

THE U.S. DEPARTMENT OF ENERGY'S NATIONAL ENERGY TECHNOLOGY LABORATORY

HOW NETL IS ENABLING

CRUDE OIL EXTRACTION

SAFELY & EFFICIENTLY

FIRST, HERE'S WHAT INDUSTRY & GOVERNMENT NEED TO KNOW

INDUSTRY

HOW MUCH OIL can be obtained from a specific well? Should we drill here?



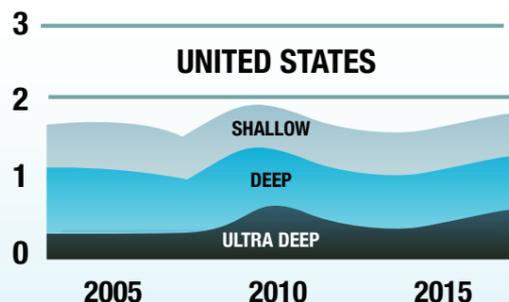
GOVERNMENT

HOW MUCH OIL does the U.S. have in reserve across the country? How effectively and safely can we produce oil?

DRILLING

Without a reliable model, drilling can become **VERY EXPENSIVE**, lead to **SAFETY ISSUES**, and U.S. oil reserves cannot be **EFFECTIVELY PRODUCED**

- Deepwater production, or production in water of depths greater than 125 meters, has **increased 25%** from nearly 7 million barrels per day a decade ago
- The share of offshore production from **shallow water** in 2015 was 64%, the **lowest on record**.



Offshore crude oil production by water depth (millions of barrels/day) - EIA

TO ENSURE SAFETY, PROFITABILITY, & GOOD RESERVE MANAGEMENT, NETL is developing better fluid properties models

MODELS

1 NETL's developed world-class densimeter & viscometer generated density and viscosity data in simulated extreme drilling conditions.



$$\iiint_V \rho(r, \theta, z) \, dV = \rho_{avg} \sum_{i=1}^N \Delta V_i$$

$$\rho(r, \theta, z) = \frac{\rho_0}{1 + \alpha \left(\frac{r}{r_0} \right)^2 + \beta \left(\frac{z}{z_0} \right)^2}$$

$$\rho_0 = \rho(r=0, z=0)$$

$$\alpha = \frac{\rho_0}{\rho_0} \left(\frac{\rho(r_0, 0) - \rho_0}{\rho_0} \right)$$

$$\beta = \frac{\rho_0}{\rho_0} \left(\frac{\rho(0, z_0) - \rho_0}{\rho_0} \right)$$

$$\rho(r, \theta, z) = \rho_0 \left(1 - \alpha \left(\frac{r}{r_0} \right)^2 - \beta \left(\frac{z}{z_0} \right)^2 \right)$$

2 These data led to the development of a new Equation of State predictive model validated with experimental data.

3 This new model now has about **only 1%** deviation between experimental and predicted density. An error of **10%** in viscosity may trigger an error of up to **10%** of the estimated oil/gas production. Future work on viscosity will address the error viscosity production.



WHICH MEANS

INDUSTRY

CAN MAKE BETTER DECISIONS WHEN:

- Deciding where to place wells based on the oil recovery rate
- Putting measures in place to ensure drilling safety

GOVERNMENT

CAN MAKE BETTER DECISIONS WHEN:

- Accurately estimating and managing U.S. oil reserves.
- Issuing penalties and fines for oil spills
- Issuing offshore oil drilling leases

THIS NEW EQUATION OF STATE MODEL IS AVAILABLE AT <https://edx.netl.doe.gov/eos> | Isaac Gamwo, Isaac.Gamwo@netl.doe.gov



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