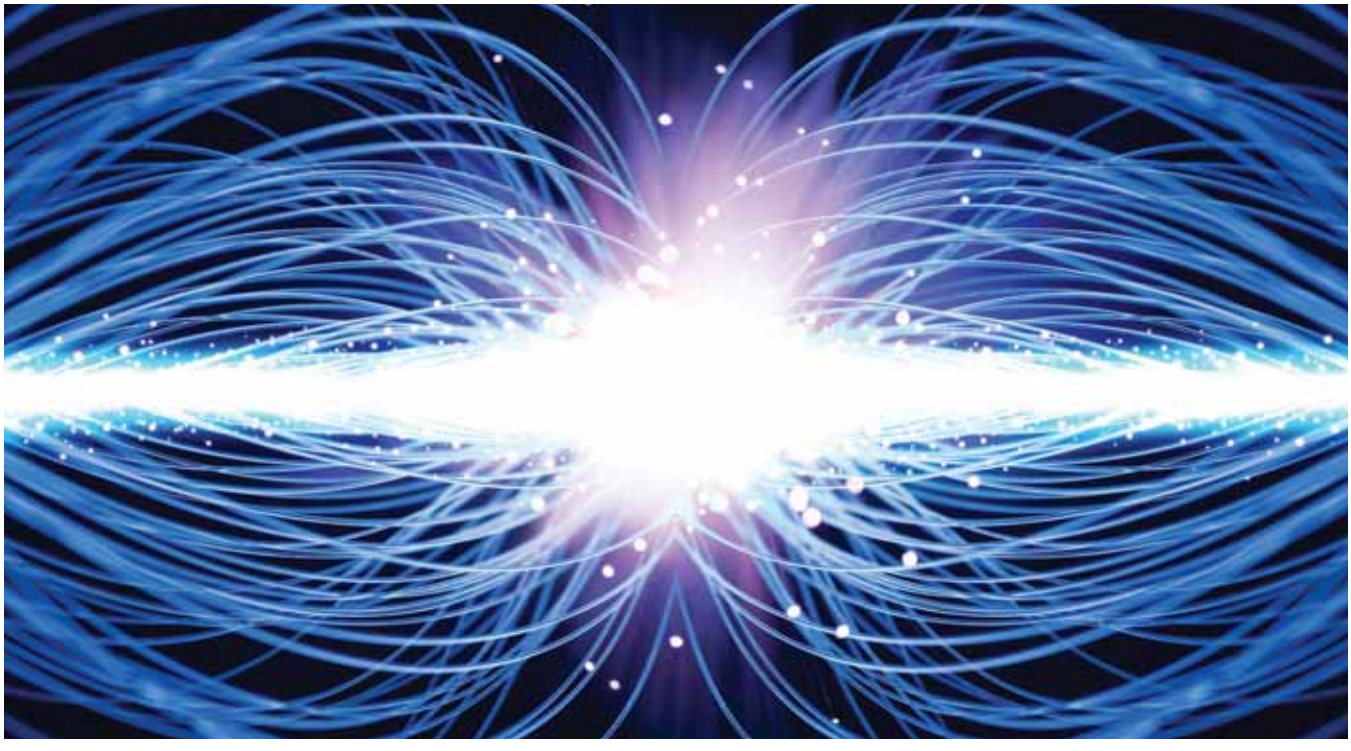
NUCLEAR POWER
RESPONSIBLE MANAGEMENT



BY WILLIAM KAY

Centuries from now, nuclear fission will likely rank as one of the greatest discoveries of the 20th century. Nuclear energy released by fission offered a million-to-one improvement over chemical combustion in terms of energy density, meaning that a handful of nuclear fuel could replace hundreds of tons of coal or oil.

With that great advance came very real public fears—first of the threat of nuclear warfare and then of the effects of ionizing radiation. The success of the global nuclear industry has been due in large part to its clear understanding of the nature and risks of radiation. There is no doubt that nuclear energy must be used carefully, but when it is compared to other forms of energy generation, many nations are concluding that it should be a larger part of their future energy portfolio.

Carbon-Free Energy

Nuclear energy can provide reliable power day and night without releasing carbon dioxide. Uranium and thorium are the basic nuclear fuels and are fairly well distributed across the globe, with energy densities so great that nations can store needed nuclear fuel significantly in advance of its anticipated use in a reactor. This is why nuclear energy forms the backbone of energy generation in industrialized countries with low per-capita carbon emissions like France.

Nuclear energy has the potential to expand greatly through more efficient use of nuclear fuels and safer, simpler reactor designs. China plans to bring 80 gigawatts (GW) of nuclear power online by 2020 and 200 GW online by 2030, becoming the world's largest user of nuclear energy. The United Kingdom and United States both plan to expand their use of nuclear energy to meet energy needs. In each case, as economies move beyond the use of fossil fuel, they find nuclear energy to be the reliable and attractive option.

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New Life to Older Plants

Today's nuclear reactors were originally licensed for 40 years of operation. But the understanding of how materials perform in a nuclear reactor has been steadily improving, and this has allowed many reactors to apply for "extensions" to their operational licenses. The operating extensions have allowed older plants to continue to safely produce carbon-free power at very low costs, since their original construction costs have been fully amortized. Extending the lifetime of these reactors has been the equivalent of bringing 26 new reactors online.

To promote the construction of new nuclear power plants, the Nuclear Regulatory Commission (NRC) introduced the idea of a "one-stop license" for a new nuclear reactor in the 1990s. Once a design is approved—and so long as the reactor can be built according to that design—a utility can build new nuclear power plants with certainty in the investment.

What About the Waste?

Operating a nuclear reactor produces two kinds of waste. One type is the resulting products of fission itself. These fission products are highly radioactive and must be isolated as they decay. Within 100 years, 90% of radioactivity will be gone.

Sometimes uranium fuel doesn't fission in a reactor when struck by neutrons, instead forming the second type of waste: plutonium and other materials. Today's reactors make more of these materials than they consume, but it's hard to call these materials "waste" since future reactors will likely use them as fuel.

Plutonium and other heavy elements drive the concerns about the long-term storage and handling of nuclear waste, while short-term storage concerns are driven by the radioactivity of fission products. The nuclear industry delivers safe management of both categories of materials. After uranium fuel assemblies

"Nuclear energy powers our economy without emitting any greenhouse gases."

Catherine Higgins, System Engineer at the Nine Mile Point nuclear energy facility in New York.

America relies on nuclear energy for 20% of our electricity and nearly 70% of our carbon-free electricity production. Professionals like Katie Higgins at Constellation Energy Nuclear Group (CENG) work every day to make certain that this source of electricity is both clean and safe.

America's nuclear power plants exceed already stringent federal safety standards through the use of multiple safety systems that layer precaution on top of precaution. And with our electricity needs expected to grow 24% by 2035, advanced nuclear energy plants, with state-of-the-art safety systems, must be built. Nuclear energy is a low cost and reliable energy source that produces electricity around the clock.

As America works to reduce greenhouse gas emissions, we need to use more low-carbon sources of electricity such as wind, solar and nuclear energy. Providing affordable electricity and ending our dependence on foreign energy sources cannot be achieved without nuclear energy playing a significant role in a balanced energy portfolio.

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For more information on safe nuclear energy, go to **safetyfirst.nei.org**

have produced heat and power in a reactor, they are removed and relocated to a spent-fuel cooling pond. The radioactivity level of the spent nuclear fuel is continuously falling after removal from the reactor, and for the first few years after shutdown water is a very effective way to remove heat from the spent fuel. After a few years, the radioactivity of the spent fuel has fallen enough that air can be used to cool the spent fuel, which is then removed from the cooling pond and loaded into a thick concrete container called a dry cask. Dry storage containers are a simple and passive way to store spent nuclear fuel for a very long time.

What about the plutonium and other heavy elements? New designs for nuclear reactors are being investigated that will actually burn this material, reducing its long-term potential hazard and generating energy and revenue.

Innovative New Containment Technologies

The highest priority of the nuclear industry is to contain the radiation inherent in the generation of nuclear energy, and responsibility and stewardship are integral to their day-to-day operations and decisions. Today's water-cooled reactors have a thick steel and concrete containment building that holds the nuclear reactors inside. The reactors themselves consist of a dense steel pressure vessel containing long assemblies of nuclear fuel. Each assembly holds uranium dioxide nuclear fuel inside zirconium-alloy tubes called cladding. Each of these structures is a barrier against the release of radioactivity.

The results of these safety systems and the safety culture of the nuclear industry have been impressive. If you stood at the fence of a nuclear power plant 24/7 for an entire year, you would receive less than one-tenth of the radiation exposure you receive from cosmic rays during a round-trip flight from Los Angeles to Cleveland. Radiation from nuclear energy facilities is less than 1% of the amount of radiation we receive from natural sources.

Radical Fuel Efficiency

Today's nuclear reactors extract less than 5% of the total energy available in their uranium nuclear fuel. To access nearly all of the nuclear energy in nuclear fuel will require taking new paths—using thorium as nuclear fuel or using fast-breeder reactors that can more fully consume the energy in uranium.

Thorium nuclear reactors can take many forms, including a liquid mixture of fluoride salts as a combined fuel and coolant for the reactor. These liquid fluoride-thorium reactors are chemically stable and can shut down without operator action. They can

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EXTRACTING URANIUM BY WORKING WITH MOTHER NATURE

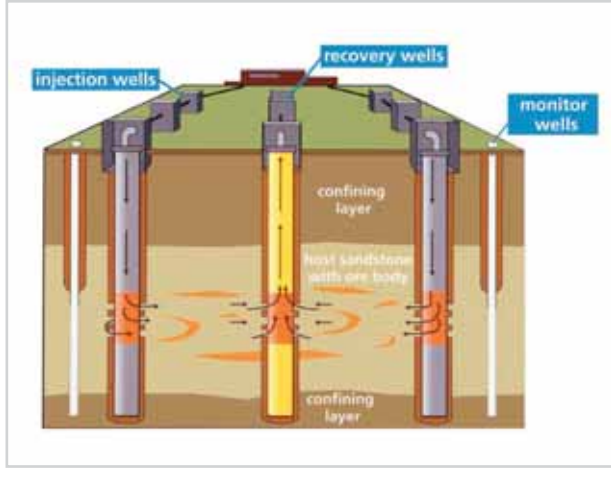
Have you ever gone into a messy room to find just one thing and struggled to find it? Imagine the challenge the mining industry faces when it has to dig through tons of dirt and rock, to extract only a small amount of precious material from a vast body of earth.

Wouldn't it be amazing if you could extract only the material you wanted, leaving the rest undisturbed? With the in-situ recovery (ISR) method of mining uranium, that's actually possible. Conventional uranium mining methods involve excavating massive quantities of earth, but with ISR mining, most of the earth is left intact while the uranium is dissolved and extracted.

Uranerz Energy Corporation is very experienced in the field of ISR mining and is one of only a few companies to have secured approval from the United States NRC (Nuclear Regulatory Commission) and state authorities to apply its ISR mining technique to uranium ore bodies in the Powder River Basin of Wyoming. Given the green light from the regulatory authorities, Uranerz has recently commenced construction, and expects to begin uranium production at its flagship Nichols Ranch project by the second half of 2012.

A typical ISR uranium mine

To extract the uranium, recovery and injection wells are bored into the ground where the uranium is located beneath the water table in sandstone-hosted rock. To start the process, groundwater is brought up by recovery wells and the water is fortified with high-pressure dissolved oxygen, baking soda and pressurized carbon dioxide before being pumped back underground through injection wells. As the fortified water interacts with the ore body, the uranium changes chemical form and becomes mobilized in the water, migrating to recovery wells where the water is pumped back to the surface to be processed. This phase of the process is similar to dissolving sugar in your cup of tea, except in this case they are dissolving uranium into the fortified water. At the plant, the uranium is removed from the water, using the same technology used in common water softeners. Then the water is refortified for reuse in the injection wells. This whole system is a closed-loop process that continuously recycles the same groundwater, thus keeping all the solutions confined.



ISR is an ingenious mining method that leaves a very small environmental footprint and results in no mine tailings (large piles of crushed rock), no disturbance to the soil beyond drilling the small injection and recovery wells, and no degradation of the groundwater after a restoration process is completed. Through careful use of water injection and extraction, the groundwater flows are controlled and directed toward the recovery wells, and a ring of monitor wells are set up around the perimeter of the extraction field to detect and prevent any possible excursions.

Uranerz is considering operating at least four different mining units in Wyoming, which, if fully realized, will generate enough uranium each year to provide 1,000 MW of carbon-free clean energy—enough to fully power a medium-size American city for nearly 30 years.

It's pretty amazing to think that all of this is possible with a few simple ingredients applied to a remarkable element that can be dissolved right out of rock.

For more information on current projects and developments, please visit **www.uranerz.com**.

Uranerz
ENERGY CORPORATION

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achieve high temperatures at low pressures and can be cooled by air instead of by water. Fast-breeder reactors once attracted a great deal of attention from nuclear development organizations, and they are still being investigated for the burning of nuclear waste. The most common fast-breeder reactor uses solid metallic fuel and liquid sodium as a coolant. Concerns about the chemical reactivity of liquid sodium have also driven investigations into other types of fast breeders that use stable coolants.

Investing in Nuclear Power

Nuclear power will be with us for many years to come, and investment opportunities in the various steps of nuclear fuel management, such as mining, processing and the enrichment of uranium fuel, are likely to be stable and productive. The development of new reactors is a financial challenge, but also is more potentially lucrative, especially as technologies for better utilization of the incredible energy density of nuclear fuel is commercialized. ■

Web Directory

Nuclear Energy Institute
www.nei.org

Uranerz
www.uranerz.com

Westinghouse Electric Company
www.westinghousenuclear.com

MAKING NUCLEAR ENERGY EVEN SAFER

BY ARIS CANDRIS AND MARVIN FERTEL

The problems at Japan's Fukushima Daiichi nuclear energy facility after the devastating earthquake and tsunami in March prompted concern about safety and raised questions about the future of nuclear energy. As a result, scrutiny of our industry, always high, has become even more intense.

Westinghouse Electric Co. President and CEO Aris Candris

We understand and welcome this additional interest, and are responding to the challenge to become even more transparent and accessible to regulatory agencies, government officials and the public. Our industry is aggressively studying the events that occurred in Japan and will apply lessons learned to make nuclear energy even safer. U.S. regulators also are conducting an independent assessment.

The United States and other nations have reaffirmed their intent to move forward with the development of new nuclear energy facilities, using advanced reactor designs that will add an extra margin of safety. Eighty-two percent of the American public overwhelmingly supports this approach, according to a September nationwide survey by Bisconti Research, Inc.

America's 104 reactors produce 20% of our electricity with production costs that are lower than coal, natural gas and oil. Nuclear energy should play an even greater role in the future.

Our industry is committed to the fundamental principles of continuous learning and working together to ensure that nuclear energy continues to provide energy security and economic growth for America and our international partners. We have been triple checking all safety and preparedness systems as well as reconfirming training at America's nuclear energy facilities. We will continue to do more to reassure regulators and the public—through actions, not just words—that nuclear energy is safe.

We are confident that a fact-based, far-ranging discussion will increase consumer knowledge of the issues. At a time of ever-increasing energy demand and growing concerns about global warming, we cannot turn our backs on the most significant carbon-free and reliable source of power on our electric grid.

NEI President and CEO Marvin Fertel

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You can be sure...
if it's Westinghouse

For a strong economy, Westinghouse is focused on safe, clean nuclear energy.

WESTINGHOUSE ELECTRIC COMPANY LLC

Nuclear energy, by providing reliable and affordable electricity, helps keep business competitive and powers future worldwide job growth. Today, nuclear energy provides 15 percent of total global electricity generation and accounts for more than 45 percent of the carbon-free electricity in the world. Westinghouse, and its more than 15,000 global employees, is dedicated to safe performance.

That's why the Westinghouse **AP1000** nuclear plant is designed to be more than 200 times safer than U.S. Nuclear Regulatory Commission requirements and be able to withstand the most extreme events. It is designed to shut down automatically, without the need for backup power, and will cool itself for 72 hours before any human intervention is necessary. This is made possible through the use of gravity, natural circulation, condensation and convection.

As the most advanced design available in the global marketplace, four **AP1000** units are under construction in China. Four units are also under construction in the United States, with an additional 14 units announced as the technology of choice. Building additional **AP1000** units will provide future generations with safe, clean and reliable electricity.

Check us out at **www.westinghousenuclear.com**

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