initial state of the ocean field as well as surface winds and heat. For example, estimates of forecast uncertainty, calculated over 32 ensemble members, accurately predicted a Loop Current eddy shedding event that occurred in the spring of 2013.

The shear associated with Loop Current eddy activity affects day-to-day offshore oil and gas operations, and it can intensify Gulf hurricanes. Thus, the ability to predict Loop Current intrusion and eddy separation could have profound socioeconomic implications. The initial success of the system, albeit for a single event, demonstrates that extended-range forecasting of unstable current systems is possible.

The system performs a daily 3-day forecast and a weekly 60-day forecast and has been running in real-time since January 2013. Testing will continue through Summer 2014, at which time it will be transitioned to the U.S. Navy's Naval Oceanographic Office to be made available for public use in anticipating and preparing for metocean events that could pose risks to operations.

Energy Data eXchange

DOE-NETL's Energy Data eXchange, or EDX, is a knowledge-sharing network being built to help researchers team up through a virtual platform. EDX houses internal energy-related data and links to externally hosted data resources. It also provides data-driven tools and applications to make energy research—including research related to deepwater exploration and production—easy, efficient, and collaborative. Secure collaborative workspaces provide online working environments. Cross-organizational search capabilities return results from inside and outside the EDX system. Public features promote information and technology exchange.

EDX is a continuously evolving platform that is being shaped to meet user needs in response to ongoing feedback. Researchers can visit EDX at www.edx.netl.doe.gov to join the system and participate in its evolution.

Geocube

Geocube is an interactive platform available through EDX that allows researchers, policy makers, emergency response personnel and other users to map and spatially evaluate data in a common geographic framework.

Geocube is currently focused on the Gulf of Mexico region. It contains data layers related to subsurface geologic formations, oil and gas infrastructure, water column physical and biological information and human marine and coastal activities, including tourism and recreational and commercial fishing.

Users, however, may upload datasets from any location worldwide to take advantage of Geocube's capabilities. DOE-NETL is also continuing to pre-populate the system with regional data layers. Next up is the Appalachian Basin.

Learn More

Until alternatives are found that can economically meet the world's need for abundant, affordable energy, fossil resources are expected to provide the majority of transportation fuels and power generation feedstock. In the United States, deepwater oil and natural gas will play an increasingly significant role in fueling our infrastructure and reducing our dependence on foreign energy supplies.

A 3D model data product of an offshore platform resulting from a Marlin System inspection. Photo credit: Lockheed Martin.

Resource Discovery and Growth

Following the first deepwater oil discovery by Shell in 1975, the 1980s and 1990s saw technology developments that allowed companies to dive further, dig deeper, and produce offshore oil reserves at steadily higher rates. Advances in rig technologies and 3D seismic mapping, coupled with improvements in industry's understanding of turbidite reservoir potential, helped deep and ultradeep production in the Gulf of Mexico reach 250 million barrels in 1998, for the first time surpassing annual production in shallow water.

A decline from 2003 to 2007 was considered by many to be a temporary drop, and that may be proving true. Since 2008, Gulf Coast deepwater production has regained momentum. The Energy Information Administration currently projects that production will meet or exceed 400 million barrels per year through 2037.

Federal research is underway to assess risks associated with ultra-deepwater oil recovery and prevent spill events. This work is important to protecting operators and ensuring that, as a nation, we are making the smallest impact possible on our marine environments.

More information about DOE's efforts to support clean, safe oil and gas exploration and production is available on the websites hosted by DOE-NETL and DOE-RPSEA at www.netl.doe.gov and www.rpsea.org.