WVHTC Foundation explores energy concepts

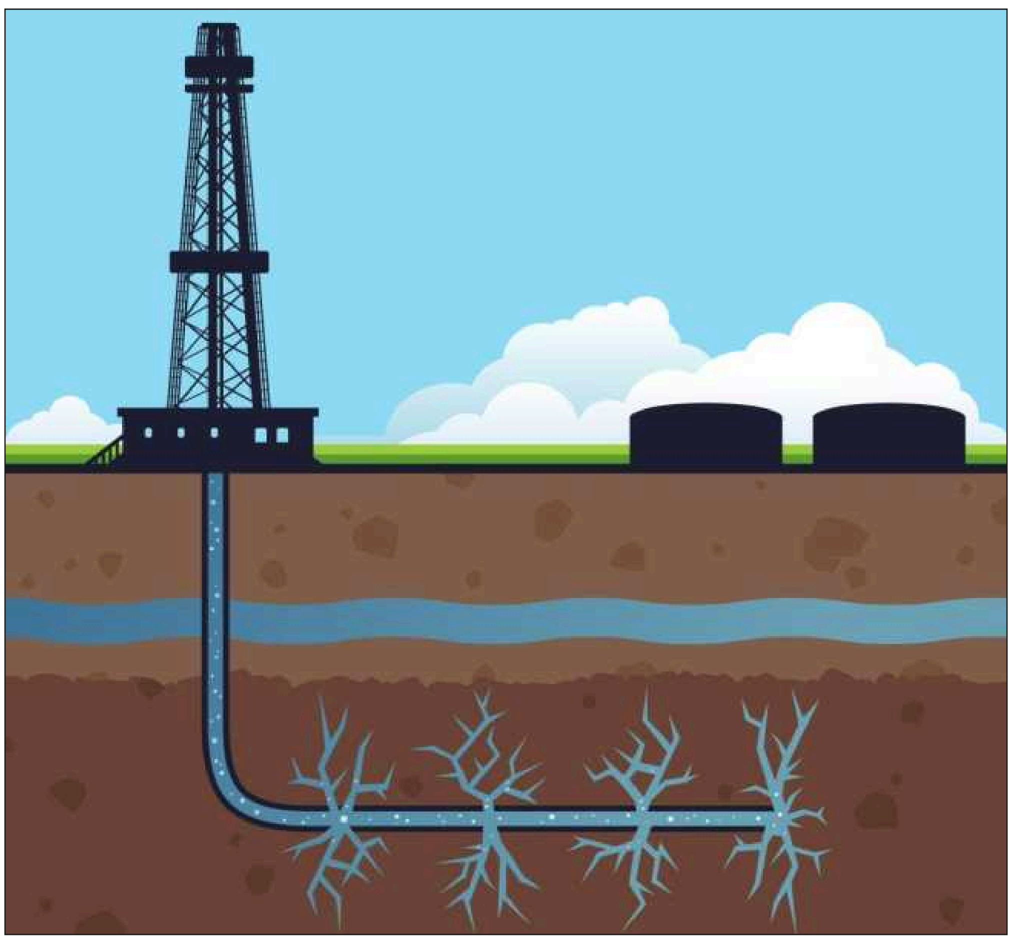
FAIRMONT — In a speech to the nation, former President Jimmy Carter once said, "Energy will be the immediate test of our ability to unite this nation, and it can also be the standard around which we rally. On the battlefield of energy we can win for our nation a new confidence, and we can seize control again of our common destiny."

West Virginia has long been on the front lines in this "battlefield of energy," bringing to the fight its vast reserves of coal that have sustained our nation for many decades.

More recently, West Virginia has offered the enormous energy potential of its natural gas reserves locked in the Marcellus shale deep underground. West Virginia also has abundant wind resources that can drive windmill generators on a large scale.

In the spirit of this noble heritage, the WVHTC Foundation is seeking to join the energy battle with a number of technologies it is now exploring. Four specific energy concepts will be summarized here that make use of technologies originally developed for U.S. government projects at the WVHTC Foundation.

Capitalizing on West Virginia's enormous natural gas resources, the first concept could help improve hydraulic fracturing operations in the Marcellus shale while preserving the environment. The second concept could help stimulate marginal oil and gas wells, extending the productive life of a large number of wells. A third concept offers a high-temperature solar absorber that could allow more efficient generation of electricity in concentrated solar power plants to help lower the cost of thermal solar power. The fourth concept provides a fuel-efficient distributed-energy system with low global warming potential for commercial buildings that uses domestic natural gas combined with thermal solar energy to generate electricity and provide building temperature control.



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The WVHTC Foundation has been developing a concept for hydraulic fracturing of the Marcellus shale that could better confine the fractures within the relatively thin Marcellus stratum resulting in reduced fluid use and improved containment of fractures close to the wellbore.

Improved hydraulic fracturing in the Marcellus shale

In order to collect gas efficiently from the relatively impermeable Marcellus shale, the shale is hydraulically fractured to open up paths for gas flow to the wellbore.

Common hydraulic fracturing methods can send fractures more than 1,000 feet above the Marcellus shale, even though the Marcellus stratum is less than 100 feet thick over most of West Virginia, western Pennsylvania and Ohio. Some have speculated that these out-of-formation fractures could intersect abandoned wells or natural faults in rock layers providing conduits to drinking water aquifers close to the surface.

The WVHTC Foundation concept would confine fractures entirely within the relatively thin Marcellus stratum. In doing so, smaller volumes of fracturing fluids would be required, lowering the potential risk of accidental spills at the surface, and reducing the extensive truck traffic involved in transporting fracturing fluids.

In addition, with fracture heights of less than 100 feet compared to the 1,000-foot heights of some conventional hydraulic fractures, the WVHTC Foundation system would avoid intersecting abandoned wells, or natural faults.

To help maintain adequate production levels with shorter fractures, the WVHTC Foundation method will produce greater fracture branching and more complete coverage of formation volumes than conventional hydraulic fracturing methods.

Stimulation of marginal oil and gas wells

Another concept that has been explored at the WVHTC Foundation could help small oil and gas companies renew production in mature oil and gas wells that have lost productivity over the years.

According to industry statistics, there were more than 375,000 oil and 322,000 gas wells that fall in this category in the United States in 2008 with combined production amounting to nearly 20 percent of total U.S. production. Some estimates indicate that as much as two-thirds of recoverable reserves remain in the ground in many of these wells.

A system for rejuvenating these wells would have an enormous economic impact even if increases are only incremental. Moreover, production gains are made using existing wells so surface disruptions are relatively minor and the environment is preserved.

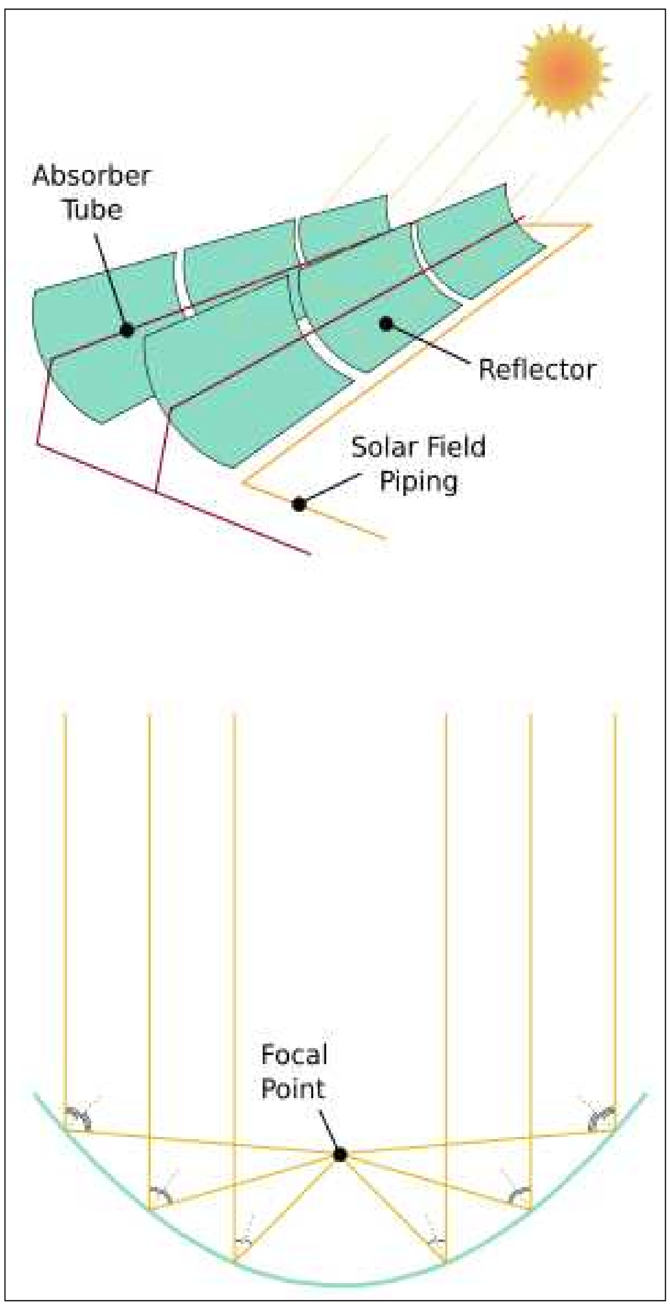
High-temperature concentrated solar absorber

On other energy fronts, the WVHTC Foundation has proposed a new device for collecting the energy of the sun in concentrated solar power plants.

Concentrated solar power plants use mirrors or lenses to focus sunlight gathered over a large area onto a relatively small solar absorber, heating a fluid that flows within the absorber to very high temperatures. Electric power is produced when heat carried in the absorber fluid is used to drive special engines that turn generators. Efficiency of the process increases with fluid temperature, so high solar receiver temperatures are highly desirable.

The solar absorber proposed by the WVHTC Foundation is an advanced device that can operate at temperatures in excess of 650 degrees Celsius. This is about 250 degrees Celsius hotter than typical receiver temperatures and close to the melting point of aluminum — hot enough that materials will glow red.

At these temperatures, concentrated solar power plants can convert a very high fraction of the concentrated solar heat into electricity, helping to make electricity from solar power plants less expensive.



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Trough systems for concentrated solar power use mirrored parabolic reflectors to focus the sun's energy on a fluid-carrying absorber tube at the focal point of the curved reflector. The WVHTC Foundation has proposed an absorber that can operate at very high temperatures for high efficiency conversion of solar heat into electricity.

Distributed energy system with low global warming potential

In a grander long-term vision, the WVHTC Foundation has been exploring an energy strategy for commercial buildings that blends concentrated heat from the sun with heat from natural gas.

Combined heat from the two sources is converted into electricity in the same way that heat from concentrated solar power plants is converted into electricity. Distributed electricity from many commercial buildings can replace a substantial fraction of the power drawn from the grid, reducing the burden on central generating stations and utility lines.

In the proposed scheme, heat from natural gas is adjusted to compensate for variations in heat from solar energy, maintaining a steady, uninterrupted supply of electricity and eliminating the need for costly energy-storage systems normally associated with solar energy. Exhaust from the system that is not used to make electricity is used to heat the building in the winter months. In the summer months, exhaust heat can power absorption coolers to provide air conditioning on hot days.

While the use of heat to provide cooling may seem paradoxical, absorption coolers running on heat from LP gas are commonly used for refrigeration and food storage in recreational vehicles. By using exhaust heat that is normally vented to the atmosphere, nearly all the energy from the sun and natural gas is put to good use in the proposed system, making the overall economics very attractive.

In addition, the proposed combined energy system can provide a means of leveling out power drawn from the utility grid by commercial buildings throughout the day. This measure can save commercial establishments a great deal of money in peak demand charges for electric power. The system can replace backup generators that are frequently installed in large commercial buildings so that savings in backup generator costs can be applied toward the combined energy system.

Since the proposed energy system is designed for use in relatively large commercial or industrial facilities with many employees, it is likely that large numbers of vehicles will be parked near the facilities, especially during daylight hours. In this instance, the proposed energy system could be beneficially integrated with an electric vehicle charging system for parked vehicles as electric vehicles become more widely used.

Clean solar energy, supplemented with energy from relatively clean-burning natural gas, could then be used to charge electric vehicles while they are parked and idle at the workplace, removing this load from the grid and providing a means of injecting relatively clean domestic energy into the nation's transportation infrastructure.

Carrying the vision one step further, a feature could be added that separates methane, the main component of natural gas, into hydrogen and solid carbon. The hydrogen would then be combusted to make electricity while the solid carbon is easily sequestered so there is no global warming potential.

Since the byproduct of hydrogen combustion is simple water vapor, a hydrogen-burning version of the proposed system would provide the ultimate in clean energy derived indirectly from natural gas. The solid carbon sequestered from the process could be sold as a raw material in a number of applications.

In general, a system for generating electricity with no global warming potential from the combustion of methane-generated hydrogen would be beneficial in the larger electric vehicle infrastructure of the nation. In this case, energy from hydrogen combustion would generate electricity that would be stored in electric vehicle batteries. A hydrogen transportation system with no global warming potential would be created by this means that need not deal with the formidable challenges of storing hydrogen fuel on-board a vehicle powered directly by hydrogen.

In addition, refueling infrastructure is much more easily envisioned for the proposed transportation system since the nation's vast electric grid already provides the basic framework for distributing energy to electric vehicles charged by generators powered by hydrogen converted from methane.

Promising energy strategies such as these are being explored at the WVHTC Foundation to help our nation reduce its dependence on foreign oil and find wider applications for abundant domestic natural gas reserves while preserving the environment.

As former President Jimmy Carter concluded in his energy speech regarding an aggressive energy program, "It can rekindle our sense of unity, our confidence in the future, and give our nation and all of us individually a new sense of purpose."

Dr. Thomas Owens

Dr. Thomas Owens is a distinguished scientist in the Advanced Technologies Group at the WVHTC Foundation.

Owens joined the WVHTC Foundation in 2004 after working many years at the Oak Ridge National Laboratory, Fermi National Accelerator Laboratory and the McDonnell Douglas Astronautics Co.

Owens received his Ph.D. and M.S. degree in electrical engineering from the University of Wisconsin, and a B.S. degree from the University of California, Berkeley.