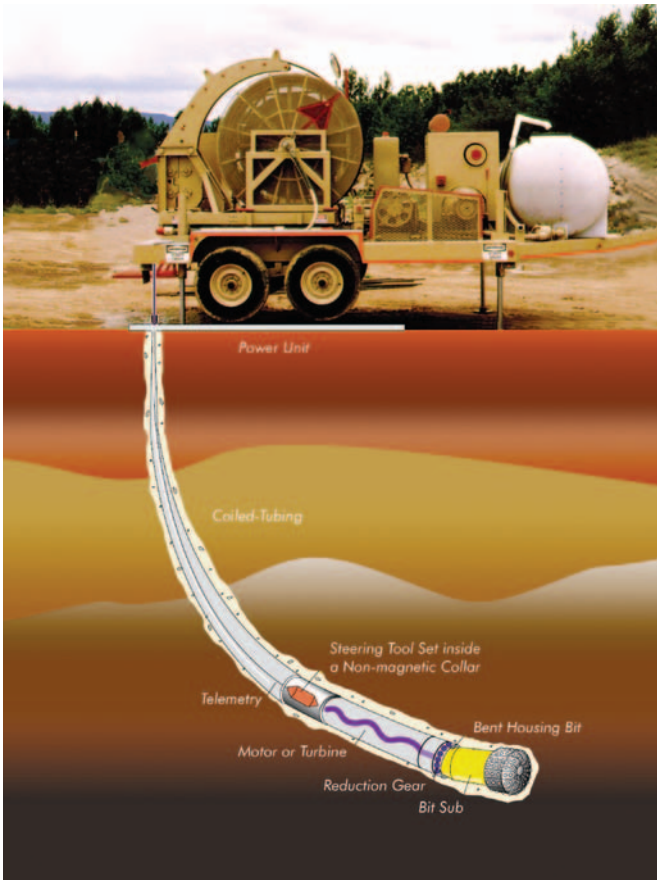
- The USA has massive reserves of shallow oil that are too expensive to recover.
- Micro-hole technology will cut drilling costs, making the recovery of shallow oil affordable.
- The new technology will also reduce environmental impact and improve data acquisition, facilitating exploration.

Getting more for less

Micro-hole technology is set to revolutionise the oil industry by allowing shallow oil to be reclaimed, reducing costs and minimising environmental impact. The DOE's Paul West explains how the USA is hoping to benefit.



Micro-hole technology promises to bring great benefits to the oil industry

At present, only about a quarter of technically recoverable domestic oil resources in the USA are economically recoverable, even at today's high oil prices. Finding a cost-effective method of recovering shallow oil is becoming an increasingly attractive proposition and micro-hole technology could be the solution.

Micro-hole drilling has the potential to greatly reduce the cost of drilling shallow and moderate-depth holes for exploration, field development, long-term subsurface monitoring and, to a limited degree, actual oil and gas production. It also offers greatly enhanced reservoir imaging, making access to data cheaper and more precise, as well as being invaluable during exploration activities.

If costs can be reduced, oil and gas reservoirs that are uneconomic today could become economically viable. The Department of Energy (DOE) has launched a micro-hole initiative to assess the potential benefits to the USA and encourage research. It includes awarding companies promising breakthroughs in this field. The main focus of US-based research is aimed at developing technologies to enable coiled tubing drilling of boreholes with a diameter of 3.5in or smaller using innovative, hybrid coiled tubing drill rigs.

Great potential

Micro-drilling technologies and micro-instrumentation are expected to benefit exploration activities and long-term reservoir monitoring as well as increase production by cutting expenses for rigtime, materials, labour and support equipment. The fact that micro-hole technologies reduce the costs of overall operations makes exploration and production economically attractive to the independent operators that produce most of the USA's domestic oil.

> At least 10 per cent of the 218 billion barrels of oil in reservoirs less than 5,000ft deep could be recovered. This represents ten years of OPEC imports.

Micro-hole technology will allow independent operators to invest in a new wave of infill drilling of shallow development wells. Re-entering existing wells will also be possible, increasing production from bypassed zones and providing a reliable capability to deepen thousands of boreholes. This will encourage deeper exploration in existing fields because the top section has already been drilled. These new low-cost production capabilities are needed to invigorate the domestic oil and gas industry so that more of the petroleum resources in the USA's mature basins can be recovered.

The predicted reduction in materials, labour and support equipment could cut expenses in half when compared with drilling a conventional well and volumes of drilling fluids and cuttings could be lowered by one fifth, reducing disposal costs. In addition, smaller footprints, reduced drilling waste and increased transportability for remote, fragile terrains will lessen the environmental impact of drilling activities, making micro-hole drilling applicable in environmentally sensitive areas. Furthermore, overall coiled tubing drilling efficiency improvements could be applied to ultra-deepwater operations.

The economic and environmental benefits are expected to increase exploration and production activities, improving domestic oil and gas production and revenues from federal lands. At least 10 per cent of the 218 billion barrels of oil in reservoirs less than 5,000ft deep could be recovered. This represents ten years of OPEC imports.

Improving access to information

Micro-hole technology will also assist exploration and improve access to data on operating wells using economic seismic technologies for reservoir imaging. Both exploration and assessment of current reservoirs will be greatly enhanced by high-resolution seismic imaging utilising MicroElectroMechanical (MEMS) technologies. This is expected to result in unprecedented seismic imaging using miniaturised sensors for high-resolution exploration methods.

Dedicated boreholes with permanent reservoir monitoring systems will provide high-resolution, real-time information while monitoring and optimising improved oil recovery (IOR) processes. This low-cost, long-term, improved imaging method of monitoring fluids in the reservoir will enhance oil recovery and allow dedicated boreholes for reservoir monitoring, eliminating production interruptions. This new-found geophysical capability utilising vertical seismic profiling (VSP) is referred to as 'designer seismic' because geophysicists will now be able to pick the location of the instrument package rather than using an existing well while production is shut in.

Ongoing research

The micro-hole initiative was based in part on the miniaturisation of seismic sensors, micro-hole rig development and feasibility studies conducted by Los Alamos National Laboratory (LANL) and its industry

Micro-hole applications

A group of oil and service company representatives have discussed the merits, needs, development and applications of micro-hole technology. The group identified the following potentially significant applications of micro-hole drilling using coiled tubing:

- **Shallow development wells.** Drilling with coiled tubing micro-hole technology requires about a third of the space and equipment loads needed for a rotary drilling rig.
- **Reservoir and seismic data holes.** Small-diameter dedicated wells can be used to monitor reservoir response to production and injected fluids. The wells will not disrupt production and can be located at optimum positions to obtain 4D images of reservoir fluid movement and bypassed oil.
- **Drilling shallow re-entry wells.** Low-cost re-entry of existing wells allows drilling single or multiple lateral boreholes that allow 'deep' perforations, imaging of lateral variations of reservoir properties by seismic array deployments and vertical flooding projects that could significantly increase recovery, especially in mature mid-continent fields, and return those fields to profitable operations.
- **Drilling deep exploration tails.** Micro-hole re-entry of existing wells can cheaply extend the wellbore to evaluate zones just below the targeted zone of interest.

Micro-hole Solicitation II Awards

In January 2005, the DOE announced the winners of its funding awards for micro-hole research. These awards are intended to advance micro-hole technology towards commercial viability and widespread adoption by the US oil and gas industry. The ten new projects are:

Geoprober Drilling Inc, Houston, Texas
Three wells are being drilled with an innovative composite-coiled tubing drilling system and a 3.125in diameter bottomhole assembly to confirm whether low-cost, shallow slim/micro-hole exploration wells can be drilled in water depths up to 10,000ft.

Gas Technology Institute, Des Plaines, Illinois
The experimental next-generation micro-hole coiled tubing rig, MOXIE – built by Coiled Tubing Solutions, based in Dallas, Texas, for coiled tubing and micro-hole drilling to a 5,000ft subsurface – is being tested in the field by GTI, which will also lead a technology transfer programme of the results.

Confluent Filtration Systems LLC, Houston, Texas
Researchers are working on a revolutionary elastic-phase, self-expanding tubular technology called CFEX, which will lead to the development of self-expanding well casings to suit any diameter, resulting in improved methods and feasibility for monobore drilling and well construction.

Tempress Technologies, Kent, Washington
A small, mechanically assisted, high-pressure waterjet drilling tool is being developed, which would boost the pressure that can be delivered by coiled tubing, maximising drilling rates.

CTES LP, Conroe, Texas
A prototype device that vibrates the coiled tubing from the surface to reduce friction along the coiled tubing drillstring in inclined/horizontal well sections longer than 2,000ft is being designed, built and tested. This will enable operators to use coiled tubing to drill micro-hole sections longer than 3,000ft in horizontal wells.

Technology International Inc, Kingwood, Texas
A high-power turbodrill, which will deliver efficient power at relatively high revolutions per minute and with a low bit weight, and a more durable drillbit using high-temperature cutters that can drill hard and abrasive rock in 3.5in boreholes are being developed and tested.

Ultima Labs Inc, Houston, Texas
Existing technologies for measurement while drilling and logging while drilling are being integrated into an inexpensive measurement system to facilitate low-cost coiled tubing drilling of small-diameter (3.5in) wells at depths shallower than 5,000ft.

Baker Hughes Oilfield Operations Inc, Houston, Texas
Researchers are developing a wireless system to steer drilling in a 3.5in diameter or smaller hole for an effective, modular coiled tubing drilling system as well as a downhole bi-directional communications and power module and a surface coiled tubing communications link.

Gas Technology Institute, Des Plaines, Illinois
A counter-rotating motor drilling system, which will concentrate weight on the drillbit in a 3.5in diameter or smaller borehole and address the limited torque on a coiled tubing drillstring, is being designed to reduce the costs associated with unconventional gas and increase the effectiveness of coiled tubing drilling for a wider range of drilling environments.

Confluent Filtration Systems LLC, Houston, Texas
To meet the need for versatile and robust downhole sand screens that are suited to a variety of drilling environments, research is being conducted on a self-expanding, high-flow sand screen that could be constructed from a wide range of materials.

partners. The feasibility study and demonstration of coiled tubing-deployed micro-drilling indicated that micro-holes could increase recovery from domestic oil and gas fields. The first solicitation from the micro-hole initiative focused on field demonstrations and the technologies needed to employ coiled tubing micro-hole drilling in the field. This involved demonstrations of 4.75in commercial micro-hole technology and applications in selected regions of the USA.

A micro-hole coiled tubing rig has been designed and built that can drill 1in through 2.375in coiled tubing boreholes with low-density, compressible drilling fluids. Micro-hole-specific mud systems that are truck-, trailer- or skid-mounted and meet USDOT regulations have also been developed. The mud system must be able to mix, circulate downhole, clean and hold diesel- or water-based drilling mud, and be compatible with an underbalanced drilling system.

Micro-hole coiled tubing bottomhole assemblies, including measurement while drilling, logging while drilling, directional assemblies and positive displacement motors suitable for drilling 3in boreholes, are also being tested. Meanwhile, completion and production equipment appropriate for ultra-small diameter boreholes are being developed.

With these developments, this is an exciting time for the oil industry, promising to reduce production costs, improve access to information and, most importantly, make the reclaiming of the USA's huge resources of shallow oil a reality for the future.

AUTHOR

Paul West is the project manager for the US Department of Energy's micro-hole systems research and development programme.

The programme aims to determine the viability of micro-hole technology as a lower cost, lower environmental impact technology that can benefit domestic oil and gas exploration and production, including the development of miniaturised sensors and other downhole drilling components.