U.S. Department of Energy • Office of Fossil Energy

Technology Development with Independents

October 2003

Overview

Petroleum is a limited, non-replenishable resource that we must effectively manage until a viable energy alternative is developed. According to data from the Energy Information Administration (EIA) *Annual Energy Outlook 2002*, petroleum (excluding natural gas) provided nearly 40% of our nation's energy consumption in 2001.

We are becoming more and more dependent on imported oil to meet growing U.S. energy requirements. In 2002, only about 40% of the oil required by the United States was supplied by domestic producers; the remaining 60% was imported. The Energy Information Administration predicts that domestic production rates will remain relatively flat for 2003, yet the demand will increase by 600,000 barrels of oil per day; (roughly 25 million gallons per day). According to the *Oil and Gas Journal*, it is estimated that there are 22 billion barrels of proved oil reserves as of January 1, 2003; most of which will be produced by independent petroleum producers.

What is an Independent Producer? Most employ fewer than 20 employees, but collectively, they are the link to future domestic supply. The basic definition of independents is a non-integrated company which receives nearly all of its revenues from production at the well-head. They are exclusively in the exploration and production segment of the industry, with no marketing or refining within their operations. Over the last decade, the number of independents has decreased from over 10,000 to approximately 7,000. Nearly 40 percent of the industry's skilled professionals will reach retirement age during this decade.

Independent producers drill 85% of the wells in the United States, producing over 40% of the nation's crude oil (60% in the lower 48 states). They produced 65% of the nation's natural gas and operated 77% of the wells drilled in the federal Gulf of Mexico waters in 2000.

In 1995, the Department of Energy developed a special program to specifically focus on assisting independent producers. Since the program began 62 projects have been initiated by small independent operators in 19 different states. Independent operators have contributed more than 70% of the investment needed for these projects. Sharing the risks and expenses has resulted in innovative methods and technologies which have boosted oil production and prevented the premature shut down of some of the nation's most endangered oil fields.

The nation will need a strong independent exploration and production industry to meet its future needs.

About *Our Program*

DOE's Technology Development with Independent Oil Producers

The goal of the *Technology Development with Independents* program is to develop and improve technology which will increase the Nation's oil and natural gas supplies. In recent years, independent producers have been rapidly expanding their operations into regions that were traditionally explored and operated by the major oil companies, such as the Gulf of Mexico and Alaska. Independents continue to acquire producing properties and exploration acreage in mature areas of the United States as major oil companies divest these higher operating cost, lower profit assets and shift their attention to international activities. As independent producers acquire a larger portion of the Nation's remaining petroleum resource base, it is increasingly important that they have access to and use the most effective and advanced technologies in their operations to maximize reserves and production and protect the environment.

Many independent operators do not have the resources to conduct in-depth or advanced research and development activities to apply to their operations. Often, they do not have access to commercial research services and facilities. Some are unfamiliar with or reluctant to apply new technologies. The DOE programs are aimed at encouraging independent producers to develop and/or apply unfamiliar technologies or innovative approaches which could increase production, reduce costs, improve operating efficiency, and/or reduce environmental concerns. DOE aggressively promotes the technology research initiative and pursues the effective transfer of the technology developed to the oil and gas industry as a way to move the United States toward a reliable and economic oil supply, enhance US technological leadership, and protect the environment.

The Department's program was initially designed to focus on working directly with small independent producers. Subsequent feedback from the independent producers indicated the need to expand the program to larger organizations and companies that could provide the technology solutions needed in the field.

The *Technology Development with Independents* is in the 4th phase. The *Technology Development with Independents* specifically targets projects by smaller independent operators (i.e., with less than 50 employees) that could demonstrate technologies especially relevant to the operations of domestic independent oil producers.

The *Advanced Technology Development with Independents* is in the 2nd phase. The *Advanced Technology Development with Independents* opened to larger independents and any organization (any business, service company, educational institution, or state agency) with advanced and key technology projects that could provide technical solutions to issues limiting domestic on-shore or off-shore oil and gas exploration and production by independent oil producing companies.

For additional information regarding the *Technology Development with Independents* program contact: Jim Barnes, 918-699-2076;
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For additional information regarding the *Advanced Technology Development for Independents* program contact: Rhonda Jacobs, 918-699-2037;
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How the programs work.

DOE will contribute up to 50% cost-shared funding for approved R&D type field demonstration projects (funding limits vary with the individual program). The focus of the projects is to develop and demonstrate technology which benefits independent operators. The results and lessons learned from the projects are then transferred to the industry through various technology transfer activities, such as the Petroleum Technology Transfer Council (PTTC), SPE, AAPG, etc. When applied in their proper environment, these technologies can be utilized elsewhere to positively affect production and profitability quickly. All of those responsible for maximizing production and profitability (operators, geologists, engineers, consultants, etc.) can benefit from learning more about results from these projects.

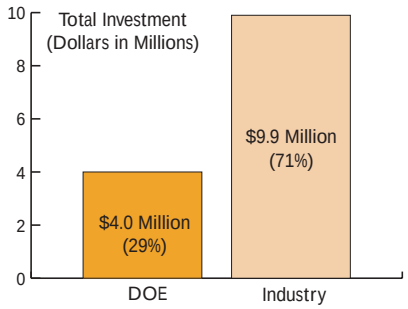
What's happened so far?

DOE has awarded 62 *Technology Development with Independents* projects in 19 different states. 40 of those projects have been completed and 22 are currently active. DOE has awarded five *Advanced Technology Development with Independents* projects in five different states. All five of those projects are in the early stages of implementation.

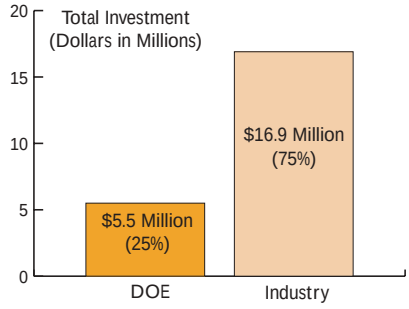
Who is PTTC?

PTTC is an industry-driven organization created to transfer exploration and production technology to U.S. oil and gas producers through programs that meet the technology needs of its customers, primarily independent producers. PTTC in conjunction with NETL, produces periodic newsletters, maintains a PTTC website at **www.pttc.org**, and conducts interactive workshops around the country, all to convey the results of technologies such as those successfully demonstrated through these projects to other operators in the oil and gas industry. PTTC periodically reviews existing DOE R&D programs to identify field demonstration opportunities of interest to industry and provides feedback to DOE on industry's technological needs.

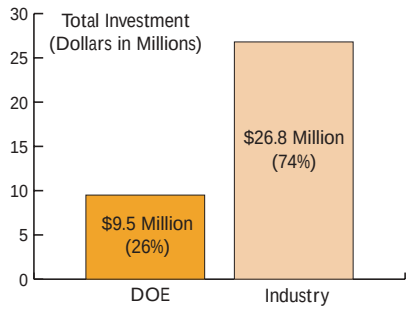
Technology Development with Independents



Advanced Technology Development with Independents



Total Program



Successful Projects

Cobra Oil & Gas (with partners the University of Alabama and Schlumberger) – Formation Micro-Imaging (FMI) Log

Cobra Oil & Gas ran Schlumberger's Formation Micro-imaging (FMI) log in a Frisco City sandstone well in Monroe County, Alabama, for which whole core was readily available, to determine if the FMI log could be used as an alternative to coring in order to reduce drilling costs and coring risks. The core was described by geoscientists from the Alabama Geological Survey and the University of Alabama Geology Department to determine the facies distribution, geological characteristics, and reservoir properties. The core description was compared to the FMI log interpretation to determine if the FMI log could be used as a less expensive and less risky means to obtain information necessary for the development of fluid flow models used for drilling, production, and reservoir management purposes. The FMI log environment of deposition interpretation did not differ significantly from the whole core interpretation, demonstrating the log's reliability for deciphering reservoir quality. The porous and permeable intervals as determined from the FMI log interpretation were consistent with the pay zones defined from the whole core analysis. The FMI log also provided paleocurrent direction and sandstone orientation data that is not available from the core description, yet this information is critical to establishing a regional stratigraphic model. The FMI log also proved beneficial in identifying anisotropic features that could be barriers to fluid flow. Core analysis did, however, indicate which porous and permeable intervals had potential for oil production (the presence of hydrocarbons in the core samples) which could not be interpreted from the FMI log.

Bottom Line: *The project confirmed that the FMI log can be used successfully as a valid alternative to whole core and whole core analysis. Cost saving are estimated to be $10,000 to $25,000 per well depending on depth and conditions.*

In most cases the GasGun™is shot from a wireline much like a perforating gun.

DAKFAM, Inc., St. Charles, IL - Oil Well Remediation using Gas Gun Technology

DAKFAM successfully re-worked 3 idle (shut-down) wells in Wayne and Clay Counties of southeastern Illinois using gas gun technology. The gas gun technology uses low-level explosives to generate shockwaves and high pressure that creates fissures which extend outward in all directions from the drill hole connecting with pre-existing fractures in which oil is trapped. The treatments were enhanced by acidizing the newly fractured network to dissolve limestone around the fractures. Previous attempts to break-down and acidize the same zones using conventional techniques were unsuccessful. Following the workover treatments, the wells are now producing a combined 26 barrels of oil per day (bopd). The successful project demonstrates the efficient and cost effective potential of the gas gun technology.

Bottom Line: *The success of this field demonstration project has resulted in returning three "zero production" idle wells to production with an incremental increase in production of 26 bopd. This technology has the potential for returning to production a significant number of idle wells with similar completion problems in this and other areas across the country.*

Sandia Operating Corp. – Low-Invasion Unconsolidated Coring System & Core Analysis

Sandia Operating Corporation successfully used a low-invasion hydrolift coring system to recover a full-diameter unconsolidated Cole sand core for core analysis in the Orlee Field area of Duval County, Texas. The hydro-lift system permits more complete and less damaging core recovery by allowing the newly cut core to enter into an aluminum inner barrel. After coring is completed, the core is frozen and retained in the inner barrel for better fluid preservation and protection from damage during shipment. The Cole sand formation water is fresh, rendering reliable log interpretation and water saturation calculation nearly impossible. Unreliable log analysis creates difficulty in identifying higher oil saturation zones for development drilling and completions. Because of the unconsolidated nature of the sand, there were previously no cores available for log calibration or core description. Core recovery from the well was 100% and only one foot of the core visually appeared to be invaded and flushed by mud filtrate. A full suite of core analyses provided information on reservoir facies, porosity, and oil saturations, and provided data with which to successfully calibrate Sw from the logs. Core analysis provided valuable information on porosity and permeability distributions not available from logs.

Bottom Line: *Correlations were developed between the core descriptions, core analysis, and log responses which will help to reliably identify potential completion intervals in future wells using just open-hole logs.*

St. James Oil Corp. – Improved Acid Stimulation of Wells

St. James targeted four wells in the Los Angeles Downtown Oil Field, each exhibiting characteristic high scaling tendencies and substantial production decline following conventional acid stimulation, to demonstrate the effectiveness of a new acid treatment. Prior acid stimulation projects in the field have experienced high decline rates following stimulation, and typically, production rates return to pre-stimulation rates in less than one year. To obtain longer lasting treatment efficiencies, phosphonic acid was used in conjunction with a conventional hydrochloric acid treatment. The addition of the phosphonic acid, known to be effective in the treatment of calcium carbonate scale, was primarily designed to provide longer-term inhibition of calcium carbonate scale formation following scale cleanup by the hydrochloric acid. Also, the phosphonic acid reacts with the aluminum in the clays and other feldspars to form a temporary protective film. This film enhances treatment penetration and reaction effectiveness of the hydrochloric acid, reacting with and reducing migrating fine particles that interfere with oil movement into the wellbore. Each well was returned to production approximately one week after treatment. As might be expected, treatment response varied between wells, however, all four wells responded favorably to stimulation.

Bottom Line: *The combined production increase following treatment was incrementally double the pre-treatment rates of 55 barrels of oil per day (bopd). Production increases of this magnitude are at least as high as are typically obtained with conventional hydrochloric acid treatments, and post-treatment decline rates remain significantly lower two years after treatment. Incremental treatment cost per well for the combined acid treatments are only about 16% higher than for conventional acid treatments. Payout was less than four mon*

Recent Awards

Visos Energy Co., Austin, TX, (in partnership with the Bureau of Economic Geology (BEG) at The University of Texas at Austin) - Improved 9-Component Vertical Seismic Profiling

The sand surfaces of the Morrow Trend of Colorado, Kansas, Oklahoma and Texas do not always generate sufficient reflected compressional (P) wave energy to produce a clear enough image to define the structural relief from conventional 3-D seismic interpretation. However, those Morrow reservoirs that generate weak P-wave seismic reflections often produce robust shear (S) wave reflections. The project operators used a vertical vibrator, an inline horizontal vibrator, and a crossline horizontal vibrator to generate and record nine-component vertical seismic profile (9-C VSP) data. The configuration generated the three fundamental wave modes required to define the full vector properties of a seismic wavefield, the compressional (P) mode, the horizontal shear (SH) mode, and the vertical shear (SV) mode. Using techniques developed at the BEG to correlate P and S-wave reflection data, the 9-C VSP data were processed to create P and S-wave images of the Morrow stratigraphy. The S reflections were often more robust that the P reflections and vertical resolution of S-wave images was as good as the vertical resolution of P-wave images. Thus surface recorded S-wave data provide a spatial resolution of Morrow targets that is equivalent to the resolution achieved with P-wave surface recorded data in other reservoirs with good P-wave reflectivity.

Bottom Line: *The success of this field research project has resulted in a new company, Vecta Technology, L.P. (with whom Visos Energy Co. merged), to commercialize this emerging technology. 9-C VSP technology can be applied to other reservoirs where P-wave data are inadequate and could result in the discovery of billions of additional barrels of oil across the United States.*

Enerdyne LLC, Albuquerque, NM, will test a new submersible pump in the Red Mountain Reservoir in the San Juan Basin, McKinley County, NM. The positive displacement, diaphragm type pump will be suspended on the end of a stainless steel wireline cable. Electric power will be sent to the pump through an electrical cable banded to the wireline. Suspending the pump on a wireline permits it to be deployed, and retrieved when necessary, in a matter of hours using a towable trailer with a portable winch. The new submersible pump can cut typical oil field capital and operating costs significantly.

Schlumberger Data and Consulting Services, Pittsburgh, PA, will demonstrate the use of cost-effective key and advanced technologies to better understand the oil reservoirs of the Detroit River and Richfield oil formations in the Beaver Creek Field, Crawford County, MI, prior to $C0_2$ flooding. The project will also demonstrate the use of advanced time-lapse seismic technologies to "see" the $C0_2$ flood front in "real-time" during $C0_2$ injection for control and optimization of the enhanced oil recovery operations.

Temblor Petroleum Co. LLC, Bakersfield, CA, will re-drill a well horizontally and underbalanced (mud weight less than the reservoir pressure) at 10,000 feet vertical depth in the fractured Monterey formation, in the Santa Maria Basin, Santa Barbara County, CA, to encounter a maximum number of vertical fractures in the reservoir. Cutting edge logging while drilling (LWD) technology will be used to verify the fracture orientation and change drill direction if required. Drilling underbalanced will allow oil and gas to flow freely to the bore hole with the minimum amount of damage to the reservoir.

Utah Geological Survey, Salt Lake City, UT, will conduct a case study of the (Mississippian) Leadville Limestone at the Lisbon field, Paradox Basin, San Juan County, UT, in order to understand the rock characteristics for regional applications. Leadville Limestone accumulations in other areas of the Paradox Basin in Utah and Colorado will be included in the study. The study will include a low-cost, environmentally sensitive field demonstration of new exploration technologies such as surface geochemical surveys of the soil, using a variety of new techniques, to detect where oil or gas may have leaked to the surface. Regional depositional environments will be determined by evaluating rock cores from wells, surface outcrops, and modern analogs. Potential oil-prone areas will be identified based on shows using low-cost microscopic fluorescence of oil in rock samples from wells. The study will be used to target areas for Leadville exploration. The project's aim is to reduce exploration costs and drilling risk, especially in environmentally sensitive areas, and add new oil discoveries and reserves.

Vecta Exploration, Inc., Dallas, TX, will test a new shear-wave seismic technology, designed to locate underground oil-bearing traps often invisible to conventional seismic technologies, to explore for subtle oil-bearing Mission Canyon oolitic limestone reservoirs in the Williston Basin of Mountrail and McLean Counties, ND. The concept employs all four types of shock waves generated in a seismic survey, the compressional P-wave plus the three other major types of shock waves, the horizontal shear SH-wave, the vertical shear SV-wave, and the converted shear C-wave, to image and identify elusive stratigraphic traps.

Current *Active* Projects

Running low-volume submersible pump, Beard Lease, OK.

American Energies Corp., Wichita, KS, is designing and implementing a low-cost, effective waterflood in the Mississippian formation of the Wellington West Field, Sumner County, KS, that demonstrates application of inexpensive but modern tools to build an integrated reservoir model, based on geologic, geophysical, and engineering characterization techniques.

Arnell Oil Co., Littleton, CO, will demonstrate alkaline-surfactant-polymer (ASP) chemical flooding technology designed to produce economical, incremental oil reserves in the Poison Spider field in Natrona County, WY. This project will demonstrate that chemical flooding is applicable to higher viscosity oil reservoirs.

Bass Enterprises Production Co., Fort Worth, TX, will acquire and analyze advanced 3C-3D seismic imaging data from a small 3C-3D seismic test patch embedded in a large-scale conventional 3D seismic survey using geophysical data obtained from a seismic survey in Reeves County, TX. The 3C-3D test patch can be incorporated into the conventional 3D seismic survey for minimal incremental cost, providing a low-risk, low-cost option for independents to acquire specific advanced seismic shear wave data across exploration prospects of interest. The 3C data can be analyzed to determine if the converted shear wave reflections provide critical reservoir information (detect faults, fractures, and other facies that influence reservoir performance) that cannot be derived from the conventional 3D seismic data alone. The comparison will provide the information necessary to determine if large-scale 3C-3D data acquisition across the prospect area is justifiable.

Beard Oil Co., Dewey, OK, is installing and testing a new type of low-volume submersible pump to evaluate its ability to lower operating costs in a typical low-production marginal oil field in Washington County, OK. The new submersible pump will be compared with conventional rod pumps to evaluate comparative pump efficiencies and operating costs.

Benson-Montin-Greer Drilling Corp., Farmington, NM, is using new log interpretation methods based on artificial intelligence and neural networks to evaluate oil well recompletion opportunities in the Mesaverde formation of the San Juan Basin in Rio Arriba County, NM.

Crystal River Oil and Gas L.L.C., Encinitas, CA, will test a new polymer gel treatment process that restricts water production in oil wells in the Alameda Field, Kingman County, KS. The new polymer gel is comprised of two chemicals, a powdered polyacrylamide polymer (a strengthening agent) and chromic acetate (a cross-linking agent) which together form a high strength thickened gel. The gel will be pumped under pressure into highly permeable, water-saturated zones, significantly reducing permeability to water so that oil can be produced from tighter adjacent rock layers.

Driver Production, Inc., Okmulgee, OK, is conducting a gas re-pressurization/well stimulation project on a six well, 80-acre portion of the Dutcher Sand of the East Edna Field, Okmulgee County, OK. The objective is to produce additional oil by repressurizing the reservoir with excess natural gas that cannot otherwise be economically delivered to local gas gathering systems.

Grand Mesa Operating Co., Wichita, KS, will demonstrate the feasibility of using polymer gel technology to increase the recoverable reserves from Mississippian reservoirs in the Dickman Field, Ness County, KS. Inadequate reservoir characterization, drilling and completion design problems, and extremely high water cuts and low recovery factors are limiting the economic viability of this vast resource. If successful, the use of polymer gels will reduce water production, reduce well operating costs, and increase oil production throughout the region.

Marks & Associates, Cypress, CA, uses biostratigraphy to establish an age zonation containing biohorizons that can be used as a standard for future drilling in the Blair/Barham Field, Santa Barbara County, CA, to increase production, reduce risk and operating costs, and reduce environmental concerns.

Peden Energy, Fort Worth, TX, will demonstrate that micro-turbines are more efficient and less costly to operate than traditional internal combustion engines for electrical generators. They will also install variable frequency drives, with computerized pump-off controllers which respond to the down hole torque demand, adjusting and varying the pumping speed of the well. The greater the torque, the faster the pumping. Conversely, as torque demand decreases, the pump speed is decreased. The demonstration project will be conducted on leases in Cochran and Hockley Counties, TX.

St. James Oil Corp., Laguna Hills, CA, will use a new hydrochloric-phosphonic acid solution to restore oil production in shut-in wells in the Las Cienegas Field, Los Angeles County, CA. The new acid treatment system is designed to dissolve severe calcium carbonate "scale" buildup and inhibit the formation of additional calcium carbonate scale. If successful, use of the hydrochloric-phosphonic acid solution could result in returning hundreds of wells to production throughout the area.

Team Energy L.L.C., Bridgeport, IL, will test the feasibility of using two different specially designed types of instrumentation, a fluid density meter and an inductive electrical conductivity meter, which will control the ability of oil well pumping equipment to limit the volume of salt water produced from stripper wells. Because the density and electrical conductivity properties differ between oil and water, the instrumentation should be able to detect which fluid is in the produced stream. The proposed technology will monitor the well to pump off only the oil, and stop the pump when water is detected in the produced stream. Two active pumping wells in the Illinois Basin in Posey County, IN, will be used to confirm the effectiveness of the two different meters.

TENECO Energy LLC, Wheat Ridge, CO, intends to restore production in the East Texas Oil Field in Gregg and Rusk Counties, TX, by using advanced computer imaging technology, new logging tools to locate promising geologic features and high residual oil saturation zones, and selectively perforate promising target intervals in the Woodbine sand.

TENECO Energy LLC., Wheat Ridge, CO, will use regenerating bio-chemicals (e.g., microbes and organic surfactants) to reverse formation damage, restore permeability and improve production in the East Texas Oil Field in Rusk County, TX. Abnormal deposits of paraffins and asphaltenes, resulting from early exploration and production practices in the 1930s, have severely reduced the productive life of this field. Successful application of bio-chemicals should remove near wellbore paraffin and asphaltene deposits and improve oil production.

Terra Oil Exploration and Production Co., Signal Hill, CA, will run newly-developed cased hole well logs to identify bypassed oil in a selected deep well in the Santa Fe Springs oil field in Los Angeles County, CA. Many productive zones of the field have been waterflooded to recover oil from more permeable sand layers. It is suspected that flooding of selected sands in this area may have bypassed lower permeable, yet oil-saturated sand intervals. Potentially productive zones will be identified, and nearby wells will be re-completed to increase recovery and add bypassed oil to improve production.

Vaquero Energy, Inc., Edison, CA, will develop wireless surveillance equipment suitable and economical for use on low volume producing wells in the Edison Field, Kern County, CA. The feasibility of the technology was demonstrated in an earlier project and the continuation involves additional testing of pumping unit vibration/frequency monitoring devices, plus the investigation and testing of other low cost wireless devices which may be appropriate for stripper oil well production monitoring.

Vecta Exploration, Inc., Dallas, TX, will complete a shear wave seismic study using data obtained from a well in Clark County, KS, documenting the imaging quality, costs, and potential benefits of combining shear (S) wave and compressional (P) wave seismic data. Conventional 3D seismic surveys use only P-wave data which is sufficient to identify the shape of a subsurface structure. However, successful drilling often depends not only on the shape of the structure, but on locating rock fractures, detecting porosity trends, and locating subtle areas of trapped oil. Combining S-wave with P-wave data can provide a more complete geologic "picture" of potential subsurface oil and gas bearing formations.

Standard pumping unit, East Texas Oil Field.

Woolsey Petroleum Corp., Wichita, KS, will study ways to improve "hydraulic fracturing" in the Medicine Lodge North Field of Barber County, KS, by investigating geologic and engineering factors critical for designing optimum hydraulic fracture treatments.

Technology Development with Independents

Project Sites

● Technology Development with Independents (4 phases) = 62 projects in 19 states
▲ Advanced Technology Development with Independents (2 phases) = 5 projects in 5 states

Total Number of Projects = 67 projects in 21 states

Cost-Share by State where Project Located (through Advanced Technology Phase AT2):

STATE (Project)	No. Projects	Oper. CostShr $	Oper. Percent	DOE CostShr $	DOE Perecnt	Total $
Alabama	1	25,000	50	25,000	50	50,000
Arkansas	1	312,000	81	75,000	19	387,000
California	11	4,700,414	68	2,188,166	32	6,888,580
Colorado	1	33,960	60	22,180	40	56,140
Illinois	1	124,105	62	74,810	38	198,915
Indiana	3	313,306	61	197,606	39	510,912
Kansas	8	1,293,748	69	589,500	31	1,883,248
Kentucky	1	60,818	55	49,753	45	110,571
Louisiana	1	41,690	53	37,400	47	79,090
Michigan	1	12,562,000	86	1,971,842	14	14,533,842
Mississippi	2	231,606	65	125,000	35	356,606
Nebraska	1	125,000	63	75,000	38	200,000
New Mexico	5	1,188,026	57	896,004	43	2,084,030
Nevada	1	74,170	50	74,170	50	148,340
North Dakota	1	1,975,250	62	1,199,997	38	3,175,247
Ohio	3	199,826	55	161,500	45	361,326
Oklahoma	10	1,559,958	76	505,775	24	2,065,733
Texas	10	1,401,828	67	695,881	33	2,097,709
Utah	2	365,187	53	317,828	47	683,015
West Virginia	1	46,430	50	46,430	50	92,860
Wyoming	2	150,000	50	147,202	50	297,202
TOTAL	**67**	**26,784,322**	**74**	**9,476,044**	**26**	**36,260,366**

Office of Fossil Energy

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