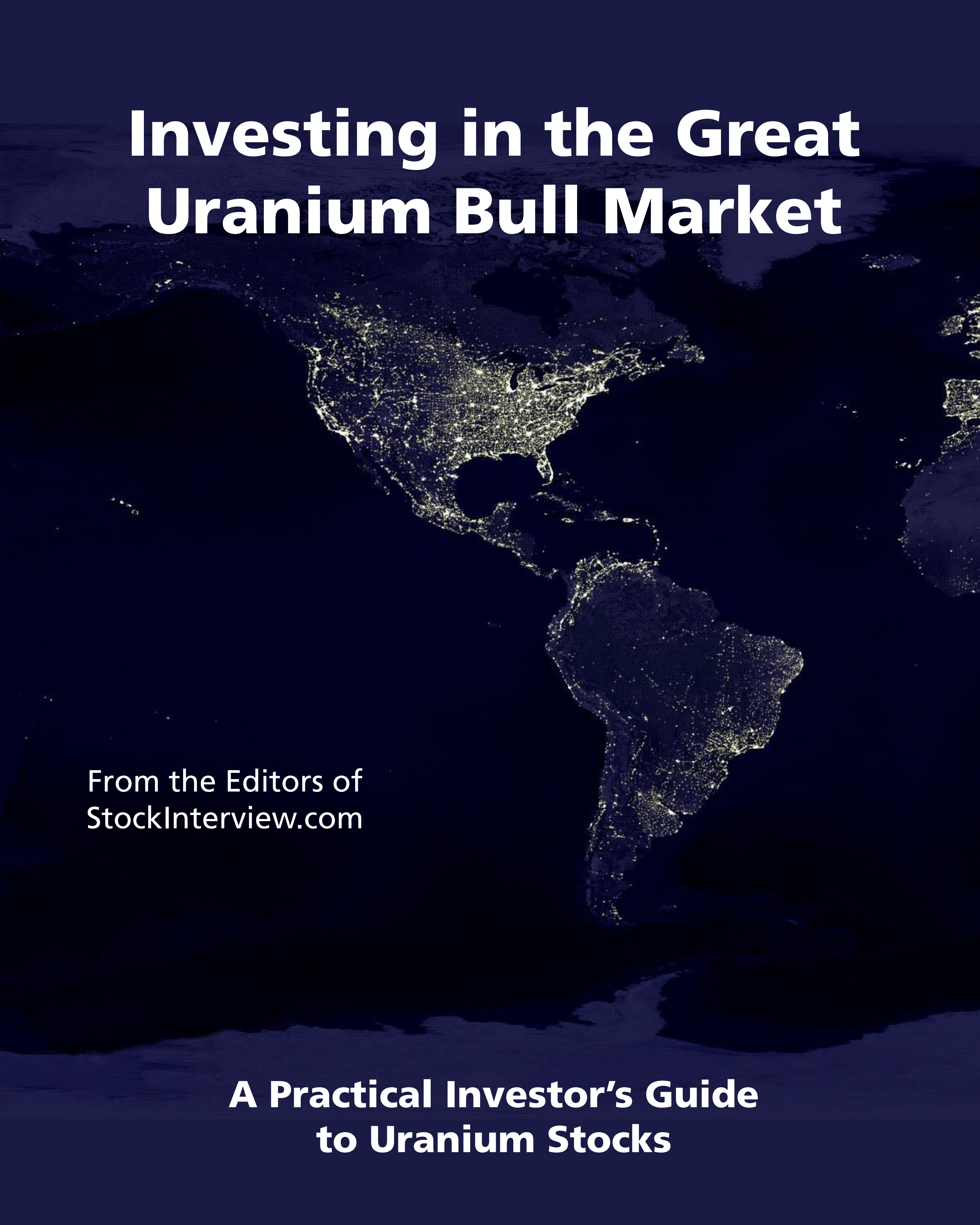
Investing in the Great Uranium Bull Market



From the Editors of
StockInterview.com

A Practical Investor's Guide to Uranium Stocks

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Chapter Three (continued)

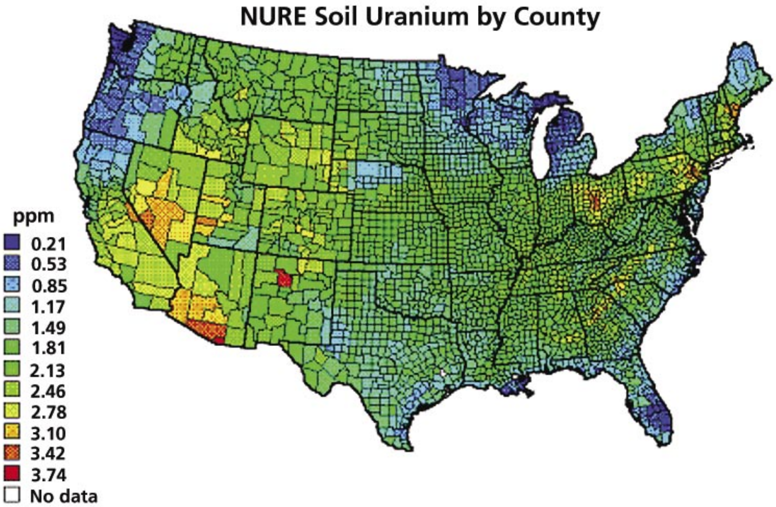
The Changing Face of Uranium Mining in the United States

CHAPTER 1

Uranium: A Misunderstood Commodity

Uranium is around us everywhere, but economic deposits of uranium are found in ore, such as the above sample.

Uranium has been around since the first century, when Romans used natural uranium oxide to add a yellow color to ceramic glazes. But ask anyone today about uranium? In response, you might either get a blank stare or suffer a lecture about the dangers of radioactivity. Many people still fear if they get sufficiently close to uranium, they will get toxic radiation, develop cancer or instantly die. Uranium is a misunderstood commodity. Increasing the average person's comfort level toward uranium has been further compli-



U.S. map of surface uranium concentrations

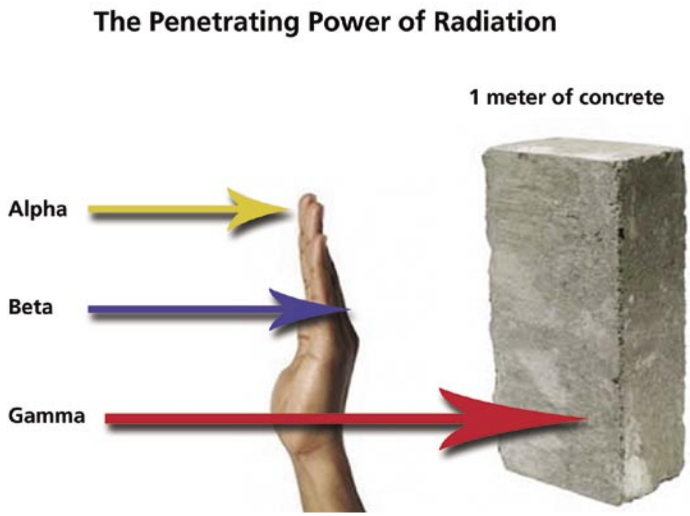
cated by six decades of military abuses, and by two highly publicized nuclear reactor accidents: Three Mile Island and Chernobyl. Neither the media nor well-funded environmentalists bothered to later clarify that both accidents were relative non-events.

Both unfortunate incidents forced the world's utilities to more greatly depend upon coal for electricity generation. As a result, we now suffer record levels of air pollution, global warming, and an atmosphere, overburdened because of carbon dioxide emissions. This clean-up may take one or two centuries, if we are able to ever accomplish this task. Was the hysteria worth it? Absolutely not. The unfortunate events only delayed the inevitable. Nuclear power is the single solution in helping to slow down global warming and out-of-control air pollution for the next two, three or more decades.

In this chapter, we endeavor to clarify some of the basic misconceptions about uranium. Perhaps we can simplify what many believe to be a complex subject.

For instance, uranium is a ubiquitous atomic element. In other words, it is nearly everywhere. Uranium can be found in most rocks, soils, plants, animals, seawater and the air. Fearing uranium is a meaningless exercise. It's just here and there and all around you. Uranium is even inside your body.

Fact: You already have about 90 micrograms of uranium in your body. Approximately two-thirds of that can be found in your skeleton, about one-quarter in your liver and kidneys and the rest in other tissues.



Three types of radiation to know about: Alpha particles do not travel far and are easily blocked by a hand or a sheet of paper. Beta particles take a little more to stop them. Gamma rays require a lot of mass to stop them.

Where Did the Uranium Come From?

Scientists believe uranium was formed in super novas more than 4 billion years ago. Evidence of uranium on an instrument cover of the now-defunct Russian space station Mir suggested the space around earth may still be getting uranium from an old supernova. Cosmic radiation, which is in our atmosphere and throughout space, is said to be from supernova explosions.

What do most people fear about uranium? Unbeknownst to most people, it is the “radioactive decay” they fear. As uranium decays, it emits radiation. What is radiation? It is the energy radiated or transmitted as rays, waves, in the form of particles. Radiation is also what provides the main source of heat inside the earth. Without uranium, and other radioactive minerals in the earth, which heat up our planet, earth would be a cold, dead planet. We humans could not survive here. It is uranium and radiation that is responsible for an earth that is alive and active to this day. Plate tectonics is a wonderful, natural, recycling process, which is driven by the heat of decaying uranium and other radioactive minerals.

Instead of fearing radiation and what harm it may do, try understanding how uranium is an essential element in your life. Uranium helps maintain our quality of life.

Fact: The human body requires potassium. It is essential for good health. Natural potassium is radioactive because it is a mixture of potassium-39 and potassium-41 (both non-radioactive potassium) and radioactive potassium-40. In other words, your body accumulates radioactivity to survive.

Etymology of Uranium

Blame the scientist who "almost" discovered uranium as to why this atomic element is named after the seventh planet from the sun. Imagine if the sequence below had taken place in any other way. What would we now be calling the yellowcake that powers nuclear reactors across the world? You would be surprised. Below is the story behind uranium's name.

The word "uranium" has a confusing past, but through no fault of its own. Since the beginning of the sixteenth century, in a silver mining town in an area which is now part of the Czech Republic, miners discovered a black mineral they called "pechblende." Pitchblende, or uraninite as it is now better known, is a uranium-rich mineral which is also comprised of lead, thorium, radium and rare earths. In the late 19th century, it was from this same northwest Bohemian town where Marie Curie got her pitchblende and isolated radium and polonium from the ore.

European scientists Roentgen, Becquerel, Villard, and others were aggressively experimenting with pitchblende and discovered ionizing radiation, X-rays, beta radiation and gamma rays. Pierre and Marie Curie named the gamma ray phenomenon, attributed to the radium in pitchblende, "radioactivity." MIT professor of biology Samuel Prescott, who was closely following Madam Curie's research, began testing those gamma rays on food. He discovered the gamma rays destroyed bacteria in food. From Prescott's work, food manufacturers discovered they could extend the shelf life of canned goods. Since then, radiation and radioactivity have become an integral part of both the medical profession and the food industry. In everything from chest x-rays to irradiating strawberries, radioactivity plays an integral role.

Let's go back about one century. In 1789, Martin Heinrich Klaproth presented his discovery of a "strange kind of half metal" to Berlin's Royal Academy of Sciences. The German chemist had, on the face of it, isolated uranium oxide from pitchblende. Klaproth suggested this new atomic element (number 92 on the periodic chart) be called "uran."

Not until 1841 did another European scientist, Eugene-Melchior Peligot, finally isolate uranium as an atomic element. Klaproth was just stabbing in the dark when he tried to identify what "uranium" was. He failed to explain what uranium was, or even to understand it. Nonetheless, his credibility remained intact as a pioneering scientist. Martin Klaproth was later credited for isolating zirconium, chromium and cerium.

Klaproth's naming ceremony for uranium was a political move. His actions came about because of Dr. Bode. Klaproth's Royal Academy colleague, German astronomer Johann Elert Bode, had been fuming because England's William Herschel had discovered the seventh planet. Herschel honored King George III by calling this planet, "the Georgium Sidus (the Georgian Planet). Bode argued the new planet should be renamed to conform to the classically mythological names of the other planets, such as Mercury, Mars, Venus, Jupiter and Saturn. Bode chose Uranus, the Greek name for their earliest supreme god.

The planetary debate about Uranus went on for decades, and was finally settled in 1850. Around the same time, a British firm began using uranium in glass to give it a fluorescent yellow or greenish appearance. The point is this: If Klaproth hadn't contributed to the Uranus-versus-Georgium Sidus debate by naming his "strange half metal" uran, we might be calling uranium stocks by some other name.

What is Uranium?

Uranium oxide in a barrel, prior to shipment.

Uran, the metal's name, evolved into uranium. As with most elements, there are different forms, called isotopes. In the case of uranium there are 16 different forms. Even natural uranium is not simple. Natural uranium is a mixture of three radioactive isotopes: 238U (99.27 percent by mass), 235U (0.72 percent) and 234U (0.005 percent). Uranium is primarily used to power nuclear reactors. The 235U is enriched from 0.72 percent to 5 percent in order generate the steam to provide the power. Yes, that's all uranium is used for: to generate steam in order to power the turbines. Uranium is a replacement for coal, petroleum and all the other dirty and highly toxic things found inside the earth.

Uranium has clearly defined properties.

- Silvery-white when refined
- More dense than lead; less dense than gold
- 1905% more dense than water
- Slightly softer than steel
- Corrodes to black oxide flakes in the air
- Heaviest of all the naturally occurring elements
- Melting point is 1132 Centigrade
- Capable of being shaped or formed
- Weakly radioactive[1]
- Under ultraviolet light, glows to lime green-yellow
- Can spontaneously ignite in the air
- Partially reacts to magnets (paramagnetic)
- Fissile: it can be split apart when bombarded with slow neutrons. It was the first element to be found fissile.

A 55-gallon barrel of uranium oxide can weigh more than 800 pounds.

Background: From Discovery to Use

After its discovery, uranium had no commercial use, other than for decorating glass. For a century after Mr. Peligot isolated uranium as atomic element number 92, no one really knew what to do with it. Scientists were experimenting with uranium, from time to time. As it is with scientific discoveries, one curiosity led to another and another, and so on. After quite a number of smaller and related discoveries, major breakthroughs began to take place. The people making these discoveries, and finding uses for uranium, changed the course of medicine, politics, war and energy.

Photography and Nuclear Physics

Much of the pioneer work, which led to nuclear fission, came from developments in the field of photography. Photography was coming into its own late in the nineteenth cen-

[1] Natural uranium – mainly 238U – has a half life of more than 4.4 billion years. The rule of thumb with radioactivity is the longer the half life, the less it is radioactive. For example, radon gas which is extremely radioactive (and deadly when inhaled) has a half life of about 3.5 days.

tury. Key breakthroughs in nuclear physics came from physicists who were experimenting with photography. One photographic experiment, which was an accident, occurred during an experiment, and it may have been the key step leading to splitting the atom. On December 22, 1895, Wilhelm Roentgen had been tinkering with X-rays, sending an energy source into a cathode tube. During the experiment, his wife accidentally moved her hand into the beam of the electron rays. Voila! An image of her skeletal hand and finger bones with her wedding ring was captured on a photographic plate.

A fellow scientist, Antoine Becquerel, pursued Roentgen's breakthrough and tried to understand the difference between fluorescence and phosphorescence. In March 1896, Becquerel was pursuing another photographic experiment involving the sun, but had to stop because of bad weather. It was an overcast day. Having given up, he wrapped his photographic plates in a drawer with uranium-laden crystals. A little while later, when Becquerel wanted to use those plates, he discovered the uranium had exposed them with "invisible emanations."

What was the big discovery? The emanations did not require an initiating energy source. The crystals, themselves, emitted rays. Becquerel didn't do anything about it, leaving it up to a husband-and-wife team working in his laboratory to figure out what this was. They pursued his "discovery" of radiation, and changed the course of modern medicine and science.

Working in Becquerel's laboratory were Pierre and Marie Curie. They investigated Becquerel's observation that emanations from uranium used the surrounding air as a means to conduct electricity. On February 17, 1898, they tested pitchblende for its electrical conductivity, discovering pitchblende generated 300 times more electrical conductivity than what uranium produced. Digging deeper to unlock this puzzle, the Curies discovered polonium (which Marie Curie named after Poland, her homeland) and radium. Upon introducing polonium, the Curies also dreamed up a new word: Radio-active. After her husband's death, Curie discovered radioactive emissions decreased over time. She also discovered how to calculate the amount of decrease (half life). She was the first to recognize that radiation was an atomic property, not an independent emanation.

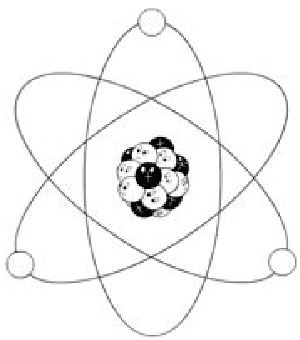
Harnessing the Possibilities

Following in Madam Curie's footsteps, Ernest Rutherford's research helped explain the structure of the atom. The New Zealander's experiments at the Cavendish Laboratory at Cambridge University demonstrated how radioactive elements decay over time. Rutherford's Cambridge colleague, Joseph John Thomson, another physicist, discovered particles within the cathode ray, now known as electrons. When Thomson explained to his friends and colleagues that there were particles smaller than atoms, they thought Thomson was "pulling their legs." Because there were particles within particles, this concept helped Rutherford pioneer "splitting the atom." He was the first to transmute one element into another. In 1913, along with Danish physicist Niels Bohr, they proved an atom was composed of a positively charged nucleus orbited by electrons. While it was Albert Einstein who developed the concept of matter being converted into energy, Rutherford's research provided the proof.

Studying the atom was a "pursuit of the truth," for many of these physicists. They wanted to understand what the atom was all about. Ernest Rutherford, Niels Bohr and others observed energy was intensely concentrated within an atom's nucleus. They also realized there was great potential for that energy. Many newspapers of the time speculated about the future of "unlocking the atom's energy." A 1903 editorial appearing in the ***St. Louis Post-Dispatch*** newspaper described such a possibility:

> *"The most wonderful and mysterious force in the universe—the atom's power—will be inconceivable. It could revolutionize the illumination system of the world. It could make war impossible. It is even possible that an instrument might be invented which at the touch of a key would blow up the whole earth and bring about the end of the world."*

The two-edged sword of what might happen when nuclear energy was harnessed had been foreseen more than four decades before the first atomic bomb was made. And civilian nuclear power was forecast almost 60 years before the first nuclear reactor began generating electricity!



Irene Joliot-Curie, Madame Curie's daughter, and her husband helped scientists better understand splitting the uranium atom, which led to nuclear fission. Photo courtesy of SA Chamber of Mines and Energy.

Splitting the Atom

Before nuclear energy could evolve into something practical or useful, the atom had to be split. In reality, not just in theory. Another incident spurred a new development, which brought nuclear fission one step closer to reality. Stuck in a traffic jam in London's Bloomsbury district, physicist Leo Szilard had, earlier in the day, been irascibly venting about Ernest Rutherford's dismissal of atomic energy in a ***London Times*** editorial. While waiting for a traffic light to change, Szilard visualized the idea of what a nuclear chain reaction would look like. After an early attempt to create his first chain reaction using beryllium and indium, which of course failed, he nonetheless filed for a chain-reaction patent in England. He assigned the UK patent to the British Admiralty to keep it classified, which makes you wonder how much of his chain reaction actually failed, or not. Szilard later filed for a US patent, with Enrico Fermi, on the nuclear chain reaction. While at Columbia University, where he met, befriended and worked with Fermi, Szilard came across new research explaining how uranium would sustain his concept of a chain reaction.

This research came from two German scientists, Otto Hahn and Fritz Strassman, who published an article in the January 1939 issue of ***Naturwissenschaften***, showing that the absorption of a neutron by a uranium nucleus sometimes caused the nucleus to split into approximately equal parts with the release of enormous quantities of energy. The term 'nuclear fission' was dubbed by Niels Bohr's colleagues Otto Robert Frisch and Lise Meitner, German refugees who had escaped to Denmark. On the transatlantic voyage to New York, Bohr discussed the nature of the discovery with Leon Rosenfeld, whom he swore to secrecy. When Rosenfeld arrived at Princeton University, he spilled the beans. The news of nuclear fission quickly spread to Columbia University and elsewhere. During 1939, experiments confirming fission had been successfully concluded at laboratories at Columbia University, Carnegie Institution of Washington, Johns Hopkins University and the University of California.

At Szilard's insistence Albert Einstein wrote to President Franklin Roosevelt to encourage the development of nuclear fission. Einstein's letter generated sufficient political clout to launch the momentous Manhattan Project. Szilard moved to the University of Chicago, with Enrico Fermi. Together, they helped create the first self-sustaining nuclear chain reaction inside the world's first nuclear reactor. Called the Chicago Pile-1 (also known as CP-1), the nuclear reactor was built under the abandoned west racquets stands of the Alonzo Stagg stadium on the University of Chicago campus.

Contrary to what many uninformed environmentalists believe, creating a fission nuclear reaction using uranium fuel is neither simple nor easy to do. A trained physicist would have to separate the rare U-235 isotope from natural uranium with chemically pure neutron moderator materials, such as deuterium, beryllium, and graphite. That's where you might have heard the phrase "heavy water." Using those materials, a trained expert can enrich uranium, making it fissionable. But during that process, chemical impurities can absorb the neutrons and bring the chain reaction to a standstill. That's called poisoning the nuclear reaction. Some fission products, such as xenon-135, can actually stop, or stall, a nuclear reactor from starting up.

The First Uranium Supply Crunch

Supplying uranium to government researchers at Los Alamos National Laboratory in northern New Mexico was a serious hurdle to overcome. There just wasn't much uranium inventory available. Until 1940, the amount of pure uranium mined in the United

Albert Einstein's letter to FDR

Albert Einstein
Old Grove Rd.
Nassau Point
Peconic, Long Island

August 2nd 1939

F.D. Roosevelt
President of the United States
White House
Washington, D.C.

Sir:
Some recent work by E.Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future. Certain aspects of the situation which has arisen seem to call for watchfulness and, if necessary, quick action on the part of the Administration. I believe therefore that it is my duty to bring to your attention the following facts and recommendations:

In the course of the last four months it has been made probable – through the work of Joliot in France as well as Fermi and Szilard in America – that it may become possible to set up a nuclear chain reaction in a large mass of uranium by which vast amounts of power and large quantities of new radium-like elements would be generated. Now it appears almost certain that this could be achieved in the immediate future.

This new phenomenon would also lead to the construction of bombs, and it is conceivable – though much less certain – that extremely powerful bombs of a new type may thus be constructed. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory. However, such bombs might very well prove to be too heavy for transportation by air.

The United States has only very poor ores of uranium in moderate quantities. There is some good ore in Canada and the former Czechoslovakia, while the most important source of uranium is Belgian Congo.

In view of the situation you may think it desirable to have more permanent contact maintained between the Administration and the group of physicists working on chain reactions in America. One possible way of achieving this might be for you to entrust with this task a person who has your confidence and who could perhaps serve in an inofficial capacity. His task might comprise the following:

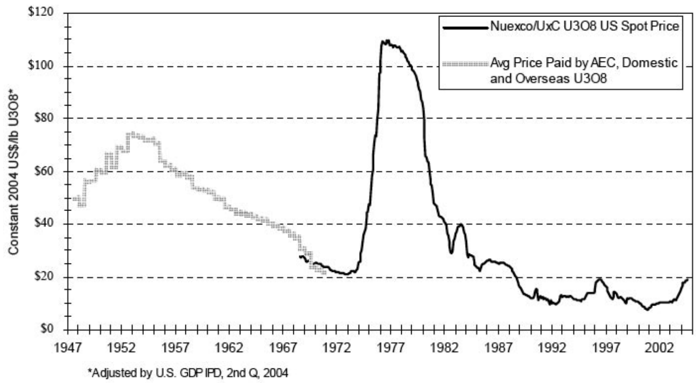
a) to approach Government Departments, keep them informed of the further development, and put forward recommendations for Government action, giving particular attention to the problem of securing a supply of uranium ore for the United States;

b) to speed up the experimental work, which is at present being carried on within the limits of the budgets of University laboratories, by providing funds, if such funds be required, through his contacts with private persons who are willing to make contributions for this cause, and perhaps also by obtaining the co-operation of industrial laboratories which have the necessary equipment.

I understand that Germany has actually stopped the sale of uranium from the Czechoslovakian mines which she has taken over. That she should have taken such early action might perhaps be understood on the ground that the son of the German Under-Secretary of State, von Weizsäcker, is attached to the Kaiser-Wilhelm-Institut in Berlin where some of the American work on uranium is now being repeated.

Yours very truly,
[signed Albert Einstein]
(Albert Einstein)

Uranium Price 1947 – 2004
(Constant 2004 U.S. $)



States was negligible. The other metals, required in the moderator process to create fission, were just as modestly available. The theoretical physicists were stymied: How could someone create a sufficient amount of high quality uranium demanded for the fission process? To understand the magnitude of this problem, Chicago's Stagg Field nuclear reactor required six tons of uranium. Until then, the researchers were an exclusive club of physicists, who dealt in very small quantities of uranium. They needed a chemist to help them produce a very large amount of pure uranium.

Canadian-born Frank Spedding, an Iowa State College chemistry professor, specializing in rare earths, was hired to establish a chemical research and development project, in Ames, Iowa, in 1942 to extract uranium from uranium halides. When Dr. Spedding first started, he had gotten the university to allocate some unused office space for the "three-month" research project. Since then the Ames Laboratory, which started as two floors in one quadrant of a chemistry building, has grown into a national laboratory under the U.S. Department of Energy.

In the 1940s, Westinghouse and Metal Hydrides were producing impure uranium in one-inch cubes. Their company handbooks had listed uranium's melting point at approximately 1800 degrees Celsius. This meant neither company understood the difference between pure and impure uranium. They were neither aware of, nor had removed, the impurities in the uranium. Pure uranium's melting point is 1132 degrees Celsius. Uranium was purified, at that time, by an ether extraction from an aqueous solution of uranyl salts. No one had, yet, grasped the various impurities involved in the process because pure uranium, as required to build an atomic bomb, had never been needed.

Within seven months, Spedding's team was able to produce large quantities of fissionable uranium. They utilized a thermite-like reaction to create molten uranium. It was successfully encased, first in graphite, and then later in a steel pipe lined with calcium oxide. As a cheaper and more pure reductant, Spedding's team finally lined the steel pipes with magnesium. This became known as the Ames thermo-reduction process. His process is still used in general commercial uranium production, as modified during scale-up.

Peace Time Nuclear Energy

Many of the same scientists, who participated in the Manhattan Project, argued to use this newly found energy for civilian purpose. In the 1940s, there were few known sources of uranium in the world. One of the world's richest sources was the Belgian Congo, which helped supply some of the uranium to help build America's first atomic bombs. Uranium oxide from the Congo pitchblende assayed as high as 80 percent uranium oxide! By comparison, the main U.S. source, in the Four Corners area, where Utah, Colorado, Arizona and New Mexico meet, graded less than two percent. The uranium-bearing pitchblende and yellow carnotite found on the Colorado Plateau had been a favorite source for Madame Curie's later research, and was previously used in war paint by Native Americans.

Until the military use for uranium came along, the preferred strategic metal in the Colorado Plateau was vanadium. It was used to harden steel. An excerpt from ***Narrow Gauge in the Rockies*** (Howell-North Press, 1958) by Lucius Beebe and Charles Clegg, describes how lowly uranium was thought of, prior to the Manhattan project:

> *"A by-product of vanadium manufacture is another something called "yellowcake" which had so little commercial value that for years it was thrown out on the tailings dumps along the San Miguel and washed away when the river flooded, which was fairly often. At least uranium oxide was valueless until Albert Einstein wrote a letter to President Roosevelt. Suddenly an entire region of which the Rio Grande Southern Railroad was the nerve center, became the most jealously guarded mineral deposit in the world and Federal agents were riding the tops of ore cars carrying cargoes that only yesterday vanadium mill owners were throwing out the window."*

Vanadium, itself, had previously been a waste product of Colorado's radium mines. Because vanadium strengthened and improved upon steel's tensility, wearability, and elasticity, when added to the molten metal with iron, the production of warships and planes during World War II triggered a vanadium mining boom. Because of the war-time interest in vanadium, scientists from the Manhattan Project were aware of where it had been mined, and heard about the uranium waste-product. They believed small amounts of uranium could be extracted from the old radium and vanadium dumps. By mining and milling the tailings, they extracted some uranium oxide for their nuclear fission testing. Canada's government-owned El Dorado uranium company reportedly helped supply some unspecified amount of uranium for America's military use.

The transition of nuclear energy from military use to peacetime purposes posed a challenge for the Eisenhower presidential administration. After 42 nuclear test explosions determined the power of the atomic bomb, it became clear this weapon could destroy most of planet earth. Russia, too, had the secret formula for making an atomic bomb. To improve relations among the countries who had "the bomb," President Eisenhower met with the Prime Ministers and Foreign Ministers of Great Britain and France in Bermuda to map out the future of nuclear energy.

President Eisenhower

During the Bermuda Conference, United Nations Secretary General Hammarskjöld invited Eisenhower to later address the General Assembly about the nuclear age the world had now entered. His speech later became known as the "Atoms for Peace" Speech. Much of what Eisenhower said on December 8, 1953 remains true today:

> "The United States knows that if the fearful trend of atomic military build up can be reversed, this greatest of destructive forces can be developed into a great boon, for the benefit of all mankind.
>
> "The United States knows that peaceful power from atomic energy is no dream of the future. That capability, already proved, is here--now--today. Who can doubt, if the entire body of the world's scientists and engineers had adequate amounts of fissionable material with which to test and develop their ideas, that this capability would rapidly be transformed into universal, efficient, and economic usage.
>
> "The more important responsibility of this Atomic Energy Agency would be to devise methods whereby this fissionable material would be allocated to serve the peaceful pursuits of mankind. Experts would be mobilized to apply atomic energy to the needs of agriculture, medicine, and other peaceful activities. A special purpose would be to provide abundant electrical energy in the power-starved areas of the world."

President Eisenhower's entire "Atoms for Peace" Speech can be read on this web page link: http://www.atomicarchive.com/Docs/Deterrence/Atomsforpeace.shtml

His speech led the world into considering the use of atomic energy for the peaceful uses nuclear fission might offer. Of special note is his remark, spoken over fifty years ago, which rings true today. And, it will ring louder as we move into the second and third decades of the 21st century:

> "A special purpose would be to provide abundant electrical energy in the power-starved areas of the world."

CHAPTER 2

Why the World Needs Uranium Now

Two uranium pellets produce enough energy to supply, for an entire month, an average four-people household.

Uranium packaged in drum, 'show and tell' package, for demonstration.

The splitting of uranium atoms in a chain reaction releases energy inside a nuclear reactor. The heat energy produced by fission (splitting the atom) boils water into steam. The steam drives a turbine generator, which produces electricity.

The uranium used to fuel America's nuclear reactors accounts for about 20 percent of the electricity generated across the United States. The simple process of splitting atoms, boiling water, generating steam, and driving a turbine is what lights up your household or office, may bring your home warmth or coolness, and might help cook your food. One-fifth of all electricity is powered by uranium. It is the second largest source of electricity behind coal.

Nuclear energy produces electricity at a lower cost than competitive fuel sources. In 2004, the average electricity production cost from nuclear energy was the lowest of the primary energy sources:

Source	**Cost per Kilowatt Hour**
Nuclear Energy	1.68 cents
Coal Fired Plants	1.90 cents
Oil	5.39 cents
Gas	5.87 cents

Fact: The energy in one uranium fuel pellet—the size of the tip of your little finger—is the equivalent of 17,000 cubic feet of natural gas, 1,780 pounds of coal, or 149 gallons of oil.

Some states depend more upon nuclear power than others. In 2003, about 74 percent of Vermont's electricity came from nuclear power. More than half of the electricity for Illinois, New Jersey, Connecticut, and South Carolina was provided by nuclear in that same year.

Fact: A 100 watt light bulb that ran continuously for an entire year would consume 876 kWh. Producing the necessary electricity would require 876 lbs. of coal, 377-324 lbs. of natural gas, 508 lbs. of oil, or 0.0007 lbs. of Uranium enriched to 4% for use in a commercial nuclear reactor.

Advocates highlight these points about the dependability of nuclear energy as a reliable source of electricity.

1. **A stable nationwide supply of electricity.** Nuclear reactors help supply the baseload generation for the U.S. electrical grid. Nuclear power plants provide stability to the electricity transmission network.

2. **Helps national energy security.** U.S. utilities know they can depend upon nuclear energy as a secure energy source. Among the world's largest producers, outside of future domestic sources, are Canada and Australia. The security of uranium supply is independent of the Middle East, North Africa, Indonesia or Venezuela. Uranium's cost of powering a nuclear plant is modest, and in lesser percentage as an operating cost, compared to fossil fuel sources.

3. **Reliability of power generation.** Nuclear power plants can run between 18 and 24 months before they need to be closed down for refueling. Nuclear plant maintenance has vastly improved. In 2005, the average refueling outage period was 38 days, compared to 104 days in 1990. Downtime has been reduced, providing more reliability.

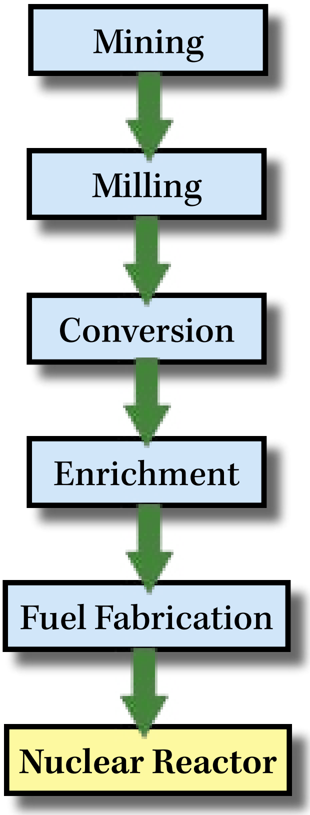
4. **High Capacity Factor.** Nuclear power rates higher than other forms of energy sources when you compare the percentage of electricity produced against the total potential a plant is capable of producing. In 2005, nuclear plants had a capacity factor of 89.6 percent, while coal (72.6 percent), natural gas (15.6 to 37.7 percent), heavy oil (29.8 percent), hydro (29.3 percent), wind (26.8 percent) and solar (18.8 percent) ran at lower capacity factors.

5. **Declining automatic shutdowns.** Since the Three Mile Island accident, U.S. nuclear power plants have been designed with more sophisticated safety systems. During an imbalance of operations, the power plant shuts down before any safety margins are exceeded. Over the past decade, training programs and plant maintenance have brought about longer continuous runs without a plant shutdown.

Converting Uranium Into Nuclear Fuel

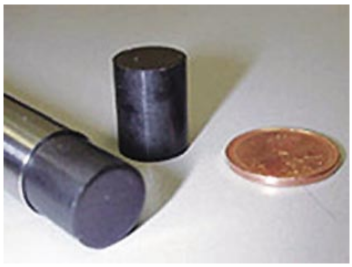
Most power plants convert a fuel source into energy by boiling water into steam. The steam drives a turbine generator, which generates electricity. According to scientists, nuclear reactions release millions of times more energy than a chemical reaction. Burning carbon in oxygen only produces about nine kilowatt hours of energy per kilogram of fossil fuel burned. Splitting the uranium atom produces millions of times more energy.

The Front End of the Nuclear Fuel Cycle



Unlike coal, you don't just shovel uranium into a nuclear reactor to boil the water and produce the steam to drive the turbines. A series of processing steps take place in an exact series: mining, milling, conversion, enrichment and fabrication. The solid ore is transformed into uranium dioxide (UO_2) and compacted into solid ceramic fuel pellets. The conversion and enrichment process purifies and chemically converts the uranium in order to increase its potency.

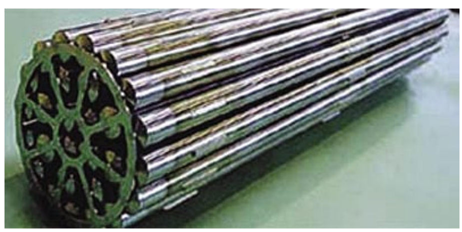
The pellets are about the size of a small finger tip or a pencil's eraser – 9 millimeters in height and 7.6 millimeters in diameter. There is a cylindrical hole of 1.6 millimeters in the centerline of the pellets, which helps balance the fuel's temperature and pressure during the fission process.



Uranium fuel pellets

The uranium fuel pellets are then loaded into a hollow zirconium alloy tube, between 11 and 25 feet long and about 9 millimeters in diameter. The tube is hermetically sealed with the uranium pellets inside, with a gap between the pellets and the tubing, so the pellets can expand at high operational temperatures. The tube containing the pellets is called the fuel rod. A single fuel rod can not generate sufficient heat to power a nuclear reactor.

Nuclear Fuel Rod Bundle



To make them more efficient, the fuel rods are bundled into assemblies. Bundling them in this way also makes it easier to replace the fuel rods during the refueling cycles. Reactors are normally refueled every 18 to 24 months. One-quarter to one-third of the fuel assemblies are replaced with new assemblies during each refueling cycle. A typical 1,100-megawatt pressurized reactor might contain 193 fuel assemblies with about 55,000 fuel rods. Each assembly can contain between 200 and 300 fuel rods. More than one million pounds of natural uranium will have been mined to fabricate approximately 14 million uranium dioxide fuel pellets. Different reactors may hold different amounts of fuel rods and fuel assemblies. Some fuel assemblies can be hexagonal, others rectangular.

Nuclear Fuel Assembly

How much uranium is required to fuel a nuclear reactor? Below is an inventory of how much uranium is mined, then milled, converted, enriched and fabricated in order to operate 7000 million kilowatt hours of electricity for a 1000 MWe nuclear power reactor.

Mining:	20,000 tons of 1% uranium ore
Milling:	230 tons of uranium oxide concentrate (with 195 t U)
Conversion	288 tons UF_6 (with 195 t U)
Enrichment	35 tons UF_6 (with 24 t enriched U) - balance is 'tails'
Fuel fabrication	27 tons UO_2 (with 24 t enriched U)
Reactor operation	7000 million kWh of electricity

Note: Concentrate is 85 percent uranium, enrichment to four percent U-235 with 0.25 percent tails assay, 80 percent load factor for reactor, core load 72 tU, refuelling annually with one third replaced.

In mid April 2006, the approximate dollar cost to get 1 kg of uranium as UO_2 reactor fuel:

U_3O_8 :	8 kg x $90.20	722
conversion:	7 kg U x $12	85
enrichment:	4.8 SWU x $122	586
fuel fabrication:	per kg	240
total, approx:		US$ 1633

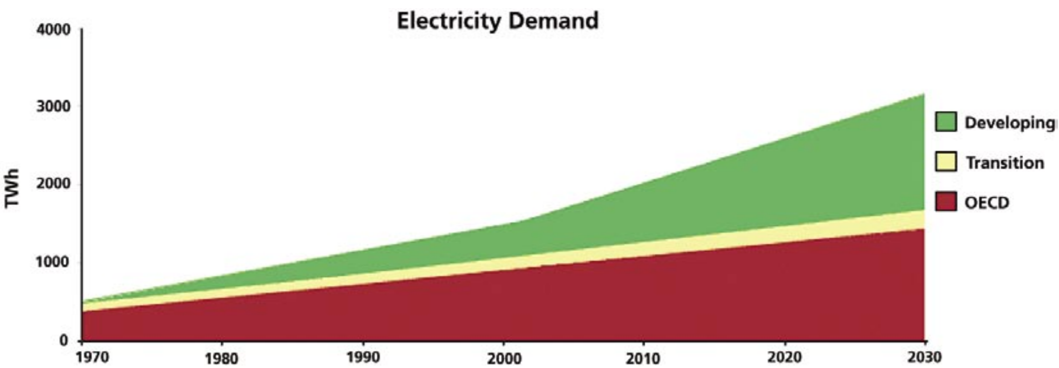
This yields 3400 GJ thermal which gives 315,000 kWh, hence fuel cost: 0.52 c/kWh.

The World Needs More Electricity - Much More!

As the world grows, it will greatly need to increase its source of energy. Projections of growth in electricity demand, for the next few years, the next fifteen years, and through 2050, are staggering. While global production and consumption expands, more energy is required to fuel this worldwide expansion. Less uranium is used to produce the same amount of energy (see below fact).

> ***Fact: To produce one Watt of electricity, it takes 1.0 lbs. of coal/kWh from coal plants using steam turbines, 0.48 lbs. of natural gas from natural gas using steam turbines, 0.37 lbs. of natural gas/kWh using combined cycle technology, 0.58 lbs. of Heavy Oil/kWh using steam turbines, and .0000008 lbs. of Uranium enriched at 4% U235 and 96% U238 for use in a commercial nuclear reactor.***

Over the past twenty-five years, worldwide energy use jumped by 50 percent. While the annual population growth has risen by 2 percent, energy consumption grew by about 3.3 percent per year. In the future, electricity growth is expected to grow by 2.8 percent per year. Demand for electricity will reportedly grow faster than overall energy use. In developing countries, electricity demand could be overwhelming. Please realize that about two billion people still do not have electricity. What happens when they finally can access electricity? Their demand will overpower existing means and energy sources to provide that electricity – unless more nuclear power plants are constructed.



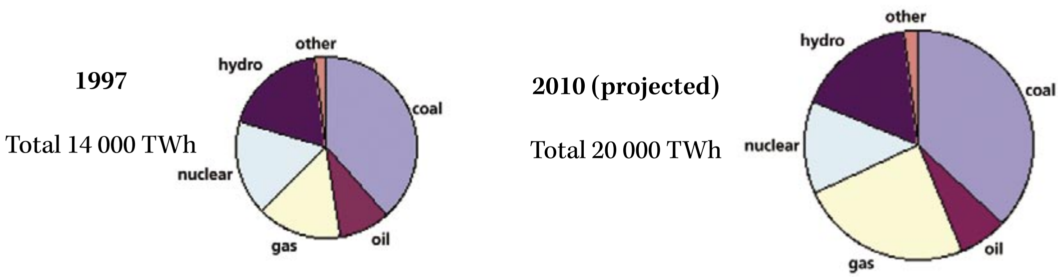
Source: OECD/IEA World Energy Outlook 2004

More than 440 nuclear power plants are operating in 30 countries to provide electricity. They supply about 16 percent of the world's electricity. At least eleven countries are constructing 27 new nuclear plants. Under discussion, or having been announced, over 100 nuclear power plants are anticipated to become operational between now and 2050. This anticipated number might easily double or triple before this decade ends.

Since 1990, nuclear power's share of world electricity production has remained at between 16 and 17 percent. Sixteen countries now depend upon nuclear energy for at least 25 percent of their total electricity needs. France, Lithuania, Slovakia and Belgium obtain more than 50 percent of their electricity production from their nuclear energy programs. France topped the list with 78.5 percent in 2005. Nuclear provides 35 percent of the electricity in European Union countries, and nearly 24 percent in OECD countries. Sweden, South Korea, Finland, Ukraine, Bulgaria, Slovenia and Hungary obtained between 30 and 50 percent of their electricity from nuclear power.

Country	%
France	78.5
Lithuania	69.6
Slovakia	56.1
Belgium	55.6
Ukraine	48.5
Sweden	46.7
Republic of Korea	44.7
Bulgaria	44.1
Armenia	42.7
Slovenia	42.4
Hungary	37.2
Finland	32.9

World Electricity Generation 1997 and 2010



In addition to more than 400 large nuclear reactors, used for generating electricity, another 480 (or more) reactors are in operation. More than 200 nuclear reactors power about 150 ships, mostly submarines. Another 280 smaller reactors are used for research and to produce radioisotopes for medicine and industry.

Some comparative electricity generating cost projections for the year 2010

	nuclear	coal	gas
Finland	2.76	3.64	-
France	2.54	3.33	3.92
Germany	2.86	3.52	4.90
Switzerland	2.88	-	4.36
Netherlands	3.58	-	6.04
Czech Rep	2.30	2.94	4.97
Slovakia	3.13	4.78	5.59
Romania	3.06	4.55	-
Japan	4.80	4.95	5.21
Korea	2.34	2.16	4.65
USA	3.01	2.71	4.67
Canada	2.60	3.11	4.00

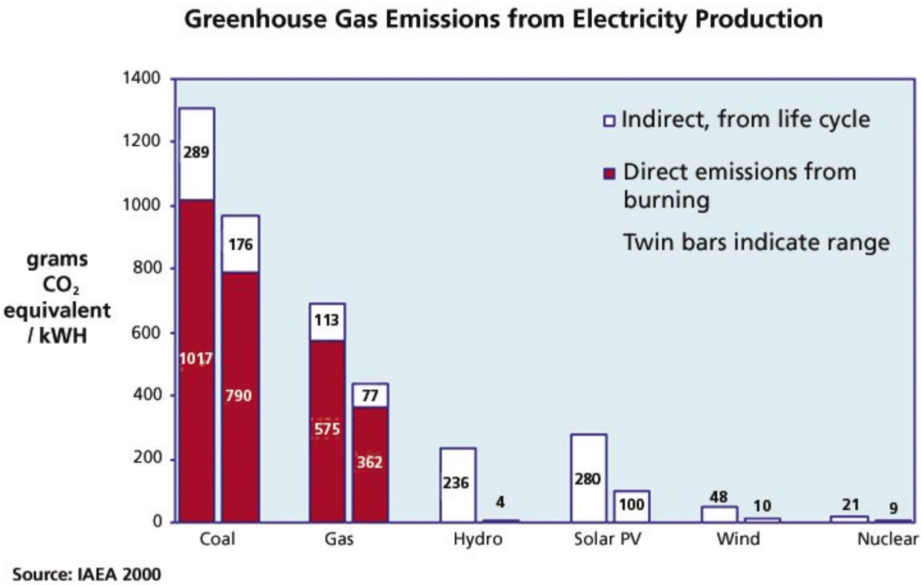
US 2003 cents/kWh, Discount rate 5%, 40 year lifetime, 85% load factor. Source: OECD/IEA NEA 2005.

Nuclear Reduces CO_2 Emissions

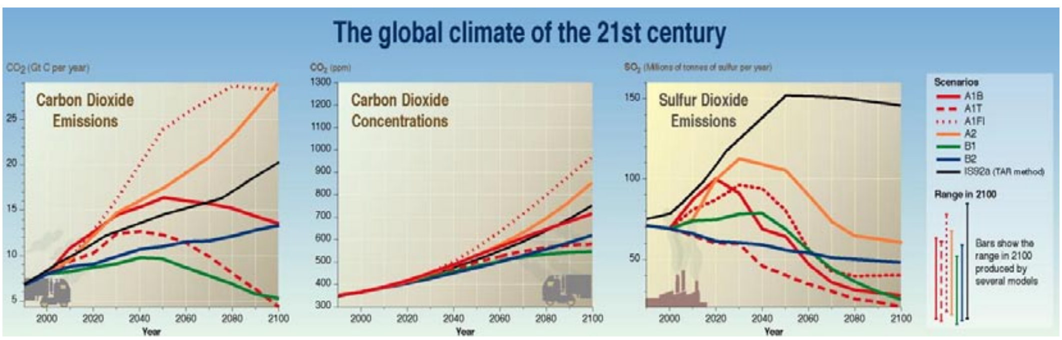
Because of the anticipated growth in electricity demand, the world will continue turning to coal as its primary energy source to generate electricity. Coal releases massive quantities of carbon dioxide into the atmosphere. It is believed that those carbon dioxide emissions hang about the atmosphere for between 50 and 100 years.

It has been reported that using nuclear power across the world can reduce carbon dioxide emissions by about 2.4 billion tons per year. It is widely believed that carbon dioxide (CO_2) contributes to approximately 50 percent of the global warming caused by humans. The United Nations Intergovernmental Panel on Climate Change studied global warming and determined that to stabilize carbon dioxide concentrations in the atmosphere, up to 80 percent of all CO_2emissions must be reduced.

Fact: When uranium replaces coal as an energy source, carbon dioxide emissions are reduced. Every 22 tons of uranium (U_3O_8), which is used instead of coal, reduces about one million tons of CO_2 emissions.



According to the World Banks' Little Green Data Book 2006, China and India recorded increases in carbon dioxide output, which caused the worldwide level to rise by 15 percent in the period between 1992 and 2002. China has become the world's second largest polluter behind the United States. China's CO_2 emissions jumped by 33 percent in that ten-year period. India's CO_2 emissions soared by 57 percent during the same period. As global GDP grows, their CO_2 contributions will continue rising. Fortunately, both countries have announced aggressive nuclear energy programs.

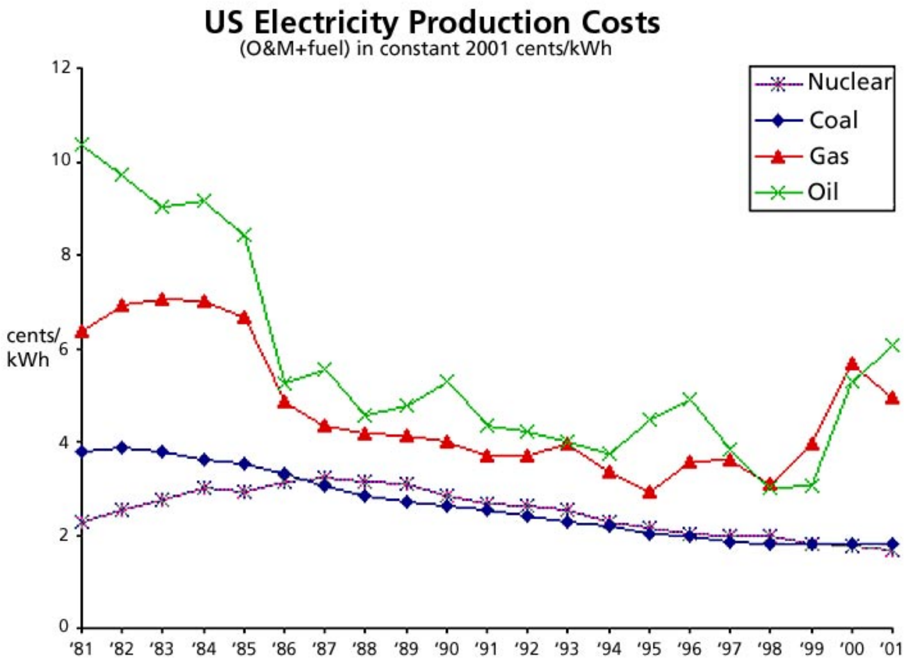


How serious is the global problem of carbon dioxide emissions? Environmentalist James Lovelock wrote in his recent book, ***The Revenge of Gaia*** (Penguin: 2006):

> *"The world's annual production of carbon dioxide is 27,000 million tons. If this much were frozen into solid carbon dioxide at minus 80 degrees Celsius, it would make a mountain one mile high and twelve miles in circumference."*

The Human Cost to Produce Electricity

One of the major attractions of uranium as a source of fuel to produce electricity is because it is relatively inexpensive to mine and mill. In turn, that makes nuclear energy attractive. Uranium is one of the most abundant of earth's elements, found in the earth's crust, in seawater and in our bodies. Two-thirds of the cost of uranium "as a fuel" comes from the enrichment and fabrication process. Additional costs are tallied up, when one calculates the expense in managing radioactive spent fuel and its disposal. Nonetheless, when all of the beans are counted, the total fuel cost to operate a nuclear power plant in the OECD is about one-third of the fuel cost for a coal-fired plant, as little as 20 percent of what is required to fuel a gas combined-cycle plant.



There is another cost in the production of electricity, which is not publicized. The loss of human life associated with producing a unit of energy is rarely mentioned when talking about costs. Deaths occur to produce our energy. Most believe nuclear causes many deaths, when it is among the safest forms of energy by actual statistic.

In a 2001 report from Switzerland's Paul Scherrer Institute, they studied deaths in the energy-producing industries between 1970 and 1992. Researchers analyzed the safety records of the world's large-scale energy sources. They compared the deaths in each of the sectors which produce electricity. The numbers were startling. They investigated how many people died during the production of a terrawatt of electricity. A terrawatt of energy is a million million watts of electricity made and used throughout a year.

Energy Source	Who Died?	Number of Fatalities	Death per terrawatt
Coal	Workers	6400	342
Natural Gas	Workers/Public	1200	85
Nuclear	Workers	31	8

Critics may scoff at the low number of fatalities associated with nuclear. However, the Paul Scherrer statistics reflect the officially published numbers of how many died at the Chernobyl nuclear accident. No statistics are ever perfect. For example, we doubt the reported numbers of coal mining deaths would be this low. Our research shows that, on average, more than 4,000 Chinese coal mining workers die each year. Environmentalists may point to hydroelectricity as a "safe" source. Yet, in the institute's report, it was noted about 4000 people died from flooding or dam breaks – another risk of hydroelectricity as an energy source, about 883 deaths per terrawatt. That's more than the three other energy sources combined per terrawatt! Where are the anti-hydro protestors?

If you were to research the two most widely reported nuclear accidents of the previous century – Three Mile Island and Chernobyl, you would discover two facts: (a) no one died from the first; and (b) between 45 and 75 people directly died as a result of the accident at Chernobyl. The World Health Organization scientists studied people who lived in the surrounding area fourteen years after the accident. Then, reported again nineteen years after the event. After the first study, the researchers found only 45 who were direct casualties of the Chernobyl accident. In the latter study, the number of fatalities rose to 75. Those whose deaths were a direct result of the Chernobyl event included firemen, workers and others who helped put out the fire in the burning reactor.

In April 2006, BBC News reported on the wildlife flourishing in the Chernobyl exclusion zone. The news agency announced the area was "teeming with life." Radioecologist Sergey Gaschak, through all of his research, only found one mouse with cancer-like symptoms. "Nothing with two heads," he told BBC. While he found evidence of DNA mutations, none of the changes affected the physiology of the animals or their reproductive ability.

While Greenpeace and others have argued that as many as 93,000 people have died as the result of Chernobyl, those agencies which are more scientific dispute those numbers. Studies by no less than eight United Nations organizations concluded the previous death toll estimates, quite hyperbolic and amazing numbers reported by rabid environmental organizations which purportedly stretched the deaths into the "tens of thousands," were disputed as gross exaggerations.

Below is another compilation of accidental fatalities in the United States. These are official figures between 1966 and 1999, published by the Federal Highway Administration, the National Safety Council, the National Transportation Board, and the Office of Pipeline Safety, Department of Transportation.

Type of Accident	**Number of U.S. Deaths between 1966 and 1999**
Highway Deaths	1,511,272
Deaths by Falling	457,389
Deaths from Poisons	186,354
Deaths from Fires	175,074
Deaths as a Result of Trains	21,018
Bathtub Drowning	6, 344
Domestic Electrocution Deaths	4,559
Deaths as a Result of Lightning	2,954
Airline Passenger Deaths	2,210
Deaths from Venomous Plants/Animals	1,885
Natural Gas Pipeline Deaths	257
Nuclear Accidents	0

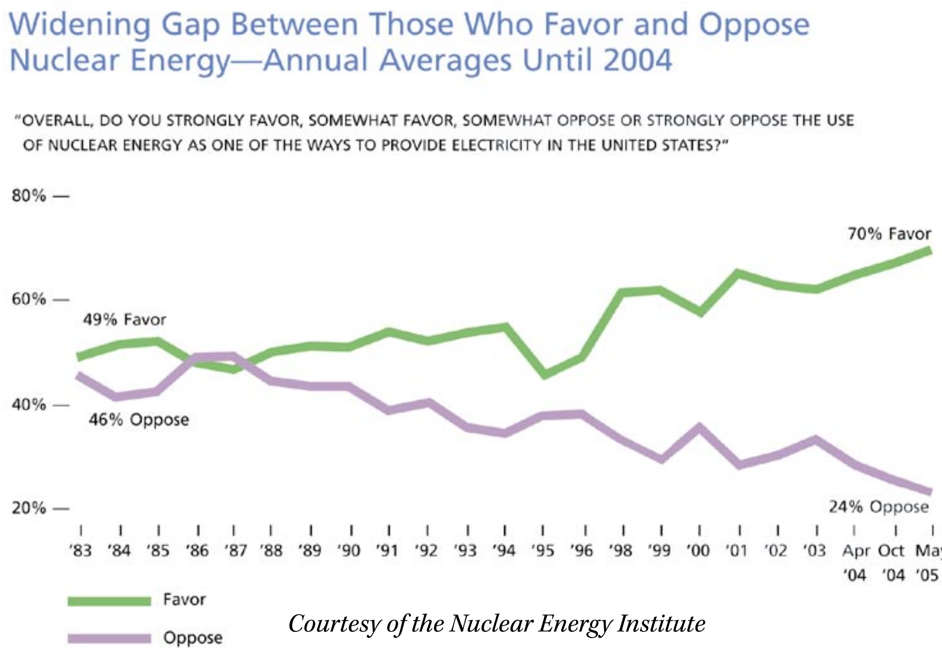
Conclusion

Claims by pro-nuclear associations grow more solid each year. Public opinion polls have been positive. In May 2005, the Nuclear Energy Institute (NEI) reported the public's opinion of nuclear energy as a source of electricity was a record high 70 percent. Those surveyed associated nuclear power with clean energy. They associated nuclear power with reliability, efficiency and safety.

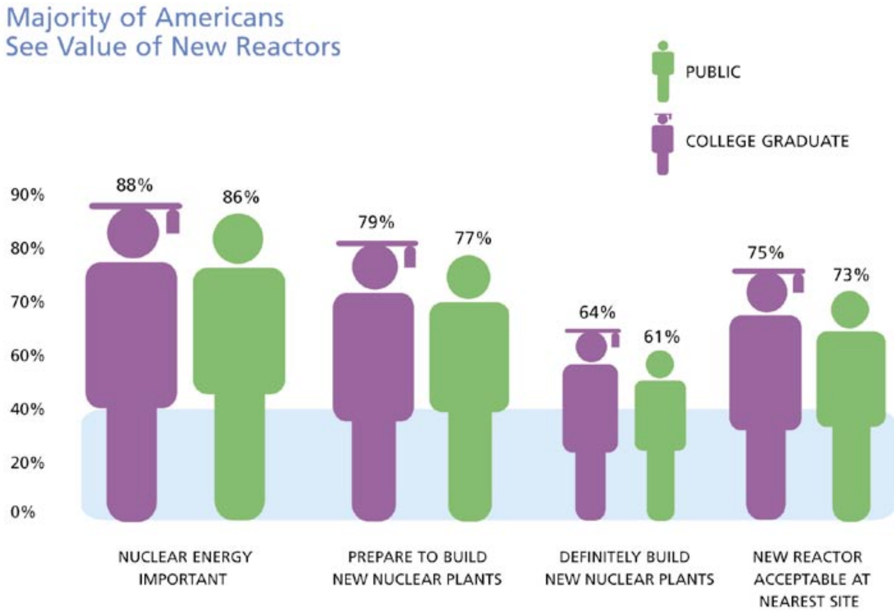
It has increasingly dawned upon a more educated and enlightened public that nuclear power is the most environmentally benign method of producing large-scale electricity. In reality, wind and solar power cost far more than have been publicized, have higher generating costs than have been reported, and are only useful for tiny and irregular amounts of electricity production. If there were no nuclear energy used to produce electricity, our world would almost completely depend upon fossil fuels for the production of base-load electricity.

Courtesy of the Nuclear Energy Institute

To produce the electricity to feed the growing global appetite for energy and electricity, the world's mining companies need to extract higher levels of uranium. Some are already mining uranium. The small number of uranium producers need to expand their deposits and produce more uranium. A greater number of uranium exploration and development companies are racing to become uranium producers. It remains a concern whether or not uranium producers and development/exploration companies will advance their projects fast enough to meet the world's need for uranium.



Courtesy of the Nuclear Energy Institute



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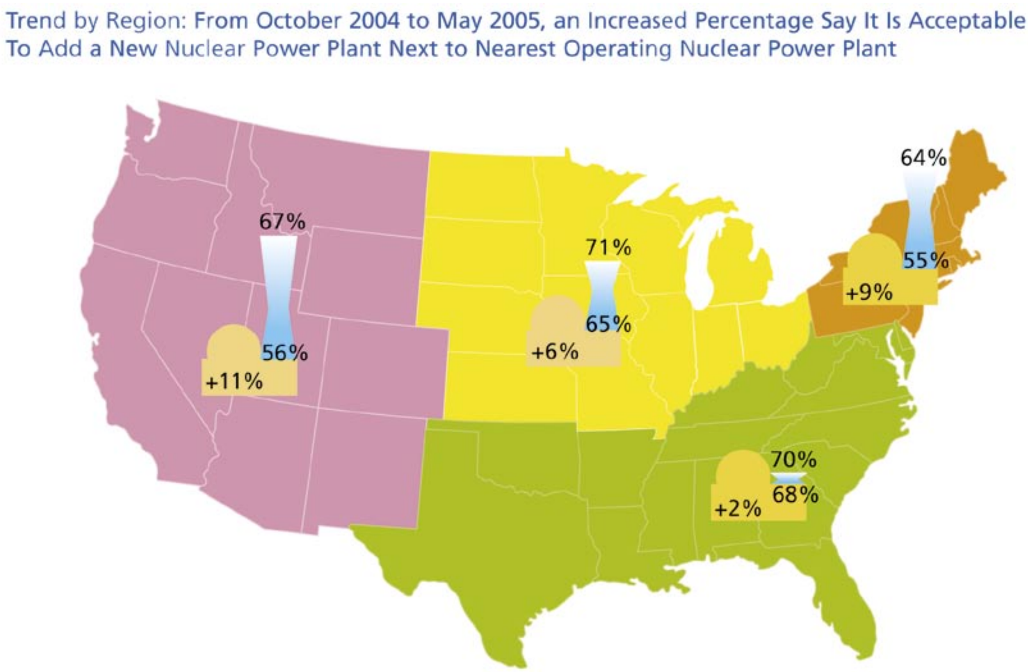
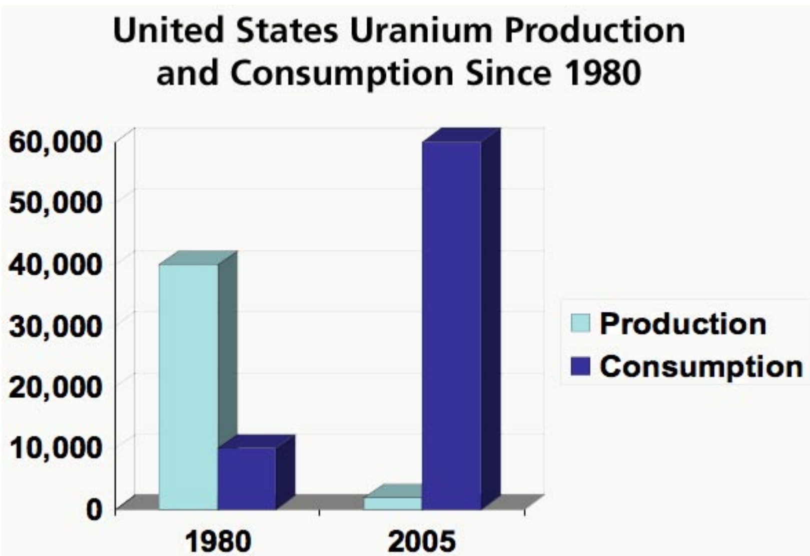


Courtesy of the Nuclear Energy Institute

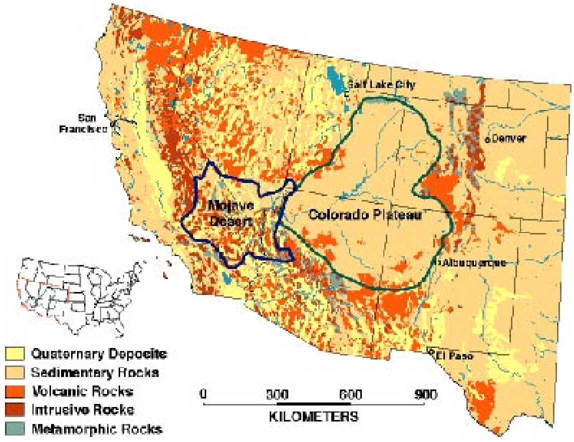
CHAPTER 3

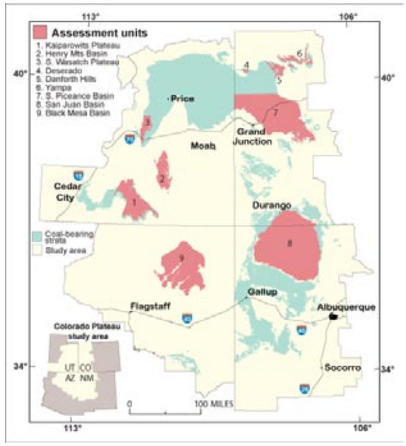
The Changing Face of Uranium Mining in the United States



While U.S. uranium production declined over the past 25 years, increased consumption drew down existing uranium inventories

Historically, the Colorado Plateau was a proven mining region, before a demand for uranium emerged. Miners were producing silver and gold for several decades in this area, before anyone thought of discussing uranium. Even then, it wasn't the uranium per





A map of the Southwestern United States with an outlined area of the Colorado Plateau and the Mojave Desert - two focus areas for USGS climate change and land use research.

se, which was of interest. It was the carnotite which attracted miners. Some, who didn't know better, confused it with gold in the prospecting process.

Carnotite: The Gem of the Colorado Plateau

Carnotite is a bright to greenish yellow mineral found in the Colorado plateau. Typically found as crusts or flakes in sandstone, the mineral is composed partly of uranium and partly of vanadium, with other trace minerals. It was known as the mineral used by Native Americans to make war paint. Later, it found a place as paint in decorative china. During the closing years of the nineteenth century, it was newly valued for its use in photography. Until the twentieth century, demand for carnotite had been relatively negligible. Precious metals mines never became big producers in the Paradox Basin, but there was steady employment and exploration in the area for a number of years.

Steady silver production kept the miners content. Carnotite was observed, but mostly ignored. To the east at Cripple Creek, in the Colorado Springs area, gold was discovered in 1891. The discovery attracted miners from the Basin and elsewhere, as silver mining lost favor. Colorado Springs, hosting three stock exchanges specializing in gold mining stocks, became a major, if temporary, financial center to service the Cripple Creek mining boom. Because of the country's bimetallism monetary policy, the price of silver collapsed and the local mines closed.

In the years following the Panic of 1893, and double-digit unemployment impacted the entire country, it took a French scientist to revive mining in this area. Radium was found in the uranium of the carnotite ore. The first Great Uranium Rush came about be-

Carnotite is composed partly of uranium and vanadium with other trace minerals.

cause of the demand for radium. Several years earlier, in 1898, Marie and Pierre Curie discovered radium was the 'daughter' of uranium decay. The scientists accidentally discovered radium's mysterious healing powers, and quickly suspected it might be useful in cancer treatment. Their medical breakthrough spurred a very strong and widespread interest in radium.

Carnotite was mined for the radium because the medical profession demanded it. Physicians wanted as much radium as they could get their hands on. Again, humble uranium was the waste product, not the desired element. After the Rocky Mountain News reported, "French/Mme. Curie Buy Large Colorado Carbonite Holdings" in September 1912, the Colorado Plateau's first uranium frenzy began the following year. Dozens of companies reportedly staked claims and began exploring the Paradox Basin near the southern Utah and Colorado state lines. Precious radium fetched $120,000 per gram during the height of the mining boom. (Editor's note: Uranium ore, from time to time, was referred to as carbonite. So profound was the French impact on the uranium industry, carnotite was named after the French Inspector General of Mines by the Curies, and the name stuck.)

Madam Curie isolated radium in 1911 and found medical uses for this element, creating a radium boom in Colorado

Before World War I, Denver became the radium capital of the world. The new wonder element, radium, was used to illuminate instruments on airplanes and navy vessels. Radium sulfide made the sights on rifles glow in the dark. The cost of extracting radium from uranium was exorbitant. Denver's National Radium Institute reported radium cost $38,000 per gram to extract from 1500 tons of uranium-mineralized ore, grading about 2.3 percent U_3O_8. Prices crashed after the discovery of ultra-high grade pitchblende in the Shinkolobwe vein deposit in the Belgian Congo. One report suggested the ore graded as high as 80 percent U_3O_8, which would be several times greater than the highest grades now found in Canada's Athabasca Basin.

This remarkable discovery crashed radium prices and collapsed employment and mining in the Colorado Plateau for nearly two decades. In 1936, it wasn't radium that re-started mining in the area, but vanadium within the carnotite (again) ore. As manufacturing in America grew, requiring more steel, more vanadium was required. During World War II, Congress passed the Strategic Minerals Act, investigating the amount of vanadium found in mines in the Colorado Plateau (among other critical minerals). The U.S. Government contracted with one vanadium producer for 6 million pounds of vanadium oxide during the war. During vanadium's boom years, before and at the beginning of the Second World War, uranium was again regarded as a troublesome waste product. Many fortunes from radium and vanadium were all built upon the mining of carnotite. After years as a bridesmaid, the uranium in carnotite was finally ready to become appreciated.

Post-War Uranium Demand Soars

The Manhattan Project was located on the perimeter of the Colorado Plateau, in the secretive mountainous retreat of Los Alamos, New Mexico. It was southeast of where the carnotite had been actively mined. Infrastructure for mining had been in place for decades. Uranium tailings dumps from previous vanadium mining provided a ready supply of the raw materials for an atomic bomb. In May 1943, Union Mines Development was openly hired by the U.S. Army to explore for minerals on their behalf. No mention was made of uranium, but this was the target metal for their exploratory efforts. In their book, ***The Secret History of the Atomic Bomb*** (Dial Press, 1977), co-authors Anthony Brown and Charles MacDonald. wrote, "Particular efforts were directed toward concealing the real purpose of Union Mines and the exact material in which it was interested. The fact that the parent company, Union Carbide and Carbon Corporation, was the world's largest user of cobalt and that it was also a user of tantalum, vanadium, and other materials served as useful 'blinds' in maintaining the desired concealment."

As noteworthy as these efforts were, other reports suggest something to the contrary. Despite the publicity, many believe the lion's share of the uranium for the Manhattan Project came from Canada and the Belgian Congo. The grades were higher in those areas and easier to mine. Perhaps, it was the fear the U.S. would have the bomb, but would lack sufficient quantity of the fuel to make the bomb. This dread drove the U.S. Army to cultivate a domestic exploration program. Paranoia about inadequate uranium inventories later became a driving force in the U.S. government's policy to expand exploration efforts for uranium.

After the war, the Atomic Energy Commission (AEC) offered financial incentives to mine uranium: a guaranteed minimum price for the metal. After President Harry Truman signed the Atomic Energy Act in 1946, the law reassigned control of atomic energy from the military to the newly created civilian agency. Congress endeavored to use nuclear energy as a means to promote world peace and bring the power of the atom into the world as an energy source. As the Soviet Union began escalating their atomic program, the AEC replied in kind, stepping up our country's exploration programs.

A major political concern of the era was controlling the nuclear cycle. Many within the government wanted to completely control the cycle, preventing the bomb-making secrets from arriving into the wrong hands. Others optimistically sought to widely disseminate this technology and help bring civilization a new era. Playing a game of who's going to blink, the U.S. monitored each of the Soviet Union's latest developments.

But, instead of seizing the mines in East Germany and Czechoslovakia, and using political prisoners as slave labor to mine for uranium, which was the case with the old Soviet Union, the AEC offered a bounty, as some called it. The military was terrified the Soviets would build more nukes than America. U.S. Army General Leslie Groves and Great Britain had launched, in the latter years of the Second World War, a global search to identify, acquire and monopolize the world's uranium resources. As we previously wrote, this search flopped because uranium was ubiquitous and in great supply. The government demanded greater domestic uranium supplies to compete with the Soviet's weapons program. Because of the military's insistence of readily available domestic inventories, and working closely with the AEC, the incentive program sent the U.S. exploration program into hyper drive.

A scraper digging a trench for an open pit uranium mine in Wyoming in the 1950s

The destination of choice was, of course, the Colorado Plateau. By 1947, prospectors descended onto the Plateau. Some smaller underground mines began starting up. With this robust exploration activity, new discoveries were made in New Mexico and Wyoming. In 1950, a Navajo shepherd, Paddy Martinez, discovered uranium by accident in a limestone ledge, first thinking it was gold until he was otherwise enlightened. A year later, J.D.

Love, a Wyoming geologist made the first discovery of highly mineralized uranium in the sandstones of the Powder River Basin of his state. In 1952, Charlie Steen hit the jackpot in Moab, Utah and began producing uranium at his 'Mi Vida' mine the following year. Uranium discovery moved east to Texas in 1954 and created a prospecting frenzy in the Lone Star State.

These discoveries attracted tens of thousands into the Colorado Plateau, and in other states, in search of the next great 'elephant' uranium discovery. Further exploration led to production at Laguna and Ambrosia Lake, ranking New Mexico as the world's leader in uranium production (a ranking it has only recently lost to Canada's Athabasca Basin). Wyoming's Powder River Basin, Shirley Basin and elsewhere became some of the world's top uranium hot spots. Cameco continues to produce uranium in the Powder River Basin through its Smith-Highland Ranch facility. Utah continued to attract and produce uranium, but not at the level of Wyoming or New Mexico. Texas began producing a greater amount of uranium through something new, which was first developed in Wyoming. It was called In Situ Leach (ISL) mining.

The fast-paced excitement continued into the late 1950s, when the AEC abruptly changed its directives. Until 1956, the AEC provided assistance in the form of access roads, exploratory drilling services and free assays. As more discoveries were made, the AEC cut back its incentive program in steps. By the end of October 1957, the AEC announced, "It is not longer in the interest of the government to expand the production of uranium concentrates." Six months later in 1958, the AEC permitted a limited expansion of some uranium reserves developed before their November 1957 cut-off date. By November 1958, the AEC restricted its forward contracts through 1966 allowing development of uranium reserves, which were proven as of 1958. Thus ended the first uranium boom.

When the next uranium boom began in the late 1960s, it was because U.S. utilities had turned to nuclear energy as a solution to America's energy needs. About 250 nuclear power plants were planned in the United States for the world's largest rollout. A second uranium mining boom has begun as major oil companies established uranium subsidiaries to provide the fuel for this overwhelming demand. Again, uranium prices soared and sustained above $40/pound for nearly four years, during the late 1970s. The Three Mile Island episode brought a long hiatus to American's nuclear energy expansion. Only 104 of the proposed 250 nuclear reactors were constructed. Of those, all but one remains operational.

During the second uranium boom, a new form of uranium mining was further developed. Because of the nature of many of the U.S. uranium deposits, the In Situ Leach (ISL) method was an environmentally friendly way (relatively so, during the early years of ISL mining) to recover uranium. It was also less expensive to build an ISL facility than to construct an underground mining and milling operation.

Because ISL mining will prove to be the predominant form of uranium mining in the United States, we have devoted the rest of this chapter to explaining and explaining it.

Conventional versus ISL Mining

Conventional Open Pit Uranium Mine
500 workers required
per 1 million lbs. of Uranium mined

In Situ Uranium Recovery Facility
75 workers required
per 1 million lbs. of Uranium mined

In Situ Leach Mining

Because of the nature of many uranium deposits in the United States, Australia and Kazakhstan, In Situ Leach (ISL) mining has become quite popular. According to the World Nuclear Association, 21 percent of the world's uranium production came about from ISL mining in 2004. Because this form of mining may play an integral part in the nuclear energy story over the next few decades, we are providing an exclusive, in-depth examination of In Situ Leach mining. ISL mining may be the predominant theme of many U.S. uranium development companies. Knowing the intricacies of this kind of mining will help provide you with an edge in better understanding the different companies who pitch their stories to you.

Description of ISL Mining by the Wyoming Mining Association

What is ISL mining? According to the Wyoming Mining Association website, ISL mining is explained in the following manner.

"In situ mining is a noninvasive, environmentally friendly mining process involving minimal surface disturbance which extracts uranium from porous sandstone aquifers by reversing the natural processes which deposited the uranium. To be mined in situ, the uranium deposit must occur in permeable sandstone aquifers. These sandstone aquifers provide the "plumbing system" for both the original emplacement and the recovery of the uranium. The uranium was emplaced by weakly oxidizing ground water which moved through the plumbing systems of the geologic formation. To effectively extract uranium deposited from ground water, a company must first thoroughly define this plumbing system and then design well fields that best fit the natural hydro-geological conditions.

Detailed mapping techniques, using geophysical data from standard logging tools, have been developed by uranium companies. These innovative mapping methods define the geologic controls of the original solutions, so that these same routes can be retraced for effective in situ leaching of the ore. Once the geometry of the ore bodies is known, the locations of injection and recovery wells are planned to effectively contact the uranium.

This technique has been used in several thousand wells covering hundreds of acres (in Wyoming). Following the installation of the well field, a leaching solution (or lixiviant), consisting of native ground water containing dissolved oxygen and carbon dioxide, is delivered to the uranium-bearing strata through the injection wells. Once in contact with the mineralization, the lixiviant oxidizes the uranium minerals, which allows the uranium to dissolve in the ground water.

Cameco Corporation's Smith Ranch In Situ Recovery well field (production and injection wells) in Wyoming (February 2006)

Production wells, located between the injection wells, intercept the pregnant lixiviant and pump it to the surface. A centralized ion-exchange facility extracts the uranium from the barren lixiviant, stripped of uranium, is regenerated with oxygen and carbon dioxide and recirculated for continued leaching. The ion exchange resin, which becomes "loaded" with uranium, is stripped or eluted. Once eluted, the ion exchange resin is returned to the well field facility.

During the mining process, slightly more water is produced from the ore-bearing formation than is reinjected. This net withdrawal, or "bleed", produces a cone of depression in the mining area, controlling fluid flow and confining it to the mining zone.

The mined aquifer is surrounded, both laterally and above and below, by monitor wells which are frequently sampled to ensure that all mining fluids are retained within the mining zone. The "bleed" also provides a chemical bleed on the aquifer to limit the buildup of species like sulfate and chloride which are affected by the leaching process. The "bleed" water is treated for removal of uranium and radium. This treated water is then disposed of through waste water land application, or irrigation. A very small volume of radioactive sludge results; this sludge is disposed of at an NRC licensed uranium tailings facility.

Ion Exchange Vessels
(February 2006; StockInterview.com)

The ion exchange resin is stripped of its uranium, and the resulting rich eluate is precipitated to produce yellowcake slurry. This slurry is dewatered and dried to a final drummed uranium concentrate.

At the conclusion of the leaching process in a well field area, the same injection and production wells and surface facilities are used for restoration of the affected ground water. Ground water restoration is accomplished in three ways. First, the water in the leach zone is removed by "ground water sweep", and native ground water flows in to replace the removed contaminated water. The water which is removed is again treated to remove radionuclides and disposed of in irrigation. Second, the water which is removed is processed to purify it, typically with reverse osmosis, and the pure water is injected into the affected aquifer. This reinjection of very pure water results in a large increment of water quality improvement in a short time period. Third, the soluble metal ions which resulted from the oxidation of the ore zone are chemically immobilized by injecting a reducing chemical into the ore zone, immobilizing these constituents in situ. Ground water restoration is continued until the affected water is suitable for its pre-mining use.

Throughout the leaching and restoration processes, a company ensures the isolation of the leach zone by careful well placement and construction. The well fields are extensively monitored to prevent the contamination of other aquifers.

Once mining is complete, the aquifer is restored by pumping fresh water through the aquifer until the ground water meets the pre-mining use.

In situ mining has several advantages over conventional mining. First, the environmental impact is minimal, as the affected water is restored at the conclusion of mining. Second, it is lower cost, allowing Wyoming's low grade deposits to compete globally with the very high grade deposits of Canada. Finally the method is safe and proven, resulting in minimal employee exposure to health risks."

The History behind ISL Mining

In this modern era of uranium mining, extremely skilled engineers, hydrologists and geologists establish ISL mining operations. Most insiders compare an ISL operation to a water treatment plant. It's really that simple to understand. However, as with every modern industrial operation, the roots of ISL mining came about in a less genteel or sophisticated manner. In 1958, Charles Don Snow, a geologist employed by the Utah Construction Company, was investigating a Wyoming property for possible acquisition for his company. During the course of that visit, he discovered a new method of uranium mining and helped pioneer its development into the modern form of ISL.

Since 1957, R.T. Plum, president of Uranyl Research Company, had been experimenting with a leach solution on his property at the Lucky June uranium mine. "They mixed up the sulfuric acid solution and just dumped it

Don Snow - Frozen core at Lucky Mc, in spring of 1959.
The hitherto unacknowledged father of modern day ISL mining.

on the ground, and soaked it through the material and collected it in a little trench at the end," Charles Snow recalled. It wasn't very scientific. Snow added, "They were just learning how, and I observed it and thought that the application could be made through some of the ore that we had in the Lucky Mc mine." The company was mining uranium this way because it was below the grades miners were used to, when mining. As Snow noted, "It was not worth mining." But it was practically at the surface. He explained what they were doing at the Lucky June, "There was an area where uranium leached out to the surface in a small area, and it had a clay under-bed. These people put solutions onto the surface, collected the solution, and ran it by resin beads to absorb the uranium."

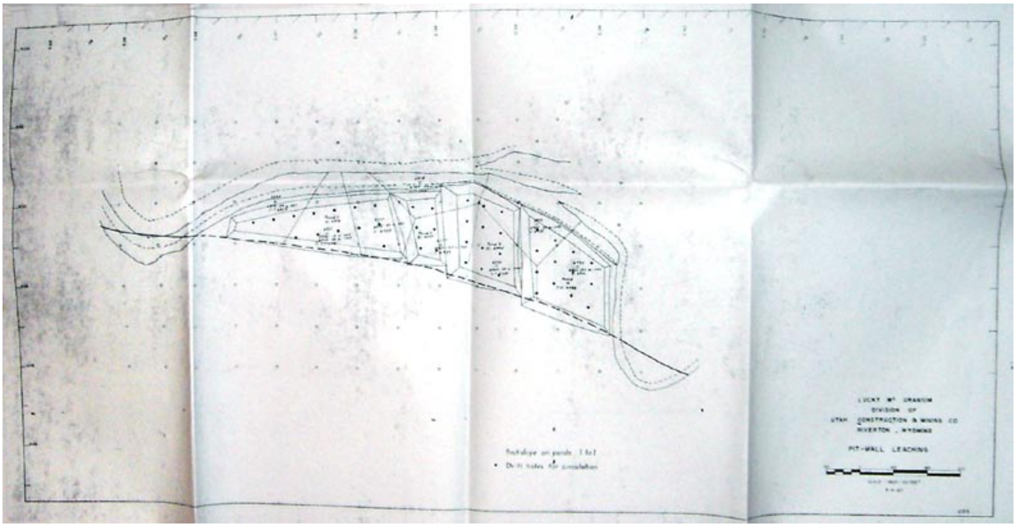
While they only recovered about $3600 worth of uranium, about 600 pounds, Snow was impressed. He later wrote an inter-office memorandum in July 1959, with the subject header: "Recovery of Uranium from Low Grade Mineralization using a leach in place process." In his conclusion, Snow recommended, "From the preliminary information available, it appears that it will be possible to treat very low grade mineralization for recovery of uranium at a large net profit." He explained the process to his bosses, encouraging them to consider this as an option:

> "In brief, the process introduces a leach solution onto the surface of the ground and allows the solution to percolate down through the area to be leached. The solution is then recovered from wells and circulated through an ion exchange circuit with the barren solution being returned to the leach area. Recovery of the uranium is made by stripping from the ion exchange medium."

He wanted the Utah Construction Company to try this method of mining where there was low grade mineralization. Snow succeeded in convincing his bosses. This began yet another innovation for Utah Construction Company, the same company which helped construct the Hoover Dam, decades earlier, before it got into the uranium mining business.

Utah Construction Becomes the First Commercial ISL Miner

Newspaper reports, through the 1960s, illustrate that ISL mining was in full bloom for more than a decade before anyone in Texas began a commercial ISL operation. On June 18, 1964, the Riverton Ranger newspaper reported, "The Shirley Basin mine is on a standby basis. The timbers are being maintained and the water pumped out. Total production comes from solution mining." Between 1962 and 1969, ISL, then known as "solution mining," was the only method producing uranium at Utah's Shirley Basin Wyoming. Later in



ISL Well Field Design of Lucky Mc Uranium Mine, a division of the Utah Construction & Mining Company in Riverton, Wyoming, May 4, 1960

A9 Drift heading near south end after it had penetrated the water table. Water is dripping and running into the drift from the face, walls, back and floors. In wet ground such as this no face could be left open for more than a few minutes without caving, hence the breast boards shown in this picture. The vertical streaks here and there in the picture were caused by water dripping from the back. The drift at this point was being driven in unaltered silty sand.

A car containing ore is ready to be trammed to the shaft for hoisting to the surface. The fingers of the trammers glove are in the black glossy mud and his jacket can be seen reflected on the surface of the ore. Much of the Shirley Basin ore as shipped to the surface was of this consistency. Behind the trammer normal, closely-spaced wall lagging can be seen.

that same article, under the section entitled, "Gas Hills Solution Mining," it was reported, "The Four Corners area is 'mined' by solution mining techniques similar to those employed at Shirley Basin."

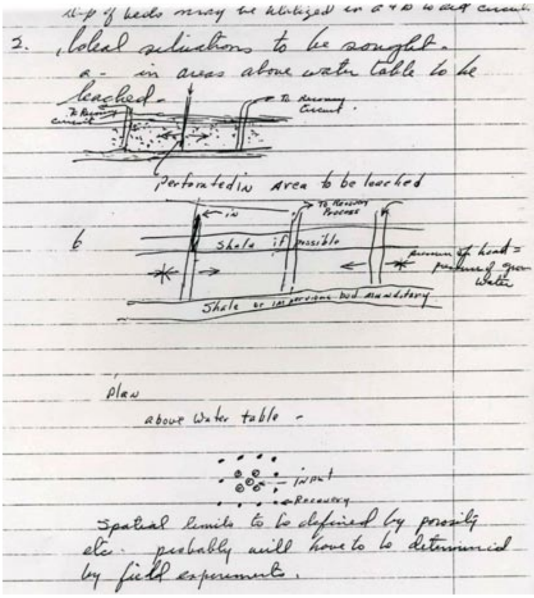
Credit for this new mining method is also reported in that same article, "Lucky Mc introduced the heap leach process of recovering values from low grade ores in 1960." Charles Snow explained how his company made the transition from underground mining to solution mining, "The underground mining at Shirley Basin was very expensive, and we were having a lot of heavy ground problems." The sandstone aquifers containing the uranium were uncemented and brittle, supported with timbers. "In some places, it was too heavy to hold with timbers," said Snow. "We had to use steel sets underground, and it was even mashing the steel sets. So the expenses were getting very high."

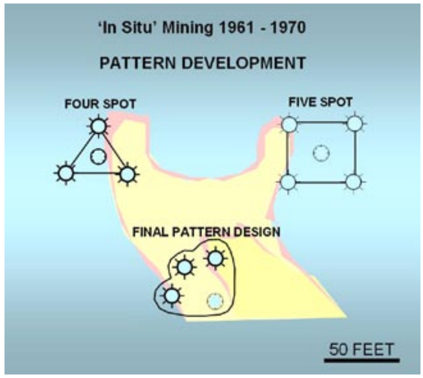
Water was flowing into the open drifts at prodigious rates. Snow recalled, "Barney Greenly said, 'Let's try solution mining over here.' They did a test, and it did operate quite well. They got some pretty good results. So the underground mine was shut down, and they went to a solution-mining program to produce the allocated pounds in the Shirley Basin area." The procedure was tested for a few years before a full-scale commercial production began. This fulfilled 100 percent of Utah's Shirley Basin uranium production allotment from the AEC.

There were problems at first. "We started out initially using sulfuric acid, and we had some reaction with carbonates in the formation." Sulfuric acid plus calcium carbonate produces calcium sulfate, and this plugged up the formation. Calcium sulfate is gypsum, which was insoluble in the leach solution. "It tended to plug up the formation and reduce the transmissivity of the fluid from the input hole to the output recovery hole."

To prevent interference with the porosity of the formation, Snow switched to nitric acid, but admitted, "We were reluctant to use nitric acid because it was much more expensive than sulfuric." But they did, because the nitric acid solution did not form gypsum. Unlike present-day ISL methods used in Texas, Nebraska and Wyoming, Utah Construction did not use a carbonated leaching solution in their solution mining. Nitric solution was used during the 1960s and continued until the Lucky Mc switched over to open pit mining.

It all started as a heap leach experiment. "We had quite a bit of low grade in Lucky Mc," Snow told us, "so we thought we would try a heap leach experiment." Results were good on the test, and Utah pioneered ISL mining. Snow wrote in an August 2, 1960 memo, "The favorable results of the heap leach project and other research indicate that the process can be successfully applied in many of the low-grade areas to recover much of the mineralization." Later in his report, Snow calculated reserves from random samples obtained from previous drilling at Lucky Mc, "The estimated reserve for the block is 147,000 tons @ 0.0361 percent U3O8, or 106,616 pounds of U3O8." He estimated the program would cost $111,471. Using a value of $6/pound for U3O8, the anticipated returns were calculated as follows:





Several patterns were developed during the experimental phase of ISL mining in the 1960s.

Handwritten drawing by Charles Snow of an ISL well field, showing two injection wells and a recovery well, dated October 2, 1959.

50 percent recovery: 53,318 pounds: $208,377
25 percent recovery: 26,654 pounds: $ 48,453

That was just the start. By the end of the decade, Shirley Basin's solution mining operation was producing U3O8 at comparable levels to present day production at any of the major U.S. ISL facilities. In a paper presented by Ian Ritchie and John S. Anderson, entitled "Solution Mining in the Shirley Basin," on September 11, 1967, at the American Mining Congress in Denver, Colorado, these Utah International executives explained the success of the Shirley Basin solution mining operation. In a summary explaining the company's activities, we discovered the Shirley Basin operation not only filled the Atomic Energy Commission (AEC) allocation requirements from 1962 through 1969 but we learned of the sizeable commitments into the future Shirley Basin was to fill:

> "In 1968 sales of uranium concentrate were made to purchases other than the AEC. One of the first sales was to Sacramento Municipal Utility District with a minimum of 950,000 pounds to a maximum of 1,100,000 pounds of uranium concentrate in 1971. Additional contracts were signed with General Electric Company and with Nordostschwerzerische Kraftwerke A.G. (Baden, Switzerland). The contracts called for delivery of 8,000,000 pounds of

> concentrate to GE between 1968 and 1975, and 500,000 pounds of concentrate to NOK commencing in July 1969."

The single reason solution mining stopped, well before the first "commercial" ISL operation began in Bruni, Texas in 1973, was because of the improved market forecast for uranium in the 1970s. Utah Construction switched to open pit mining because they needed to produce a lot more uranium. The nuclear renaissance of the 1970s demanded massive quantities of uranium to fuel the rapidly growing nuclear power industry.

Don Snow's initial field tests, begun in the late 1950s, resulted in continuous production achieved by late 1962. Subsequently, production in the underground uranium mine was shut down by May 1962. The underground mine had been maintained on a standby status until 1965, when all underground operations were written off. Millions of pounds were mined by Utah Construction through its ISL operations in Shirley Basin. It wasn't heap leaching as some later belittled it.

Sufficient evidence confirms Wyoming, not Texas, first pioneered commercial ISL mining. Not only were well fields designed as early as 1960, but the entire concept of an ISL "water treatment" plant can trace its roots to Utah Construction's pioneer work. Everything from injection wells to production wells were pioneered in the early 1960s. We challenged Charles Don Snow that some have claimed it was heap leaching, not ISL mining. Snow shot back, "No, we drilled holes in the ground and the material had never been mined. We got our ideas, certainly, from heap leaching, which came from the copper industry." Snow explained after the solution mining experiment was successful, "A recovery plant was designed and put into the hoist house, where they had had the underground mine. That was designed by Robert Carr Porter and Ian Ritchie." Snow added, "In fact, Ian Ritchie and J.S. Anderson have a U.S. Patent on the well completion procedures that we used at Shirley Basin."

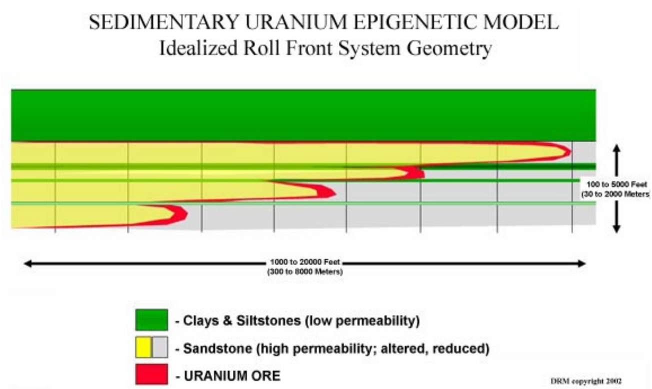
Important Geological Points in an ISL Property: How to Minimize Your Risk

Starting around 2004, the common myth circulating among investors had been "pounds in the ground." How many pounds of U3O8 does a company have in the ground? The more pounds a company claims, and more importantly gets institutions and investors to believe, the higher its market capitalization began to run. Bigger is always better in most cases, but recovering uranium through an ISL operation, like any other mining operation, has its quirks.

During the early stage of this uranium bull market, pounds-in-the-ground was an important yardstick. But just as one can have a million-ounce gold deposit, with a complexity of metallurgical problems prohibiting a robust economic recovery or the metal or offer a paltry grade of gold in the ore, investors may discover the same problems in properly evaluating a company's uranium claims. Instead of asking a company's investor relations department how many pounds of uranium they have in the ground, find out how much uranium pounds they can actually recover and produce, and how much it will cost them when mining their property. Ask these questions:

- How permeable are the ore bodies you plan to mine?
- What is your average grade?
- Over what area does your rollfront extend?
- What is the depth of your ore body?

By the time you have finished reading this section, you should have a better grasp of the economics of ISL mining. You should be better equipped to make a more intelligent decision about your favorite company. First, let's examine the nature of a uranium mineralized rollfront. Understanding the rollfront will give you the key tools required to accurately evaluate the prospects of any ISL uranium development company.



Total system is very large. Width is 100 to 1000 meters and can be greater. Strike length is typically many 10's of kilometers, often exceeding 100 km in length. Average grade over all is .20 to 1.0%. Courtesy of David R Miller.

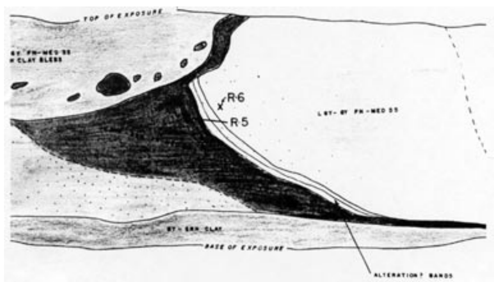
The "ROLL FRONT" is a Uranium Deposit

In the previous section, we had discussed Charles Don Show, who helped pioneer ISL uranium mining as an economic means to extract lower grade ore from underground mining operations. In Snow's 1978 article entitled, "Gas Hills Uranium District, Wyoming

– A Review of History and Production," published in the Wyoming Geological Association Guidebook, he wrote about the development of the "roll front" theory. Snow talked about discussions the project geologists were having in the summer of 1955 about Utah Construction Company's recently acquired option on the Lucky Mc uranium properties in Wyoming's Gas Hill District:

> "Offset drilling Project 4 intersected one major mineralized zone with a grade thickness product over 10 percent U3O8. An offset of this and one other mineralized hole about 2500 feet away were barren. Many discussions of why the ore was in these 'isolated' pods were carried on late into the night. After one discussion in December 1955, ten more drill holes were allocated for the Project 4 area to prove or disprove its value. As remembered, it was late one night when pondering over the maps that Don C. Anderson said there had to be a connection between these two mineralized areas; and in so saying, sketched a sweeping arc between the existing wide spaced drill holes stating, 'It has to be here!' The orebody was indeed there and drilling following that line led to the development of sufficient reserves to justify the mill. It was during the period of development of the reserves that members of the staff started referring to different layers and separated pods as areas of mineralization where chemical changes had caused deposition and soon the word 'chemical front' was in common usage."

Early photograph of "front" in Pit 4A Lucky Mc Mine. Taken by P. A. Riddell, June, 1958.



Geologic cross-section of "front" in Pit 4A. Geology by P. A. Riddell, June, 1958.

Three years later, Paul A. Riddell prepared a report to document the ore occurrences at the Lucky Mc mine. He was among the first to use terminology that has since become an integral part of the "Roll Front" concept. In his project report, Riddell wrote:

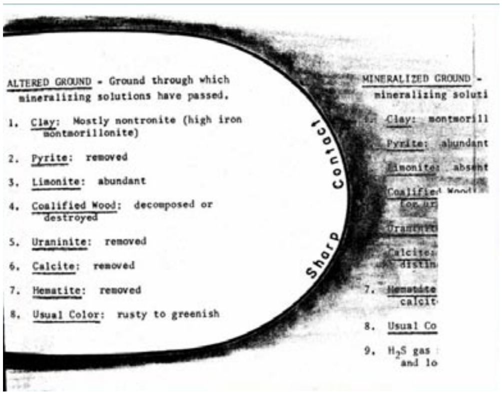
> "In conclusion, the uranium appears to be restricted to more porous beds, but is not evenly distributed within these beds. The boundaries between ore and lean material are erratic – sometimes sharp and sometimes gradational. They do not appear to be related to changes in sedimentation within the beds. Others have suggested that the boundaries represent 'chemical fronts,' and this theory appears reasonable in light of present information."

Indeed, this was the foundation for later research into uranium roll fronts. In 1966, these same geologists encouraged the Atomic Energy Commission to prepare a paper on the subject, entitled "Roll Fronts in the Gas Hills." Another was published immediately thereafter, by J.W. King and S. Ralph Austin, entitled "Some Characteristics of Roll-Type Deposits at Gas Hills Wyoming."

Originally called chemical fronts, these "pods" contained various grades of uranium. Each pod or roll front is comprised of different mineralization. Understanding that mineralization and how to extract the uranium alone determines how viable a deposit might be.

If you imagine roll fronts in a uranium area as if they were lily pods in a pond, you are off to a good start. When a company announces it has uranium mineralization on its property, this could mean it has many pods, or fronts. Ideally, you hope to have multiple "fronts" available on your ground. "Typically, the meat of the front (multiple percent of uranium) is only a few feet to ten feet wide at the most," Strathmore Minerals president David Miller explained. "This is the part that your ISL wells have to address correctly. If you look at all the mineralization in a single front system, above 0.03 percent, then from the tails to the front could be 100 feet or more. If you look at the multiple fronts in stacked sands, and you look at one end of the system to the other, the width can be several miles. The length of any of these can be tens of miles, but the good stuff comes and goes."

Miller compared these multiple fronts to "pearls on a string." There may be one, two or three roll fronts in one well field. "There may be more than three roll fronts," Miller added. "There may be that many or more even in one pattern." Again, they are pods and they may be stacked in layers, like lasagna. "The number of roll fronts in a pattern does not really matter, except for operational reasons," Miller explained. "It is more complex to properly address multiple roll fronts than a single roll front, and you may not be able to optimize recovery of all of them."



The mineralization within a uranium-mineralized roll front.

Permeability is the Key

Glenn Catchpole, CEO, Uranerz Energy

Getting down to the business of ISL mining a roll front requires that we understand the role permeability plays in this mining method. Permeability is the flow rate of the liquids through the porous sandstone. Knowing the permeability of the orebody will let you know how much water you can get through the sandstone formation. The typical porosity of sandstone can be between 20 and 28 percent. Porosity is the void space between the sandstone grains. By comparison, clay has a porosity of between 45 and 55 percent. Uranerz Energy Chief Executive Glenn Catchpole, who is also a hydrologist, said, "A property's formation has to have sufficient permeability to make the project economic."

In order to dissolve the uranium into solution, you have to know the "pore volumes." That's the measure of the pore space in the rock. "You're passing fluid through the formation about 30 times to dissolve the uranium," explained UR-Energy Chief Executive William Boberg. "Part of a successful operation is knowing how many pore volumes we feel it's going to take to make it all work." Uranium Energy Corporation Chief Operating Officer Harry Anthony, an internationally recognized ISL expert, noted, "You need higher grade ore for tight formations. With high permeability, you can space your wells further apart."

Harry Anthony, COO and Director, Uranium Energy Corp

As with any industry, it boils down to economics. How much to operate the plant? Anthony gave an example of an ISL plant operating at 5000 gallons per minute. Running 24 hours daily, the plant would process 7.2 million gallons of water. That's more than 2.6 billion gallons of water processed every year. Operating costs are based upon cost per thousand gallons of water. "This includes electricity, reagents and labor," said Anthony. On a daily basis, it would cost more than $21,000 to run an ISL plant, based upon Anthony's calculations of $3.03 per thousand gallons of water. Using a 5,000 gallon per minute scenario, a plant might produce 2360 pounds of U3O8 every day or 80,000 pounds monthly. The cost to produce each pound would be $8.18. Using that math, the uranium grades would be about 44 parts per million (ppm) or 0.08. Anthony said, "I like to see 70ppm or higher."

With low permeability in a tight formation, you may need to space more wells in a typical well field pattern. How much does each well cost? That depends upon the depth of the roll front deposit. While explaining that costs are fixed and variable, Anthony computed the cost of a production well for a 500 foot deposit at $15,000. An injection well could cost $11,000 to install. By comparison, in New Mexico, where the deposits are wider and of higher grade, a 2000-foot production well might cost $27,000 and the injection well could cost $18,000, and it would still be economic.

Why are we talking about well installation costs? Again, it comes back to permeability. If the flow rate is lower, bringing an ISL well field into production costs more. Glenn Catchpole explained, "If your plant is running at 3000 gallons per minute (gpm), and the formation is tight, each production well might only have 10gpm flowing. A more permeable formation might have 20gpm flowing." That means twice as many production wells are required to satisfy the ISL plant's 3000gpm flow level. Installation costs have doubled, and that would also impact operating costs. And a company which once might have looked like it had an economic orebody could now smell like week old fish.

Pump Testing for Permeability

"The pump tests are extremely valuable," explained Boberg. In one of series of tests, Boberg explained, "We take a core out of the hole (3 inches diameter and 6 inches tall) and test it vertically by forcing fluid through it." Because the movement of the fluids in the substrata, from one well to another, is horizontal, the only way to really find out the permeability and porosity is by drilling a hole and putting a pump in it.

Catchpole explained the procedure, "You put the equipment down your monitor wells to measure drawdown." Quite simply, you measure how far the water goes down. "The pump test will tell you permeability." A good pump test takes between 24 and 72 hours to complete.

The make-break point for a formation's permeability is its Darcy rating. How high is the Darcy? A typical Darcy can range from minus 1000 to plus 3. The higher the Darcy, the more permeable the formation and that would help determine how economic the orebody is. An acceptable range would be one-half to one Darcy. What is a Darcy? Catchpole said, "It is gallons per day over feet squared." He added a pure hydrologist would calculate the feet per day or centimeters per second to get a more accurate permeability assessment. However, the Darcy is a widely accepted measuring unit in the industry.

Until a company gets a Darcy rating of the orebodies on its property, one can't be completely certain the property can be mined by ISL. What guidelines does one depend upon? Catchpole said, "Historical research can give you permeability levels for a formation." How permeable the formation will be answered with the pump tests.

Other Key Factors

Uranium grades can be a contentious point, so we asked our ad hoc panel of experts. "Grade is the driving force," Harry Anthony shot back. We asked him about companies which said they could run an economic ISL operation with grades as low, or lower than 0.02. Anthony laughed, "They are crazy. They'd be out of business before they started." Catchpole was more reserved in responding, "It probably wouldn't have an economic recovery." Strathmore's David Miller offered a more technical analysis, "Frankly, that will not likely have enough recoverable pounds. The operating grade feeding the plant will be too low. What is the best grade? 0.5, 0.10, or 0.15. It depends upon the deposit."

How much can you actually recover? Boberg explained the problems of pounds-in-the-ground. "Let's say we've got 100 million pounds of uranium now. How much of that can we actually mine? There may be 10 million in a particular orebody that looks like we can mine it. If we build an operation around that, we might be able to develop an access to maybe 7 million pounds of that. And in a recovery process, we might only be able to recover 70 percent of that." Every company has to also be very careful

William Boberg, CEO, UR-Energy Corporation in studying their orebodies before building their plant. “We’ve got to make sure that the plant we’re building isn’t built over a potential resource,” Boberg emphasized. “We’ve got to drill under that to make sure we’re not accidentally putting the plant over another part of the deposit.”

Another worry with an orebody is channeling. “You don’t want channeling,” Catchpole insisted.” Channeling suggests the water is going through a very narrow path. “If your orebody has a thickness of ten feet and your channel of flow is one foot, you are missing most of the uranium formation,” said Catchpole. “You may have good flow rates, but not much U3O8 recovery.” Sometimes, a channel can be a natural occurrence, where the flow is along a fault. The channel creates a smaller, but preferred path for the fluids to flow through. Unlike fracturing a formation to release natural, or coalbed methane, gas, a fractured channel has the opposite effect on ISL uranium mining.

How much does it cost to install a well field pattern, and is it economic to do so? “The art part of an ISL operation is interpreting the ore body and the hydrology,” Catchpole explained. “Your hydrologic test results determine where you think the solutions are going to flow best. In other words, which direction has the best or least permeability? This has to get factored into how you lay out those patterns, the width of your orebody and how far out to the edge of the orebody you go.”

In a well field pattern, Strathmore’s David Miller can determine the economic viability of the ground. “The keys to what is recoverable are: (a) how many pounds are recoverable per pattern? and (b) what does it cost to install a pattern?” Miller explained. “If you have 10,000 pounds in place and can recover 8000 pounds, your well field development cost can be $8/pound, if it costs you $80,000 to install that pattern. Add your operating cost, capital amortization and restoration cost, and you would have a total cost.”

Finally, the cost to install a pattern also depends over how much territory your roll front deposits run. “Ten million pounds over an area of one-half mile will cost less than those same pounds over an area of two to four miles,” remarked Terrence Osier, senior geologist for Strathmore Minerals. “That means more injection wells and more production wells.” Depth of the wells influences its installation cost, as mentioned previously, and impacts its daily operating cost. “A few years ago, when uranium costs were $7/pound, a company needed 70,000 pounds per pattern,” Harry Anthony commented. “Now a company might only need 4,000 pounds per pattern to make it economic.”

There are many variables within the above advices provided by these experts. However, the important point to realize is the time of hyperbole and hoopla about “pounds in the ground” has passed. As more uranium development companies move closer to establishing an ISL operation, the go/no-go consideration, as William Boberg aptly described it, will come down to permeability. After that, the economics of a project will either make it viable or not.

Reversing Mother Nature: How ISL Mining Works

"Blossom" is what underground uranium miners called the crystals forming on the tunnel walls. Because the ore was in contact with air inside an underground mine, and as ground water moved slowly against the mine's walls, a visible crust of uranium crystals would precipitate, or blossom along those walls. Making the uranium soluble doesn't require a lot of oxygen and water because oxidization is a natural process. Adding more oxygen to the groundwater found in, and around, a uranium-mineralized orebody is the principle upon which present-day In Situ Leach (ISL) uranium mining is based.

Eons ago, the uranium was soluble and moved, on or below the surface, with the ground water. "In roll front uranium deposits the uranium was transported into the area through the natural groundwater system and precipitated from solution due to some reducing environment," explained Harry Anthony. Often, the reducing agent was something organic, such as coal, deep-seated oil and gas deposits, or hydrogen sulfide gases. In its reduced form, the uranium crystals are insoluble. "It will precipitate as a coating on the existing sand grains of the sandstone," added Anthony. "As more water containing uranium sweeps through this area, and encounters this reducing environment, more uranium is precipitated until there is a sufficient concentration to make it a commercial deposit."

After the geological team has delineated a company's uranium "roll front" deposit and determined it is of economic value, the company must turn to its ISL design engineers to complete the "mining" process. While it takes stellar geologists such as David Miller of Strathmore Minerals, Bill Sheriff of Energy Metals, or William Boberg of UR-Energy to accumulate large, proven uranium-mineralized holdings, as they have done in Wyoming, New Mexico, Texas or elsewhere, each must turn to their engineers to extract the uranium from those sand grains and process them to produce an economic quantity of uranium oxide, or U3O8. The majority of ISL facilities, designed in the United States, were engineered by Harry Anthony, Doug Norris and Dennis Stover.

How Does ISL Mining Reverse Mother Nature?

"In its natural, reduced environment, uranium exists as a solid in the +4 valence," Anthony explained. "In the mining stage, we are reversing Mother Nature's process by adding oxygen, oxidizing the uranium from a valence of +4 to a valence of +6." The uranium was oxidized at one time, but then reduced by Mother Nature. By drilling wells into the ore zone, circulating the water and adding oxygen to it, the uranium is made soluble again.

Is it really this simple? Yes and no. Energy Metals Chief Operating Officer Dennis Stover outlined the process, "You're simply adding, into the injection well, gaseous oxygen, just pure oxygen, but you're doing it under the water level in the well. The natural pressure, created by that column of water above the injection point, allows the oxygen to dissolve into the water so that there's no free gas being put into the well."

Inside a "header house." Many who know how ISL (Solution Mining) operations work compare this to a water treatment plant. The tubes connect to the aquifer from where the uranium is extracted. Right: Water in; water out. Just as you would find at a water treatment facility.

Stover compared the oxygen dissolved in the liquid to the carbon dioxide dissolved in a bottle of soda. The soda remains clear, dissolved in the liquid, when stationery. "But when you shake it up, the gas will break out," added Stover. "The pressure that's available that lets you dissolve the oxygen is determined by the amount of naturally occurring water pressure that's on the uranium deposit." Stover explained that if the deposit is 100 feet below the water table, you can dissolve a certain amount of oxygen. "If the uranium deposit is 200 feet below the water table, or twice as deep, you can dissolve twice as much oxygen."

Historically, ISL mining evolved from acid leaching to leaching with sodium bicarbonate or sodium carbonate. "Most people add only carbon dioxide in dissolved oxygen at this point," Stover explained. "There's a chemical relationship between carbon dioxide gas, bicarbonate, and the carbonate ion. The host rock typically contains calcium carbonate or sodium carbonate minerals." By adding the carbon dioxide, Stover said, "It will lower the PH of the solution just slightly." That enhances the solubility of the naturally occurring calcium carbonate." According to Stover and the other experts, the addition of carbon dioxide is an effective replacement for the previously added bicarbonate ion.


The Gurus of In Situ Leach Mining (ISL). Harry Anthony (left), Doug Norris (center) and Dennis Stover (right). Harry Anthony and Doug Norris lead the ISL engineering team for Uranium Energy Corp (OTC BB: URME) and Dennis Stover is the Chief Operating Officer of Energy Metals Corporation (TSX: EMC).

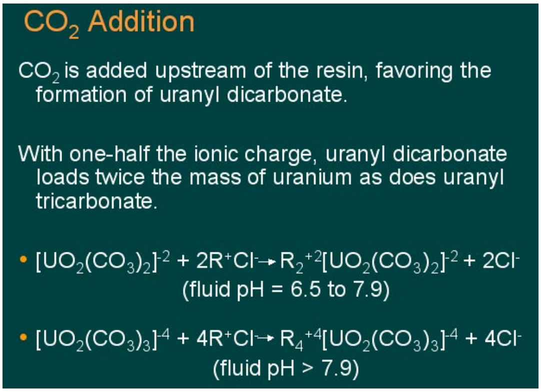
The goal is to get the uranium out of the sandstone and soluble. "We're accelerating Mother Nature and making the uranium soluble again," said Doug Norris, engineering manager for Uranium Energy. "When it's soluble, we can just pump it out of the ground. But it is dissolved in the water like salt in sea water. You can't see it, but it's there."

"Mining" the Uranium

ISL "mining" and processing the uranium is a very simple process. It's a water treatment plant with hundreds of water wells. There are two types of wells: injection and production. The water plus reagent (oxygen, carbon dioxide) is injected into the ground via water wells. Outside the United States, where environmental regulations may be less restrictive, an ISL's aquifer may be bombarded with harsh acid leaching. On Harry Anthony's engineering services website, he describes the process he observed in the Czech Republic, "Over 4,100,000 tons of H2SO4 (sulfuric acid), 270,000 tons of HNO3 (nitric acid), 100,000 tons of NH3 (ammonia), and 25,000 tons of HF (hydrofloric acid) were consumed by the mine."

It would be nearly impossible to get an ISL project permitted in the United States using these chemicals to leach the uranium. The water quality division, within a state's Department of Environmental Quality (DQE), demands restoration to background, which is about where the groundwater was before ISL mining began. "The less things you add, the less you have to reclaim at the end of the process," Doug Norris pointed out. "The more stuff you add trying to get it out of the ground, the more you have to clean up."

Dennis Stover explained how the fluids presently used came about, "Historically, most ISL operations had a great deal of difficulty with plugging or fouling of their injection wells due to the precipitation of excessive amounts of salts." He pointed out that the chemistry which miners were using in conventional milling operations didn't work in ISL mining. "Because they had very high concentrated salt solutions, they were trying to accelerate everything," Stover told us. "When you take those concentrated solutions and put them underground, Mother Nature is not always happy. Other salts that were present in the rock would dissolve, solutions would become supersaturated and they would precipitate out. The wells would plug up."



Norris explained that often you have to add a carbonate source, such as carbon dioxide "to stabilize the dissolved uranium as uranyl dicarbonate." Norris said, "The uranium is in a solid state in the ore, as Mother Nature left it. We oxidize it and turn it into uranyl dicarbonate." What goes to the processing plant is called lixiviate, the dissolved uranium in its ionic form. According to Anthony, "Today, most ISL mining operates at neutral pH, and the uranium is complexed as a dicarbonate."

Water is circulated through the injection wells with the expressed purpose of separating the uranium coating the sandstone. Each time you circulate the water through the orebody, you are capturing some of the uranium. Each pass-through is called a pore volume. "It's like filling up a bucket of sand with water," explained Anthony. "Once you have the bucket full of sand, you can still pour in water. The amount of water you can pour in until you just bring it up to the top of the sand is termed a 'pore volume.' Pore volume is the interspatial volume."

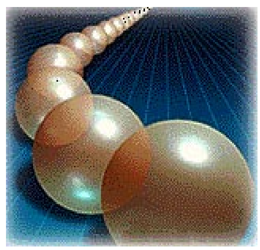
In Anthony's models for operating an economic ISL plant, he calculates 20 pore volumes (PV). Porosity, or the spaces in between the sand particles, where the water can travel (permeability), helps determine how much uranium can be recovered. "It takes about 20 PV to 30PV to recover the highest percentage," said David Miller, who was once Cogema's chief ISL geologist in the United States, before becoming President of Strathmore Minerals. "But, as the price of uranium keeps going higher, it may be economic to recover a higher percentage of the orebody. Maybe 40PV to 50PV will be possible with the direction the prices are moving. Of course, your average processed grade will go down. A few years ago, you would want to shut wells off at 15 parts per million (ppm), but now you might want to run them at 10ppm. At $50/pound uranium, you may be able to run at 7 or 8ppm."

Typically, an ISL operation should recover about 70 percent of the uranium in the ore, under the 20PV to 30PV scenario. However, in the case of the Czech Republic's Diamo project, once Europe's largest uranium mining operation, only 55 percent was recovered. Clearly, the more uranium recovered with the least number of pore volumes, the lower the operating costs. Trying to recover more uranium is only possible if you have the plant capacity. Because of the rising price of uranium, we would expect more companies to attempt to recover a higher percentage of uranium. Miller warns, however, "You will not make your production quota if your plant is 'sized' at a certain gallons per minutes at a certain grade to meet your annual production. If you lower the average grade and fail to increase your flow rate, your annual production will decrease."

ISL Extraction and Processing

During ISL mining, water is pumped to the surface from production wells that contain uranium in very low concentrations, on the order of parts per million concentrations. The next step in the ISL process is to extract the uranium dicarbonate. Extraction is done by chemically exchanging ions inside a processing facility. "The ion exchange process is very analogous to a home Culligan® water softener," Anthony revealed. "It removes hardness or calcium from the water by replacing it with sodium, using ion exchange resins. If you go to Lowe's or Home Depot, and buy a water softener, you basically have a home version of a uranium extraction plant." The main difference is your water softener will have a cation exchanger. "For a uranium plant to function properly, you need to use an anion exchange resin, which is specifically designed to load uranium," Anthony clarified.

And what is this magical "ion exchange resin"? The resin is comprised of little polymer beads, which are charged particles having an affinity for uranium anions. "There are literally millions of these small resin beads in a vessel, which can adsorb low concentration of uranium in solution," said Anthony. Adsorption is when something is attracted to something else or clings to it, like static electricity.



Millions of small polymer resin beads adsorb the uranium in solution.

Why do you have to process uranium like this? "In essence, the ion exchange process is a beneficiation (reduction) process that concentrates large volumes of low concentrate uranium solution into a much smaller volume containing a much higher concentration of uranium," said Anthony. In other words, the beneficiation is just concentrating the uranium from the large

Each 11.5 ft. ID ion exchange vessel contains 500 Ft3 resin. Three trains of vessels are installed. Each train consists of two vessels that are operated in series. Upon exiting the 2nd ion exchange vessel, the lixiviate is pressurized by the 2nd booster pump station, refortified with oxygen and injected into the Well Fields.

volume of water in which it is mined into a more compact form. The preferred means is through an ion exchange.

Anthony gave a real-life example of the beneficiation process, "Three million gallons of wellfield solution containing dilute concentrations of uranium, of 100 parts per million minus 0.10 grams/liter, is passed through a bed of ion exchange resin. This might take 24 hours to achieve if the solution is flowing at 2,500 gallons per minute. After this length of time, the resin becomes loaded with approximately 2,500 pounds of uranium."

Stripping the Uranium

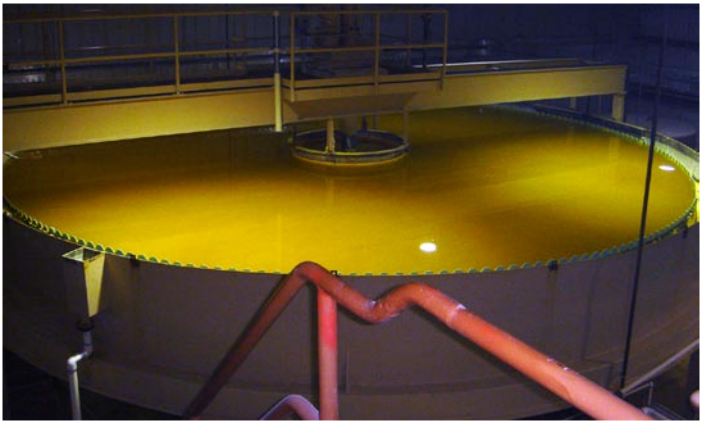
Stripping the uranium is called the elution process. This is done through a chemical exchange of positively and negatively charged ions. Resins are classified by the charge on the active sites. "The active sites on the resin are positively charged for anion resins and negatively charged for cation resins," Norris enlightened us. "The resin's ability to extract chemical ions from a solution is derived from what's called an active site," he continued. "In our case, chloride ions obtained from ordinary table salt are used to stabilize or temporarily neutralize this positively charged active site." The negatively charged chloride ion sticks to the positively charged site, held in place by what Norris called "electrostatic forces." When the negatively charged ions, such as uranyl dicarbonate, are placed in contact with the solution, it will kick off the chloride and replace that with the uranyl dicarbonate.

A three-staged elution circuit is used for uranium concentration that is required for precipitation of a yellowcake product. As an eluate batch advances forward and contacts a new resin bed, the uranium concentration in the batch is increased. Over 90% removal efficiency is achieved in the first elution step.

That was the chemistry lesson. Anthony summed it up in a nutshell, “They just displace it. There’s a greater affinity for the chloride ion to the resin than there is for the uranium. So, the uranium is stripped from the resin bed.” The processing facility chemically strips the loaded uranium from the resin by soaking the entire package of uranium-laden resin in a salt bath solution. “The volume of salt solution is on the order of 10,000 gallons resulting in a solution concentration of 30 grams/liter uranium,” Anthony said, describing the process of how the uranium becomes concentrated. “The stripped uranium solution concentration is magnified 300 times more than the wellfield solution,” he explained. “The concentration level can now be economically processed for recovery: precipitation, dewatering, drying and drumming for a nuclear facility.”

Getting the Uranium into the Drum

After the uranium has been removed from the solution, it is precipitated. At this point in the processing stage, you have yellowcake slurry. Up close, it looks like a sort of yellowish and wet, runny cement mixture. The dewatering process does just that, it removes the water from the yellowcake mixture.



The suspension of uranyl peroxide crystals is pumped to a cone-bottom thickener where the solids settle and concentrate. The liquid overflows the thickener and is routed to a Reverse Osmosis (R.O.) unit.

"I use a filter press, a device that is designed to separate solids from solutions," explained Anthony. Filter presses are extensively used in various types of food, chemical and drug processing across the world. "The uranium solids, now looking more like yellowcake, are retained in the filter press, where they can be washed and later air dried, before drying them to a powder with a low temperature vacuum dryer," said Anthony taking us step by step through this process.

So what is the filter press and how do you end up with the finished yellowcake when you're done? "It's a series of plates and hollow frames, or it could be a series of recessed chambers," Anthony answered. "Filter cloth is draped over the plates or chalked in the recessed chambers. The yellowcake slurry is pumped through the filter allowing the liquid phase to pass through the filter cloth, trapping the uranium oxide inside the device." Anthony likes to pack the filter press up with as much yellowcake as it can hold. "It is then washed with clean water to displace the chloride ions to a low level," Anthony explained. If you don't remove the chloride concentrations to the acceptable level required by a uranium enrichment facility, a small fine is assessed against that shipment.

Yellowcake slurry is pumped from the bottom of the thickener and routed to a recessed plate filter press where to solids are captured and dewatered. To meet the converter's specification, fresh water is used to flush dissolved contaminates from the filter cake. By using the filter press, the cake is flushed in plug-flow fashion. When compared to simple dilution that requires up to 110 pore volume, plug-flow washing reduces water requirements to 6 pore volumes. Once washed, typical dried yellowcake contains 200 to 300 PPM chloride, well within the converter's specification of 500 PPM.

Washed yellowcake is pumped to one of two rotary vacuum dryers. The slurry is dried under vacuums of up to 20 in. Hg for about 17 hours. The vacuum drier prevents the formation of insoluble uranium compounds in the final yellowcake product.

The final steps include conveying the yellowcake to the vacuum dryer. The uranium oxide's color depends on how high or low a temperature is used to dry the "yellowcake." Patrick Drummond, the Smith-Highland Ranch plant superintendent, showed us pure uranium oxide dried at high temperatures. It was nearly black. After the drying process is complete, the uranium is packaged up in DOE-approved 55 gallon drums and transported to an enrichment facility. After the final processing, the enriched uranium can finally be used to power a nuclear reactor and provide an inexpensive source of electricity.

Patrick Drummond,
Smith-Highland Ranch superintendent

Sheep are happy and healthy, grazing on the Smith-Highland Ranch Uranium In Situ Recovery facility. This contrast contradicts what environmentalists claim about the dangers of In Situ uranium mining posed to livestock.

Cleaning Up the Project

Not so fast. Shipping the uranium out of the ISL plant isn't the final step. The water has to be cleaned up, the property returned to its original condition. If done properly, then the footprint of the ISL uranium operation should have been nearly erased.

Why is restoring the water back to background important? "In the mining process, you're basically elevating sulfate," explained Anthony. "You're also elevating calcium because you're lowering the pH a little bit, down to 6.5 to 7. Because you run it across the ion exchange circuits, you get a little leakage of chlorides into the lixiviant." Subsequently, the water will have sulfate, chloride, calcium and bicarbonate circulating within it. "When you add carbon dioxide, you're forming bicarbonate," Anthony noted. "These are the major ion groups you are elevating during the mining process." He also added that in some projects, you may get arsenic, vanadium and/or selenium. "They all go into the solution so that at the end of your mining process, these ions will be elevated above their baseline values." The water will need to undergo a purification process to return them back to a quality consistent with baseline values."

What does the ISL operator do with the water once the facility has mined out the uranium? There are three options, which we discussed with Glenn Catchpole, who has also set up previous ISL operations. In 1996, Catchpole was the General Manager and Managing Director of the Inkai uranium solution mining project in Kazakhstan. "Here's my order of priority: If you have a receiver formation for deep disposal on your project, that's my first choice." Sometimes, a project may not have access to a deep disposal aquifer, warned Catchpole.

The water is sent down the receiver formation, down about 4000 feet. "You're usually sending this water to a formation that is very briny, a poorer quality than what you're sending down," Anthony pointed out. Another option, according to Catchpole, would be operations ponds, or evaporating ponds, where the water is evaporated. A third option is "land applied." Catchpole explained this was for land application. "You take your waste stream, you treat it to remove the certain level of impurities, according to the government requirement, and then you're allowed to disperse it on the land surface, as if you were irrigating." When applied to the land, it is soaking into the land. "It's growing grass, and it's going into the groundwater system," concluded Catchpole, "Whatever water quality standard they allow for you to put that water in the land, they want to ensure it doesn't accumulate some particular chemical over time that is going to build up and contaminate the land."

Generally, during the restoration process, the water is circulated through the barren orebody about eight times. It's another instance of pore volumes – eight more times through the sandstone formation. Anthony explained, "Normally, the first pore volume is evacuated and disposed of via a disposal well." But he warned, "This will cause an inflow of surrounding native water back into the mine zone. The resulting water is pumped to the surface and processed through a reverse osmosis unit." Anthony compared this to the desalination of seawater. "The reverse osmosis equipment acts like an 'ion filter,' allowing pure water to pass through a membrane and filtering out ions of sulfate, calcium, uranium, bicarbonate and so forth," Anthony explained.

Two streams of water are produced by the reverse osmosis unit. One stream is called "product water," and is normally consistent with drinking water quality. The smaller stream of water is called "brine." It contains, according to Anthony, "95 percent of all the dissolved ions that were in solution." He said, "The brine is disposed down a deep well into an underground formation, which is typically not suitable for any use."

Conclusion

For all the lip service and media attention paid to the environmental movement in terms of financial support, recognition and respect, it is the ISL miner who cares more about the environment and about preserving Mother Nature. Environmentalists remain ignorant of, or care not to publicize, the dangers of coal-fired electrical generation. Mining and burning coal to generate power for industry and residential electricity poses a greater threat to Mother Nature than ISL mining and nuclear power-generated electricity.

No more evident a case in point is New Mexico, where the Navajo Nation "banned" uranium mining, because their president was misled by environmentalists in believing ISL uranium mining could pose a threat to groundwater. At the same time, the Navajo Nation enjoys over $100 million in coal royalties each year, as their air is polluted by carcinogens filling their air from coal mining in the San Juan Basin and coal-fired plants, which produce most of their electricity. It is time for the world's environmentalist movements to wake up and smell the air they are breathing.

Unfortunately, ISL uranium mining will not replace conventional uranium mining in many deposits across the world.. "The overriding constraint of ISL is the technology is only applicable to selected uranium deposits," Stover cautioned. "It's those deposits wherein the uranium ore resides in a permeable environment, where you can flow water through the deposit and where you can bring the dissolved oxygen and carbon dioxide into contact with the uranium." Stover explained that, during the evolution of ISL mining, a number of projects failed because the uranium was associated with organic material, was not accessible to the leaching solution, or the uranium was tied up in clays or shale-like material. "They were not able to flow fluid through it," explained Stover. "The key issue at the onset is a careful characterization of the host environment in which the uranium exists."

The key advantage to ISL is the far lower capital costs to start up a project, compared to the hundreds of millions required for a conventional mining and mill complex. For example, UR-Energy's William Boberg and Uranerz Energy's Glenn Catchpole both believe they can install an ISL operation on their Wyoming properties for as little as $10 million. Labor costs are also less. Doug Norris pointed out, "In its heyday, the Highland mine probably had 4,000 working in it." By comparison, Cameco's Smith-Highland ranch in Wyoming may soon ramp up to nearly 100 employees. "We're talking about installing a centralized water treatment plant supported by a large number of water wells, typically completed with PVC," Stover explained. "That's in contrast with conventional mining, where you have extensive earth moving equipment, in the case of an open pit or extensive underground workings, and a more complicated, much larger processing plant."

In terms of environmental impact, ISL offers something sensible to the environmentalists. "ISL is much less intrusive, and it is short lived," Stover said, echoing the sentiments of all who have been involved in this type of uranium mining. "It's acceptance by the general public is much more favorable," he concluded.

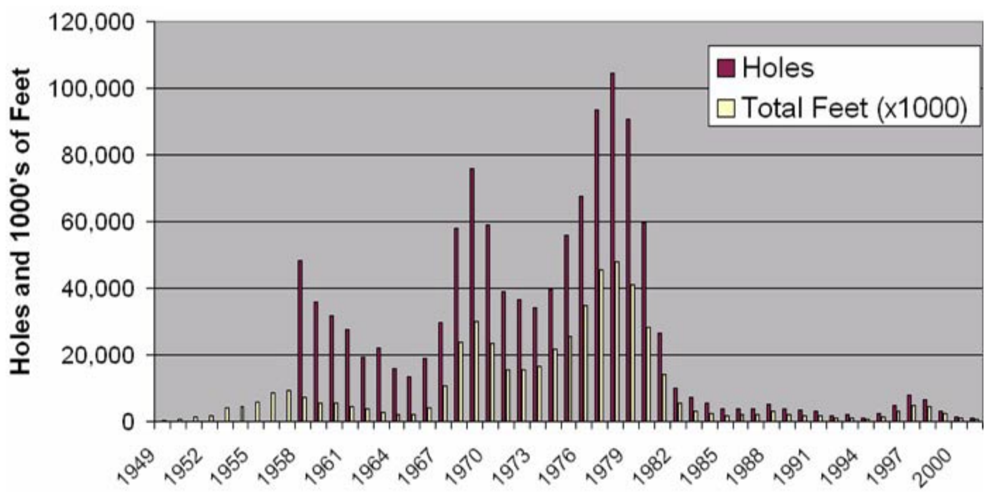
What does the future hold for ISL uranium mining in the United States? "Up until 2004, prices were flat," Norris pointed out. "The economic picture has just now switched to where mines can start coming on again."

ISL mining may be the wave of the future of U.S. uranium mining, or it may become an interim mining measure, in areas where the geology is appropriate for ISL. For the time being, U.S. utilities are confident in their existing supply chains for uranium inventory. As the "already mined uranium" becomes more difficult to obtain, more American utilities will turn to the new ISL uranium producers in Wyoming, Texas and New Mexico. ISL mining may remain the leading uranium mining method in the United States through the greater part of the Great Uranium Bull Market and possibly until the end of the second decade of this century. However, at some point, an overwhelming need for uranium for the nuclear fuel cycle may again put ISL mining in the backseat. In that not-too-distant future, uranium miners may return to conventional mining methods.

CHAPTER 4

The Hottest Mining Spots in the United States

Uranium Exploration US



The United States has experienced more than one-half billion feet of drilling over the past five decades. Numerous uranium deposits have been found and some have not yet been developed.

Sandstone formations host uranium deposits in Wyoming, New Mexico and Texas. Photo at right shows sandstone.

Sandstone deposits in the Western Cordillera region comprise the key uranium provinces in the United States. Wyoming, the Colorado Plateau (New Mexico-Utah-Arizona) and south Texas's Gulf Coast Plain are the three areas of interest. The Cordillera is a series of mountain ranges, stretching from Alaska to South America. In the United States, some of those mountain ranges include the Rocky Mountains, the Sierra Nevada and the Cascades. In South America, these become the Andes.

We mention these mountains because the Cordillera is the eastern half of the "Pacific Ring of Fire." This is a large zone of earthquakes and volcanic eruptions, stretching from New Zealand across Indonesia, the eastern parts of Asia, across the northern Pacific Ocean – from Japan to Alaska, and down the western coast of North and South America. About 90 percent of the world's earthquakes occur in this zone. The Ring of Fire behaves this way because of movement and collisions in the earth's crustal plates. The upheavals can also lead to mineral deposits. Most geologists first study plate tectonics to understand where they may discover a deposit.

The Western Cordillera hosts numerous uranium deposits.

Because of the massive exploration efforts by the United States government, through the 1940s and 1950s, to identify uranium deposits for military use, much of the grassroots work has been done. During the energy crisis of the 1970s, as American utilities were expanding the nuclear energy program, major oil companies further drilled and delineated uranium deposits in the key uranium provinces. More than fifty years of initial exploration and hundreds of millions of dollars in drilling and delineation drilling have minimized the risk for known uranium projects in the United States.

Here is why this is important. After all of this exploration work was done, and uranium resources were more clearly understood, the bottom fell out of the uranium market. Oil companies abandoned these projects, after having invested tens of millions of dollars. Three Mile Island brought U.S. nuclear energy expansion to a grinding halt. During the bottom of the depression in the uranium market, a small number of publicly traded companies snapped up these properties. Some acquired the drilling databases, which accompanied these properties. All the basic work had been done. Consequently, this provides an excellent opportunity for many uranium development companies to advance their projects to the operational stage.

Let's look at the three main areas for uranium development in the United States in the sections that follow: Wyoming, New Mexico and Texas. In a fourth quarter 2005 report by the Energy Information Administration (EIA), there were four operational ISL plants in the United States. Two were owned by Cameco: Crow Butte Resources (Nebraska) and Smith Ranch-Highland (Wyoming). Their operating capacities stood at one million and

U.S. Forward-Cost Uranium Reserves by State, December 31, 2003

State(s)	$30 per pound			$50 per pound		
	Ore (million tons)	Grade[a] (percent U3O8)	U3O8 (million pounds)	Ore (million tons)	Grade[a] (percent U3O8)	U3O8 (million pounds)
Wyoming	41	0.129	106	238	0.076	363
New Mexico	15	0.280	84	102	0.167	341
Arizona, Colorado, Utah	8	0.281	45	45	0.138	123
Texas	4	0.077	6	18	0.063	23
Otherb	6	0.199	24	21	0.094	40
Total	**74**	**0.178**	**265**	**424**	**0.105**	**890**

[a] Weighted average percent U3O8 per ton of ore.

[b] Includes California, Idaho, Nebraska, Nevada, North Dakota, Oregon, South Dakota, and Washington.

Notes: Uranium reserves that could be recovered as a byproduct of phosphate and copper mining are not included in this table. Reserves values in forward-cost categories are cumulative: that is, the quantity at each level of forward-cost includes all reserves at the lower costs. Totals may not equal sum of components because of independent rounding.

Sources: Estimated by Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, based on industry conferences; U.S. Department of Energy, Grand Junction Office, files; and Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey," Schedule A, Uranium Raw Material Activities (1984-2002) and Form EIA-851A, "Domestic Uranium Production Report" (2003).

two million pounds, respectively. Two companies in Texas, Mestena Uranium LLC (a private company) and Uranium Resources, a publicly traded company, also have ISL operations, which produce uranium.

The preceeding chart, provided by the United States Energy Information Administration, outlines the uranium reserves, the grade (or percent of uranium oxide) and the millions of pounds available at certain price points, state by state.

Assessing Wyoming's Potential

Wyoming is a High Plains state with basins and mountains.

Wyoming Governor Dave Freudenthal in his office during an interview with StockInterview

Wyoming presently offers the most pro-uranium mining environment in the United States. The state's Governor welcomes uranium miners with open arms, a state bureaucracy readily familiar and eager to do business with uranium miners, and a government infrastructure comprised of elected officials who have roots in uranium mining.

In late February 2006, we interviewed the Wyoming Governor about his opinion on the increased uranium mining activity in his state. Below are excerpts from this interview.

Wyoming Governor Dave Freudenthal really likes the current uranium bull market, "I hope the price of yellowcake stays up, and things get moving." Yes, the Wyoming Democratic governor strongly endorses uranium mining in his state. That would make sense because Wyoming is currently the largest U.S. uranium producer. More than 40 percent of the known available uranium reserves of the United States are located in Wyoming, according to the reserves and resource estimate published by the U.S. Energy Information Administration (EIA).

Unlike some states, where uranium mining is frowned upon or banned, Wyoming welcomes the industry with open arms. "We've always sort of been comfortable with the uranium industry," Freudenthal said. "The uranium industry is part of our history. It's not something that is frightening or alarming to us." Freudenthal clearly sees nuclear energy as a potential solution for the energy crisis, "I don't think anybody has any reservations that we need to have greater domestic capability in energy. I think, in the circles that worry about those equations, there is clearly a role for nuclear power."

Freudenthal urged the capital markets to act on the energy crisis by turning to Wyoming and mining the abundant supply of uranium, "There's got to be some clear signals to the capital markets that investment in this area will ultimately be rewarded. We certainly have the resource." Since June 2004, publicly traded junior uranium companies and speculators have created a staking frenzy in the state. Wyoming's Office of State Lands and Investments reported developers are snapping up tens of thousands of acres of state leases. The reading room, where prospectors and developers study potential federal lands for leasing purposes in the Cheyenne office of the U.S. Bureau of Land Management (BLM), was recently filled to capacity as many were reviewing claims for potential ground.

Wyoming Governor Dave Freudenthal

We asked if the unusually high level of staking activity in Wyoming by publicly traded companies, such as Strathmore Minerals (TSX: STM; Other OTC: STHJF), Energy Metals Corporation (TSX: EMC), Kilgore Minerals (TSX: KAU), UR-Energy (TSE: URE) and Uranerz Energy (OTC BB: URNZ), was merely speculative, Freudenthal responded, "I think we're past the sort of speculation of people running through and picking everything up. We're down to serious players trying to make serious decisions."

Freudenthal was optimistic more companies would bring their projects to Wyoming, "These are not light investments. But you also don't go out and re-activate uranium production, if at the end of the day, you don't have a buyer." When we informed him that decommissioned Russian nuclear warheads now powered about one in every twenty electric light bulbs in the United States, and that the swords-for-plowshares arrangement might end in 2013 (end of HEU), Freudenthal responded, "If that timing is correct, then they should already be making decisions to invest in Wyoming. I hope they do."

A large number of Canadian and European financiers believe there is a nuclear renaissance. Where does the Governor stand? "We're ready," Freudenthal shot back. "They just need to start bringing the projects and the money (into Wyoming). I think we have a very good regulatory climate. I think if they move into the 'in situ' (ISL) mining, we've got some experience with that." And if the public companies bring their projects to Wyoming, how does Governor Freudenthal feel? "This state is IN PLAY!" he exuberantly announced.

Asked to compare Wyoming with New Mexico, once a top uranium-producing state, he responded, "This state, historically, is just much more comfortable with commodity development." On the other hand, he somewhat deferred to New Mexico's own nuclear renaissance, where rumors are flying of a new nuclear power plant and the expansion of uranium mining and nuclear in that state. Freudenthal said, "New Mexico is closer to some larger energy consuming markets. They have fewer miles of transmission lines to build if they are going to get to California or Nevada. It wouldn't seem illogical if I were a private investor to look there first."

What does the Governor have to say to the new flock of uranium development companies, joining Cameco's Power Resources in mining Wyoming's uranium? There are several companies, which have staked land, and are now beginning to move their projects forward. Freudenthal advised, "They need to start allocating greater capital at a rate that the project sponsors are comfortable. We're past the speculators. People know it (uranium) is here. Nobody wants to hit the market too early. And they don't want to be too late. It'll move. I just don't know when. But when it does, we're in a position to respond to it. We've got the goods. We've got the right regulatory climate."

Would Governor Freudenthal invite or discourage a public utility in building a nuclear power plant in Wyoming? "I don't have a problem with one. The question really has always been, and most of what we are focused on, right now, is getting power lines built. If we don't have power lines, we're not going to get nuclear plants. We're not going to get coal-fired plants. We're not going to get anything. Ours is an export state. There is not enough internal demand for electricity to justify the construction of a plant."

Does Everyone in Wyoming Love Uranium?

While other states' politicians are wondering how to keep their voters employed, Wyoming's mining companies are scrambling to find workers for their projects. In late February 2006, we talked to Matt Grant, Assistant Director of the Wyoming Mining Association, who said, "The mining industry has at least 700 job openings right now." He added, "Those are direct jobs. If you include the service industry jobs, for which there is a ratio of three service industry jobs for every direct job, then the real number is closer to 2,800."

Wyoming Secretary of State Joseph Meyer

Grant explained that an unskilled worker could start tomorrow with an annual salary of $44,000. "A skilled electrician can make up to $100, 000 per year," Grant explained. Living in Wyoming isn't expensive, and of course, energy costs are somewhat lower. When we interviewed Grant, the Campbell County's Chamber of Commerce, the Casper Area Development company, and Sweetwater County's job recruiters are slugging it out to find laid off auto workers for the increasing number of job openings this state offers. As Wyoming's Secretary of State Joe Meyer told us, "If the companies are going to build uranium plants, tell them to bring their own workers. There's none here."

With a rising spot uranium price, and Wyoming "suddenly" becoming in vogue again, Wyoming politicians are celebrating. Grant re-iterated the oft-quoted uranium oxide (U3O8) figure for Wyoming's reserves: 300 million pounds at $50/pound. In the intriguing, and yet confusing, method in which the Energy Information Agency calculates ore body reserves for uranium, the higher the price of uranium, the more the reserves. It doesn't matter, though, because Wyoming has plenty of uranium.

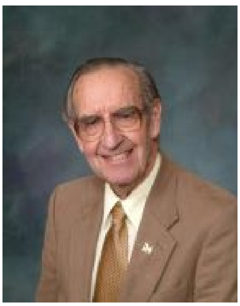
Wyoming's Political Pulse on Uranium Mining

Wyoming Representative Dave Edwards (center) said, "One of the best things we have in Converse County is the 'in situ' mining uranium operation." On the right, Norman Burmeister, CEO of Kilgore Minerals and (left) Wyoming Represenative David Miller, also president and chief operating officer of Strathmore Minerals discuss uranium development in Wyoming with Edwards.

State legislator, Dave Edwards, who represents Douglas, the nearest town to Cameco's Power Resources' operation at the Smith-Highland ranch, where uranium is ISL mined, remarked on the wild frenzy of staking for uranium claims in Wyoming, "We are already feeling the effects. It's good for the real estate market." But how does he feel about uranium mining for those who voted him into office? "It does provide high-quality jobs," he responded. "If there were no uranium mining, there would be a big impact."

Edwards, a former Navy pilot with more than 1,000 jet landings on aircraft carriers, during the Vietnam War, doesn't believe all the myths about the dangers of uranium mining, "I've not heard any talk from any of my constituents about how dangerous uranium mining is. I think people have common sense. I think people understand what nuclear power really is, and when properly taken care of, there is no need for hysteria. It's just not going to blow up anybody's brain or screw up any children. We're at that point in mining and using uranium."

That's quite a contrast from those who say "not in my backyard," as was sometimes heard by the less well educated in rural New Mexico, when talking about uranium mining. Edwards spoke frankly about the Smith Ranch uranium operation, "One of the best things in Converse County we have is the 'in situ' (ISL) mining uranium operation on the Smith Ranch. It's done by Power Resources, and they do a very nice job of it." Edwards has, from time to time, toured the Smith Ranch facility to inspect the uranium mining operation and gives Cameco the thumbs up, "The uranium metal never hits the air space. It is enclosed, virtually from the time it comes out of the ground until it is put in a barrel, loaded into a truck and hauled off."



Wyoming Senator Robert Peck

Senator Robert Peck, who represents the Riverton area, and also publishes the Riverton Ranger newspaper, is savvy to the uranium industry. One acquaintance told us it was Senator Peck's earlier successes in the uranium business that paid for his house and his nest egg. He believes there is still growth ahead for Wyoming's uranium industry. Responding to whether there is any uranium left in Wyoming after the massive extractions of the past 50 years, Peck answered, "There's lots left." He remarked upon Cameco's Power Resources subsidiary, "Their largest resource of their many holdings, around Wyoming, is in the Gas Hills. That was the center of uranium production for over a thirty year period. There were three uranium mills there and they still show 50 to 60 million pounds of recoverable uranium in the Gas Hills proven by previous drilling."

How does Peck envision the uranium industry in Wyoming playing out, over the next decade? "I think we are going to see three or four companies that are comfortable with, and knowledgeable about, uranium and nuclear power running the show in the uranium resurgence." He likes Cameco (NYSE: CCJ), that's for sure. "I see Cameco just becoming better and better positioned with uranium mining, and uranium fabrication of fuels. They are in the entire cycle, as well as having big operations in Kazakhstan, where they will be producing a significant amount of uranium there. In the mean time, they think they've got the best uranium reserves in Wyoming already with what they picked up during the down period, including the Gas Hills remaining reserves."

Peck also had kind words for Strathmore Minerals (TSX: STM). "Strathmore Minerals has got properties all around the country and the world, too, but they're not in production yet," Senator Peck said. "They are gathering capital and deciding where to best invest this capital, where it will have the best chance of a successful payoff. They're getting in from the ground up for uranium production."

Wyoming could become a relatively steady uranium producer, but it won't be the good old days. "We're not going to be up to where we were at the peak, when we produced 150 million pounds," Senator Peck admitted. "We're going to be up to 4 million pounds per year, which is going to make a solid, but significantly smaller industry. I don't think we're going to see the days when we used to have the greatest collection of Caterpillar scrapers in the world, out here moving millions of yards of dirt in the Gas Hills to go down 300 or 400 feet, to get to the roll fronts."

Senator Peck is very clear about his views on nuclear power, "I think the future of the nuclear industry is very bright. I see the utilities are gaining courage. We're going to see the next generation nuclear power stations stepping forward and getting permitted right alongside existing power plants, where people are used to them and comfortable with them." And what is his take on the spot uranium price? "We're seeing the emerging nations like India, China, Korea, and others looking to nuclear for a significant portion of their energy needs," he said.

Could Wyoming Rival Canada's Athabasca Basin or Australia's Northern Territories?

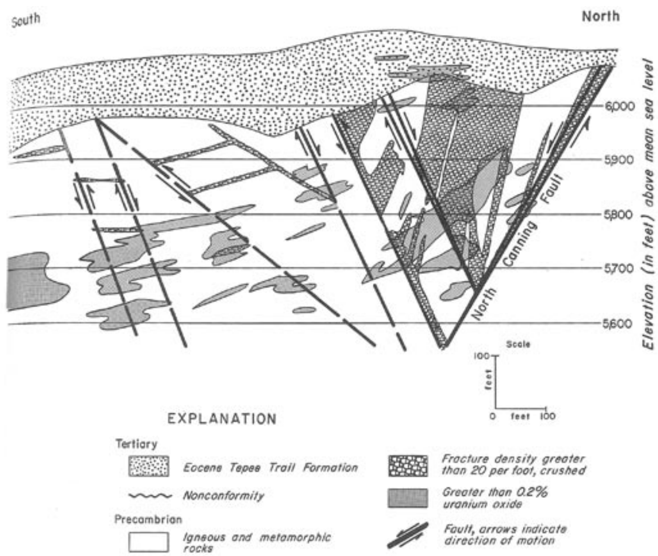
We talked to Ray E. Harris, before he passed away on March 7th. One of the gurus of Wyoming uranium, he shared his broad knowledge of Wyoming uranium exploration with us.

Ray Harris

After a stint as the chief metals geologist for Burlington Northern, Harris worked for nearly 25 years as the uranium geologist for the Wyoming Geological Association. He traveled the world, investigating and studying uranium deposits. He was well versed on the geology of every significant uranium deposit on earth and was also involved in the exploration, development and mining of uranium. In a ***Geological Survey of Wyoming Public Information Circular***, published in 1986, Ray Harris presented a unique, and possibly controversial, thesis, "The genesis of uranium deposits in Athabasca, Canada and Northern Australia – Wyoming exploration significance." In his introduction, Harris wrote: "Wyoming has some uranium occurrences in geological environments similar to those of Australia and the Athabasca Basin, and appears to have the potential for a uranium deposit similar in magnitude to those deposits."

A bold statement, indeed, and there will be geologists who would dispute Mr. Harris' theory. Perhaps there may be truth in Harris' claim. In 1981, E.S. Cheney published an article in ***American Scientist***, entitled "The Hunt for Giant Uranium Deposits," where he explained a giant deposit would contain more than 100 million pounds of recoverable U3O8. But can the parts amount to more than a single giant uranium deposit? William Boberg in his 1981 article, "Some Speculations on the Development of Central Wyoming as a Uranium Province," published in the ***Wyoming Geological Association Guidebook***, wrote, "The Wyoming Uranium Province consists of several uranium districts (Gas Hills, Shirley Basin, Crooks Gap, Red Desert, Powder River Basin and Black Hills) each of which is made up of a few to numerous individual uranium deposits.

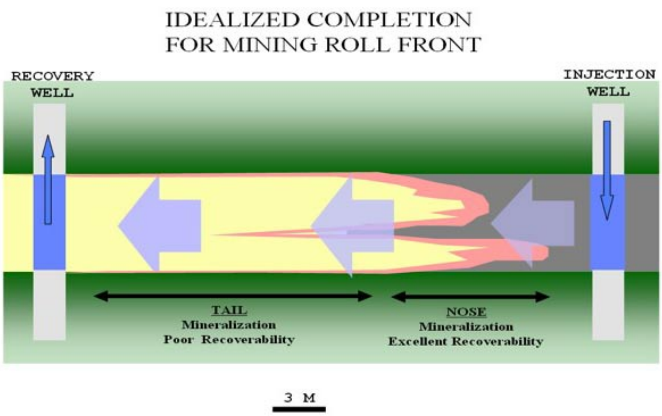
Ray Harris wrote in article, "There are no producing ore bodies in the United States similar to those of the Athabasca Basin and Northern Australia, but two deposits, not currently being mined, may be of similar genesis. These are the deposits near Chatham, Pittsylvania County, Virginia, and at Copper Mountain, Fremont County, Wyoming."



Schematic cross section, North Canning area, Copper Mountain, Fremont County, Wyoming. (After Yellich and others, 1978.)

Harris cited the Chatham, Virginia uranium deposit, grading four pounds per ton of ore, and which he believed might contain 30 million pounds of uranium oxide. He wrote, "... the setting is similar to non-conformity uranium deposits... on first glance, it seems to have formed similarly to the Athabasca and Northern Australian deposits." The Virginia legislature voted to ban uranium mining, which has set back mining this deposit. That is certainly not the case in mining-friendly Wyoming, where Copper Mountain is located. According to the Strathmore Minerals website, the company's Copper Mountain property, previously drilled by Anaconda Uranium Corp through 1997, lists an historical contained resource of more than 38 million pounds of U3O8. Strathmore has neither done sufficient work to verify this resource estimate, nor to confirm a similar genesis to the Athabasca Basin deposits.

Wyoming's Roll Front Uranium Deposits



Courtesy David R Miller

It is known that Wyoming has a very large number of roll front uranium deposits in its sandstones. Ongoing development could make Wyoming the U.S. center for in situ leach mining (ISL). However, as Ray Harris had suggested during our interview there may be a larger uranium source, possibly one that may be competitive with Athabasca Basin or Northern Australia. It is a premise he had argued in the 1980s, in the previously quote work, and again in 1993, Harris' paper, entitled "Geological classification and origin of radioactive mineralization in Wyoming."

In his 1986 work, Harris concluded, "Given the impressive length of exposure, the relatively shallow subcrop depths of favorable nonconformities in Wyoming, and the great amounts of uranium available for mobilization, a nonconformity-related uranium deposit should exist somewhere in Wyoming." One possibility, as Harris suggested, may be in Fremont County's Copper Mountain area. Harris wrote that at the Copper Mountain area, "Uranium occurs in fractured and faulted Precambrian rocks and in the nonconformably overlying Eocene Tepee Trail Formation. The uranium occurrence is subeconomic but of promising grade and size." He added, "The uranium is spatially related to fractures and subsidiary faults associated with the Laramide North Canning fault. Rocky Mountain Energy Company has conducted detailed drilling on the North Canning deposit."

Harris explained that mineralization occurs in the Precambrian granite and enclosed metasediments. The mineralization is said to be primarily low-temperature pitchblende and coffinite. Harris compared the North Canning deposit to nonconformity- related uranium deposits. He wrote, "It is likely that the deposit formed by processes similar to those that operated in the Athabasca and Northern Australian regions." Strathmore Minerals' David Miller told us his company, "owned all the federal minerals in the area that covered uranium mineralization: about 75 percent of the gross uranium resources. The Canning Deposit is owned about 60 percent by us and 40 percent by Neutron. Strathmore Minerals has around 100 mining claims in the area."

Source of the Roll Front Deposits

The source of Wyoming's roll front uranium deposits are open to debate and have yet to be completely clarified. In 1981, William Boberg wrote, "The major deposits of Wyoming occur in the Lower Cretaceous Inyan Kara Group of the Black Hills, in the Paleocene Fort Union Formation in the Powder River Basin, in correlative Eocene sandstones in all of the major uranium districts." Warren Finch later described Wyoming's roll-fronts, in his previously quoted work, "The predominant type of uranium deposit is the roll-front sandstone deposit in Tertiary continental fluvial basis developed between uplifts. These ore deposits were formed by oxidizing uranium-bearing ground waters that entered the host sandstone from the edges of the basins. Two possible sources of the uranium were (1) uraniferous Precambrian granite that provided sediment for the host sandstone and (2) overlying Oligocene volcanic ash sediments."

Ray Harris appeared to lean more toward the former. William Boberg has argued more toward the latter explanation for a uranium source. Boberg wrote, "It appears that currently available evidence is in support of a hypothesis calling for combined sources of Precambrian granites and volcanic ash falls which produce a unique, uranium-rich, ore-forming liquid that invades very porous and permeable young sediments to form large altered tongues and discrete deposits in a geologically short period of mineralization." It has been calculated that a typical altered "tongue" would take 700,000 years to form; a typical roll-front uranium deposit could be formed over 50,000 years.

Boberg speculated it was the numerous and extensive uranium-enriched ash falls from Middle Eocene volcanism, which were responsible for these deposits. He wrote, "Of greatest importance is the fact that a series of volcanic events from a variety of extrusive centers began about 50 million years ago generating tremendous volumes of ash, which was distributed across Wyoming and adjacent states for greater than a 40-million year span of time."

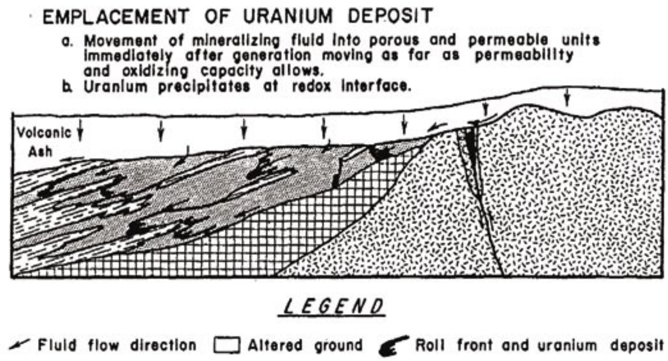
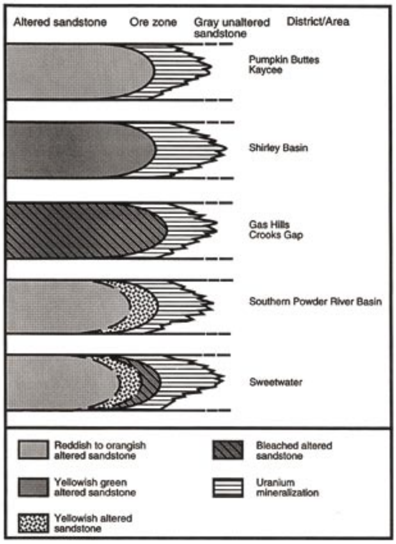


Illustration excerpted from Boberg's article,
"Some Speculations on the Development of Central Wyoming as a Uranium Province"

Boberg's explanation of the volcanic ash provided a valuable insight into how Wyoming's uranium deposits were formed:

> *"The volcanic ash, when flushed by the first rainfall, produced a unique fluid, which was acidic and charged with ions. The chemical reaction of the buffering on this fluid on contact with the Precambrian granites, the ash and other rocks brought the pH back to approximately neutral but leached additional uranium from the granites and probably the ash. The high rainfall and climate assured a steady supply of dissolved oxygen to the fluid resulting in the formation of a unique, oxidizing, uranium-enriched fluid, which entered the unconsolidated, reduced sediments oxidizing them and carrying the uranium to the eventual maximum extent of oxidation."*

Boberg explained the development of the roll-fronts, writing, "Fluid flow through the very porous and permeable sediments would be relatively fast allowing for the development of large oxidized tongues with the young sediment as well as scattered uranium



The different compositions of roll-fronts in each of Wyoming's uranium districts or areas.

deposits at the redox (oxidized reduction) interface within approximately a million years. Deposits formed near the granitic highlands would be larger and of higher average grade because of the proximity to the dual source of granite and ash."

J.D. Love's uranium discovery in Tertiary sandstones, in 1951, was a near-surface roll-front type of redox deposit. A roll-front deposit follows a sinuous linear trend, often C-shaped. Colorado and Utah miners began calling the cross-sectional configuration a "roll" in the early 1940's. Roll-fronts occur in sandstones, bordered above and below by less permeable shales. In Wyoming, the "rolls" are bordered by altered and unaltered sandstone. It is generally concave from altered ground and convex into unaltered ground. Harris' idealized roll-front uranium deposit would have "uranium concentrations decrease abruptly away from the concave boundary, and concentrations gradually decrease away from the convex boundary in reduced rock."

Uranium is not always present everywhere along a roll front. It may be unevenly distributed and there are often other elements, such as vanadium, selenium, molybdenum, copper, silver, lead and zinc. Geologists look for where coarse-grained sandstones grade into finer grained or clay-bearing equivalents as indicators for uranium ore. As uranium geologists know with roll-front deposits, it may be mined as long as it is below the water table. Once deposits are brought above the water table, the uranium concentration can be eroded and severely modified.

It is not the roll-front uranium deposits, which interested Harris, but the tabular redox uranium occurrences found in many parts of Wyoming. He found those most prominently in the Cretaceous Inyan Kara Group in the Black Hills. Harris explained, "The uranium mines in New Mexico and many other parts of the Colorado Plateau are also tabular deposits." The tabular bodies, Harris noted, describe their irregular tabular form, and are found parallel to bedding, dissimilar to roll-front mineralization, which crosses bedding. Harris believed some of the tabular bodies in Tertiary rocks were "the limbs and detached limbs of roll fronts left in less permeable rocks at fluvial channel margins." He also said that tabular bodies could be preserved in oxidized rock due to high concentrations of other rock, such as coal or pyrite.

In any event, Harris agreed with other geologists that Wyoming is a uranium province with uranium occurring in nearly all major time divisions in the state. He concluded, "Uranium was available for mobilization during every major weathering period related to the nonconformities." In our final minutes together, he was convinced that many of the uranium development companies should sink more funds into exploration and find the elephant uranium deposits, which he pointed out in three different areas of Wyoming. To his way of thinking, this would be more exciting than the simple ISL extraction of uranium from previously drilled areas. As with others we interviewed, few of those areas will hold surprises. Instead, those already drilled properties offer the opportunity for steady, cash-producing uranium extraction which can help develop budding companies. Mined uranium is what U.S. utilities, and utilities from other countries, are eagerly seeking right now. Wyoming uranium could fuel many of the U.S. nuclear reactors as more companies commence ISL uranium operations.

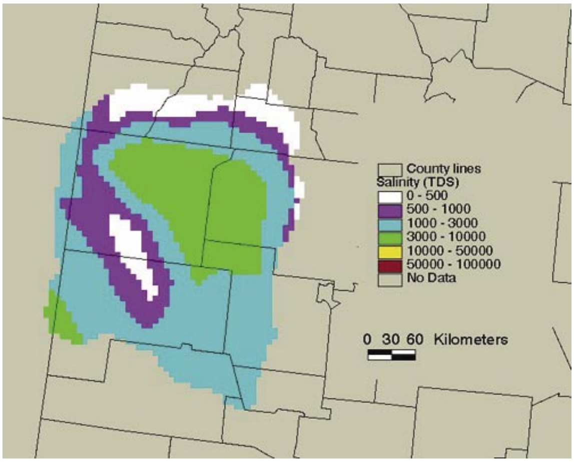
Assessing New Mexico's Potential

NASA Satellite Map of New Mexico

New Mexico's published uranium reserves are less than the resource found in Wyoming. But, the average uranium grades are more than double of those in Wyoming. Why is that important? Uranium development companies will be able to more economically extract a larger quantity of U3O8. More uranium can be extracted from New Mexico properties at a lower operating cost in several cases.

The Grants and Shiprock uranium districts in the San Juan Basin host the most important New Mexico uranium deposits. Sandstone within the Morrison Formation (Jurassic) holds these uranium deposits, and they can be extracted through the environmentally safe ISL method. These immature and tuffaceous sandstones have the potential to react with high-CO2 brine. The framework grains of the coarser grained sandstone in the Westwater Canyon area are mainly comprised of quartz and lithic fragments. The finer grained sandstone beds are comprised mainly of mudstone and rare limestone nodules and lenses. A 1987 study noted the water is typically either a sodium chloride, with 35 grams per liter, or calcium bicarbonate type, with less than 2 grams per liter.

The last uranium company to have produced uranium in New Mexico was Rio Algom Mining, which ceased operations in December 2002. They extracted about 18,400 pounds of uranium from waters recovered from the inactive underground operations at Ambrosia Lake, near Grants, New Mexico. Since then, only two companies have made serious



New Mexico's environmentalists have argued their water is "pure" in the San Juan Basin, while U.S. Geologic Survey hydrologic investigations show otherwise. The water is heavily salted, briny, and certainly not pure.

progress toward developing uranium operations in New Mexico: Uranium Resources and Strathmore Minerals. Both plan, and are moving forward with, ISL uranium mining in northwestern New Mexico. Both have reported they are planning to commence operations during the current uranium bull market.

In sharp contrast to mining-friendly Wyoming, New Mexico currently has issues with uranium mining. A few scattered environmentalist groups have lobbied several liberal corporations and foundations for funding. The zealotry found with such groups tends to raise the local temperatures on the subject of uranium mining. For example, one such group aggressively solicited a few politicians within the Navajo Nation about uranium mining. Their decade-long efforts persuaded the current Navajo Nation president to promote a ban uranium mining on sovereign Navajo lands. The Navajo ban occurred in 2005, but hasn't impacted the rest of New Mexico. As a result, the political sentiment is mixed. Each month, however, political sentiment appears to be leaning in favor of uranium mining.

From neighboring Arizona, a state in which the Navajo have their nation's reservation headquarters, senior U.S. Senator John McCain from that state, told Fox News television in January 2006, "We've got to get quickly on a track to energy independence from foreign oil, and that means, among other things, going back to nuclear power."

U.S. Sen. Pete Domenici (R-NM) invited Louisiana Enrichment Services (LES) to build a gas-centrifuge uranium enrichment facility near Eunice, New Mexico. The facility is currently undergoing the permitting process. An international consortium reportedly plans to build a $1.2 billion plant near the Texas-New Mexico border. This would provide up to 400 jobs during the construction phase and about 250 jobs when it becomes operational.

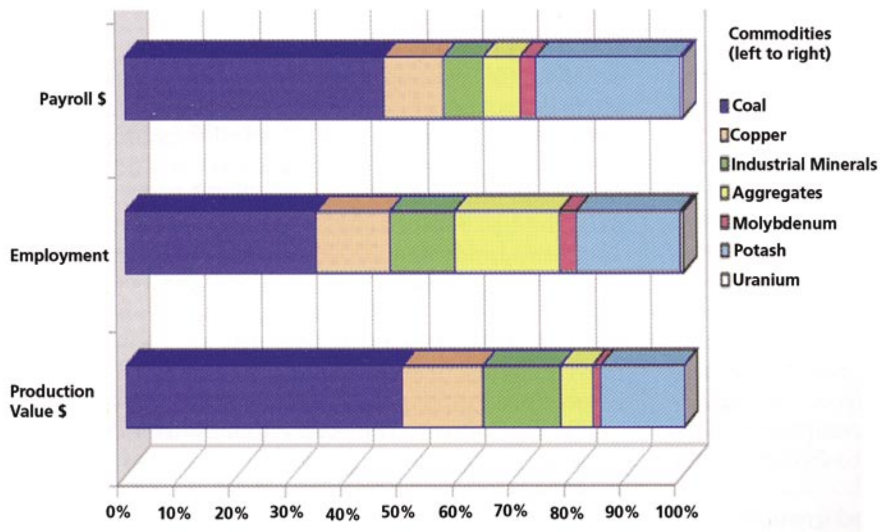
New Mexico is primed for a uranium revival through the widely popular In Situ Recovery method. In a conversation, in November 2005, with Grants Chamber of Commerce and Mining Museum employee Barbara Hahn, a deep resentment resounded in her voice when talking about the collapse of the uranium mining business in the 1980s. Grants, New Mexico was a boom town, during the 1970s uranium boom, when spot uranium prices climbed, and stayed above $40/pound.

"Grants replaced the lost mining jobs by opening prisons," she told us. "Now, others bring us their prisoners." Ms. Hahn believed only 35 percent of the uranium had been extracted from the Grants Mineral Belt. "Most of it is still there," she added. According to a McLemore and Chenoweth geological report, a resource of 558 million pounds (279,000 short tons) might still be extracted.

"The geology for this area, with regards to In Situ uranium operations, could help make New Mexico an important supplier to U.S. utilities, possibly before the end of this decade," Strathmore's David Miller explained. "I would not be surprised at all if there were more uranium to be found in New Mexico than is currently estimated. That's why companies have exploration programs." From a state, which has produced over 300 million pounds of uranium, and which may have between 300 million and 600 million additional pounds of uranium, New Mexico will be a prime target for uranium companies as long as the price of uranium continues to rise.

Hypocrisy of the Environmentalists

Percentage of New Mexcio's production by value, employment, payroll and revenue generated by commodity (calendar year 2002 statistics).



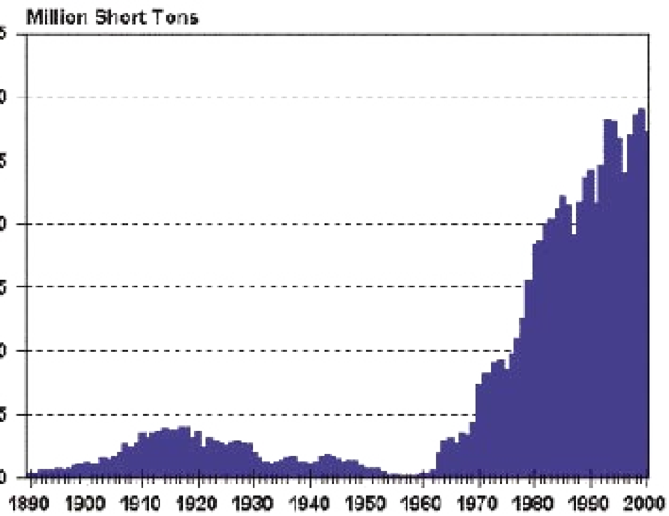
Coal mining rules the haven of environmentalist, New Mexico.

The environmental issue needs to be addressed, but few which to debate the obvious contradiction. Why is coal mining such a wonderful activity while uranium mining invokes the devil for the current Navajo Nation's President? New Mexico's environmentalists appear to turn a blind eye to the dangers of coal mining and coal-fired plants. Both the Navajo and the local environmentalists are surrounded by coal mining activity in New Mexico, yet rarely a word is uttered on the toxicity of coal, both in the mining process and in its use.

According to the Harvard School of Public Health, about 2400 people die every year from the air pollution caused from each million tons of sulfur dioxide emitted. In 1999, it was estimated that over 1.05 billion tons were produced, releasing 11.856 million tons of sulfur oxides and more than 5 million tons of nitrous oxides. While visiting one very vocal (and well-funded) anti-nuclear activist group's headquarters in New Mexico, we found no anti-coal mining literature.

Environmental activists have scant fund-raising interest to close down New Mexico's large coal mines. In fact, more U.S. coal mining deaths were reported in 2005 than deaths from uranium mining (zero). The environmentalists appeared unconcerned about the Black Lung, a direct results of coal mining and which blackens the lungs of of coal miners. Talk about uranium and you'll get your ear chewed off about the radon gas emitted from uranium mining. While uranium mining in New Mexico came to a standstill about twenty years ago, coal mining continues full steam ahead in this state, as it has for seven decades.

Historical Coal Production



Coal is King in New Mexico. Source: EIA.

Don't expect the coal mines of New Mexico to be closed any time soon. No matter how deadly coal mines are, coal production is irreplaceable at this time. According to the New Mexico Bureau of Geology and Mineral Resources, tax revenues from coal in 2001 exceeded $30 million. Nearly one-half of the New Mexico's energy needs are met through coal-generated power. The coal industry employed 1,800 people in 2001. New Mexico is the country's leader for methane gas production from coal beds. Coal is the state's third largest source of revenues. Doesn't that make you wonder about whose side the "environmentalists" are really on?

Navajo Double Standards on Uranium?

The Navajo power plant: a coal-fired, electric-power-generation plant near Page, Arizona (USGS)

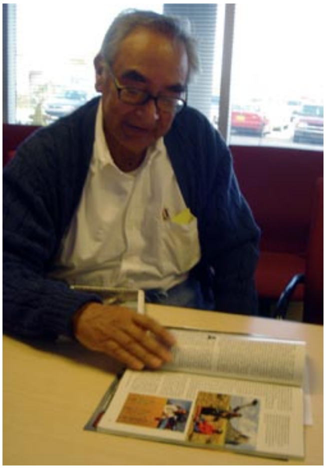
An EPA Toxic Release Inventory report published in 2000 reported that two power plants and their coal mines in New Mexico's San Juan County released 13 million pounds of chemical toxins into the Four Corner's area (New Mexico, Arizona, Utah and Colorado). Four Corners is the heart of the Navajo Nation. It was also reported that 6.5 million tons of solid waste was buried by the two San Juan County power plants on their sites or at nearby coal mines. Those airborne toxins were miniscule compared to over 300 million pounds of other emissions, such as particulates and nitrogen dioxide released into the air, and which can travel for hundreds of miles. Reports confirmed those power plants were among the worst polluters in the United States. The eighth worst emitter, at the time, was Giant Refining, about 17 miles from Gallup, New Mexico, which emitted 608,000 pounds according to the EPA report. Any visitor to the Gallup area can readily smell the stench circulating in the air.

Why haven't the Navajo banned coal mining on the reservation as they have uranium mining? According to Anna Frazier, a Navajo affiliated with a local environmental group, "Our Navajo Nation is certainly not going to do that. They would rather have the revenues coming in from the coal companies and the power plants." According to a news report published in ***Indian Country*** newspaper, "The Navajo Nation receives the bulk of its annual $100 million operating expenses from royalties, leases and taxes from its coal, oil and gas. These revenues provide operational expenses for the tribal government, including the salaries of the 88-member Navajo Nation Council, the tribe's annual budgets show."

For more than 35 years, Peabody Energy has operated massive mines on Navajo territory. The closure of one such coal mine, the Black Mesa, sent the Navajos rushing for their

Maalox. Ironically, it was out-of-state environmental activists who forced Southern California Edison to close their Mojave Generating Station nearly 300 miles away in Laughlin, Nevada. The utility was given a choice: cough up $1 billion to stop polluting the Grand Canyon or shut it down. It had been called "one of the dirtiest coal plants in the West," and air emissions from that plant reportedly polluted half a dozen other national parks in the Southwest. But, that coal mine provided about 15 percent of the Navajo's annual budget. George Hardeen, the current Navajo president's media voice, complained about the mine closing in late 2005, "This is going to have a terrible effect on this entire region because the Navajo economy is so fragile."

John Dougherty complained about the Navajo Nation's tactics in the ***Phoenix New Times*** newspaper in March 2005, observing, "Environmental groups have long exploited the Native American tradition of sacred places to fight their battles to preserve wilderness areas...It's always the soulful Native American who steps forward as the high priest of sacred geography. In the background lurks the environmentalist equipped with charts and data on tree-trunk diameters and spotted-owl nesting sites." Dougherty concluded, "The cries of environmental destruction and cultural murder from Navajo and Hopi leaders ring hollow."



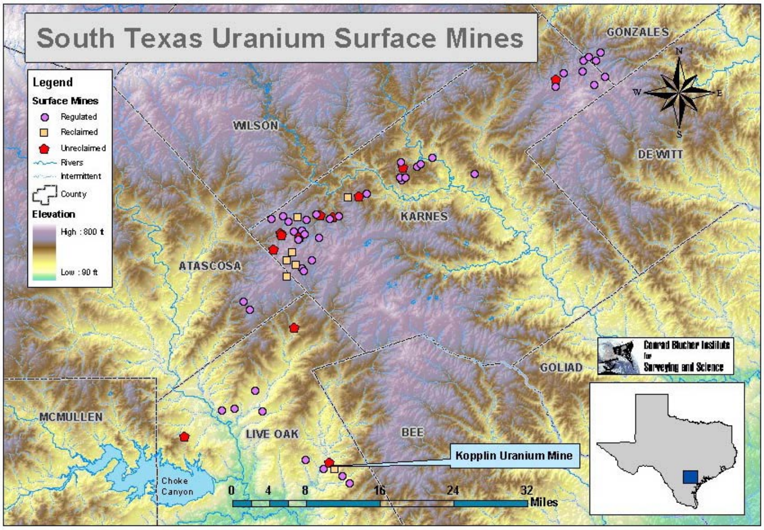
Fred Begay, Navajo and Nuclear Physicist at Los Alamos National Laboratory (StockInterview.com, November 2005)

On Navajo reservation land and just in New Mexico alone, Joe Shirley Jr may control more than 75 million pounds of uranium, with a gross value presently exceeding $2.7 billion. Some say this number could run much higher, into the hundreds of millions of pounds. Don't expect Mr. Shirley to over turn his ban on uranium any time soon. Dr. Fred Begay, a Navajo and nuclear physicist at Los Alamos, whose highly respected career has been featured on BBC Television and in the pages of National Geographic, and celebrated by the New York Academy of Sciences, explained the problem, "The Navajo don't get it. They think that they'll have miners. They have illiteracy on mining and uranium." Dr. Begay clarified that the Navajo have failed to differentiate between conventional uranium mining and ISL operations, which he considers safe, "They think that miners are going in there and digging it out."

New Mexico Conclusion

New Mexico could become a significant uranium producer again. Against a global perspective in the context of cumulative worldwide uranium production, New Mexico was one of the world's leading uranium producers. The Grants Uranium District is one of the premier uranium districts in the world, having produced over 340 million pounds of uranium. Between 1948 and 2000, the Grants district produced 97 percent of New Mexico's uranium, and more than 30 percent of the uranium mined in the United States. There are few regions in the world which can boast such prodigious production.

Assessing Texas' Potential



Texas doesn't have a lot of uranium reserves. The grades are among the lowest in the United States, of states in which uranium is mined. Since the 1960s, the state of Texas has only produced about 76 million pounds or U308. With an average of less than 2 million pounds per year over four decades, the state might never become a major producer.

Texas is an easy place, however, to start a low-cost In Situ operation. Uranium Resources (URI) has been the longest lasting ISL player in Texas, having produced uranium in this state for two decades. Now URI is expanding into New Mexico. Why? We believe it is because the grades are higher and their opportunity is better.

New uranium development companies, such as Energy Metals, Uranium Energy and perhaps others, hope to launch their initial operations in Texas. But, Energy Metals hopes to expand into Wyoming and New Mexico within this decade.

Unlike other mining states, encumbered by state departments of environmental quality (some of which have closet activists within them), Texas is blessed with the Railroad Commission. Through a convoluted political evolution, the Texas Railroad Commission regulates uranium mining. It also regulates the oil and gas industry, gas utilities, surface coal mining, pipeline safety, and other related safety issues. Established by the Texas legislature in 1891, this commission is the state's oldest regulatory agency. For our purposes, it oversees the uranium permitting process. Since 1894, all three members of this commission have been elected officials. I ronically, railroads are no longer regulated by the Railroad Commission. A number of uranium industry insiders told us, "The Railroad Commission makes it easy to set up an ISL operation in Texas."

Just as Paddy Martinez, a Navajo shepherd, set off a mining rush for uranium with his discovery in New Mexico, and J. D. Love, a Wyoming geologist, did the same for the Powder River Basin, Clarence Ewers launched a scramble for mineral leases after his 1954 discovery of uranium in the sandstone rock exposures of the Texas Coastal Plain area. There were several uranium leaching operations in Texas, in the mid to late 1960's following Wyoming's successes with ISL. These were followed by larger scale ISL operations in the 1970s.

Uranium mineralization is found in the Catahoula Formation of the Oligocene age, in a coastal-plain fluvial system. Each uranium district has a name. In Texas, it is the Karnes uranium district. It is located at the northern end of the South Texas Gulf Coastal Plain. The Catahoula Formation consists of porous sandstone comprised of volcanic ash. These sandstones were deposited in river channels and inter-channel areas on the original flood plain. The region has numerous faults, which are commonly marked at the surface by tall siliceous knobs. It is in the major growth fault zones, roughly parallel to the south Texas coastline, where geologists have found oil, gas and uranium deposits. Uranium mineralization appears to found at the fault hinge lines.

Exposure of roll-front in south Texas uranium mine. Light tan oxidized zone surrounded in C-shape of uranium ore zone. Reddish sands at bottom are rich in molybdenum.

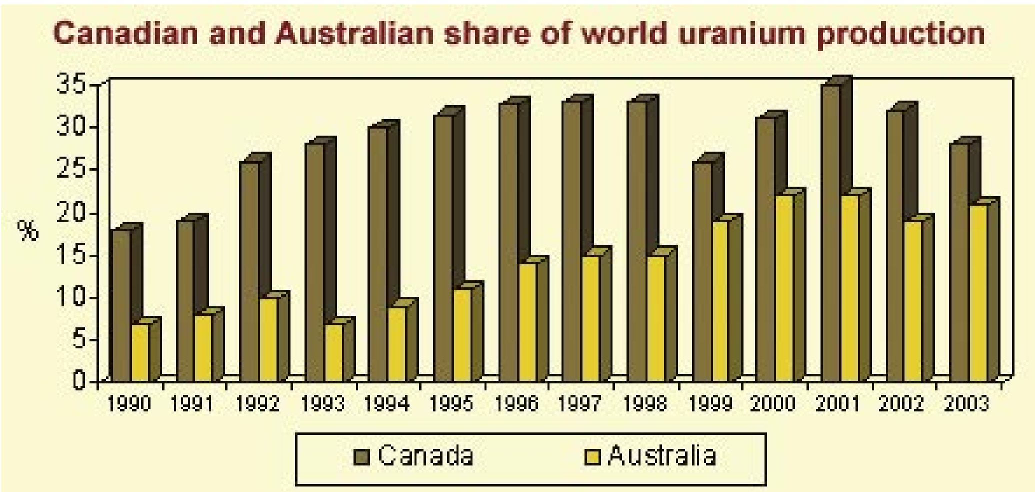
Texas may enjoy a brief mining renaissance through the year 2020, during this current bull market. Its recoverable uranium reserves, at 23 million pounds with $50/pound uranium, could be "mined out" by then, if there is widespread interest to start ISL operations in that state.

Conclusion

Other states may also share in the uranium bull market. Prospective candidates include Utah, Arizona, Nevada and (possibly) Montana. For the rest of this decade, the primary players will be mining in New Mexico and Wyoming. To a lesser extent, other states could become important uranium producers, depending upon market conditions.

CHAPTER 5

World Uranium Assets



The world's two top uranium producers.
More than one-half of the world's uranium production comes from these two countries.

Most of the uranium consumed by U.S. utilities comes from outside the United States. Since the boom and bust cycles of the 1950s and 1970s, the U.S. uranium industry has only recently begun to emerge from its twenty-plus years of economic depression. During that time, it was a buyer's market for American utilities. Low-cost production from Canada made it tough for domestic uranium companies. Grades found in Canada's Athabasca Basin were very rich and plentiful. Canada is currently the number one uranium mining center in the world, and should remain in the top ranking for decades to come.

As you can see from the chart below, there are five countries (aside from Russia), which merit consideration: Canada, Australia, Kazakhstan, Niger and Namibia. Countries with the world's highest percentage of known recoverable uranium reserves are: Australia (34 percent), Kazakhstan (20 percent) and Canada (14 percent). By contrast, the United States reportedly holds about three percent of the world's total reserves.

Country	2001	2002	2003	2004
Canada	12 520	11 604	10 457	11 597
Australia	7756	6854	7572	8982
Kazakhstan	2050	2800	3300	3719
Niger	2920	3075	3143	3282
Russa (est)	2500	2900	3150	3200
Namibia	2239	2333	2036	3038
Uzbekistan	1962	1860	1598	2016
USA	1011	919	779	846
Ukraine (est)	750	800	800	800
South Africa	873	824	758	755
China (est)	655	730	750	750
Czech Repub.	456	465	452	412
Brazil	58	270	310	300
India (est)	230	230	230	230
Germany	27	212	150	150
Romania (est)	85	90	90	90
Pakistan (est)	46	38	45	45
Spain	30	37	0	0
France	195	20	0	7
Portugal	3	2	0	0
Total world	36 366	36 063	35 613	40 219
	(42 886 t U3O8)	(42 529 t U3O8)	(41 998 t U3O8)	(47 430 t U3O8)

Canada leads the world in uranium mining, producing about 29 percent annually. With the world's largest proven uranium reserves, Australia produces about 21 percent of the world's uranium mining.

We'll review the top five countries in this chapter. Some uranium "watchers" might complain that we've excluded Mongolia and others. We are aware of developments in such countries, but were hesitant to include them in this chapter. Perhaps others will be included in a later version of this publication.

Canada

Since World War II, Canada has been an active uranium producer and a supplier to the United States, whether to the federal government, during the early years of atomic energy, or later to U.S. utilities. Canada's crown corporation, El Dorado Mining, helped play a significant role in the expansion of America's nuclear energy programs. It was later merged with Saskatchewan's provincially owned mining development company to form the world's largest uranium producer, Cameco Corp. (Canada also has an active nuclear energy program and is planning to expand it.) The world's top ten uranium mines produce nearly 70 percent of the world's total. More than 40 percent of this production comes from three Canadian mines found in the Athabasca Basin in northern Saskatchewan. See table on following page.

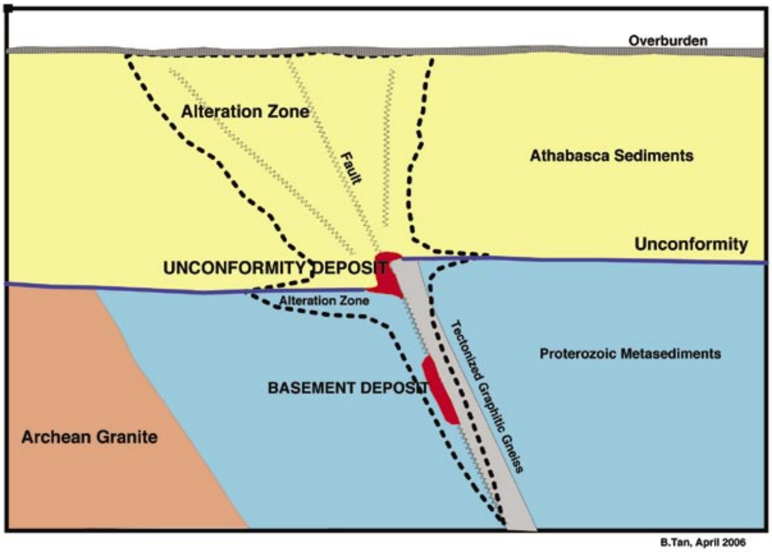
The World's Largest Producing Uranium Mines

Mine	Country	Main owner	Type	Production	% of world
McArthur River	Canada	Cameco	underground	7200	17.9
Ranger	Australia	ERA (Rio Tinto 68%)	open pit	4356	12.1
Olympic Dam	Australia	WMC	by-product/ underground	3706	9.3
Rossing	Namibia	Rio Tinto (69%)	open pit	3038	7.5
McClean Lake	Canada	Cogema	open pit	2310	5.7
Rabbit Lake	Canada	Cameco	underground	2087	5.2
Akouta	Niger	Cogema/ Onarem	underground	2005	5.0
Arlit	Niger	Cogema/ Onarem	open pit	1277	3.2
Beverly	Australia	Heathgate	ISL	920	2.3
Vaal River	South Africa	Anglogold	by-product/ underground	756	1.9
top ten total				27 654	68.8

The table above shows the paucity of options which exist for investing in uranium companies. Only one of the top uranium producers, Cameco, is a pure play uranium stock. Cameco Corp trades on the New York and Toronto exchanges and sports a market capitalization of more than $13 billion.

There are numerous junior companies, which might provide speculative opportunities, exploring in the Athabasca Basin. Because two new uranium mines are scheduled to open during this decade (and also because of the steadily rising uranium price), exploration in the Athabasca Basin has ramped up. The spot uranium price has also set off further exploration in Labrador, the Northwest Territories and elsewhere. The primary difficulty with grassroots exploration is that, in heavily regulated political environments, it can take about 20 years to bring a discovery through all the various stages into a producing uranium mine. And it has been about 20 years since the last new significant uranium deposit was discovered.

The center of the uranium universe is Canada's Athabasca Basin. We invited Dr. Boen Tan to write about the area's geology. Dr. Tan previously helped discover two uranium deposits in the Athabasca region, both of which became producing uranium mines.



Example of Athabasca Region Geology by Dr. Boen Tan

Unconformity-type Uranium Deposits of the Athabasca Basin

Editor's Note:
This essay was provided by Dr. Boen Tan (Chief Geologist) and Rick Mazur (Chief Executive and President) of Forum Development Corp.

Unconformity-type uranium deposits are among the richest and largest in comparison to other uranium deposit types. Those found in the Athabasca Basin in northern Saskatchewan, Canada are unique. They are much higher grade than other deposits of this type found elsewhere in the world. One-third of the world's uranium, with ore grades ranging from 1 percent (20 lbs. per ton) to over 20 percent (400 lbs. per ton) uranium is produced in Saskatchewan from unconformity-type deposits. For this reason, the Athabasca Basin is an attractive place to explore for uranium.

The original sources of uranium were derived from various types of basement rocks such as granites of Archean age (greater than 2 billion years old) and black shale and arkosic rocks of Proterozoic age (1.8 to 2 billion years old). Further uranium enrichment occurred 1.8 billion years ago during the Hudsonian Orogeny. This was a geological event which created mountains higher than the Himalayas. Uranium mineralization containing a few hundred ppm (parts per million) to a few percent uranium were formed at this time in pegmatites and metasomatic deposits.

Following the Hudsonian Orogeny, erosion and a long period of weathering, similar to today's tropical weathering, altered the basement rocks. The Athabasca Basin has a thick accumulation of sandstone, which was deposited around 1.7 billion years ago, during an extended period of river systems following this long period of erosion. The contact between the Athabasca sediments and the altered basement rocks is the "Unconformity" surface which marks the position where these uranium deposits were formed. During the time of deposition of the Athabasca sediments, uranium, which travels in solution under oxidizing conditions, was transported along with the sediments.

Unconformity-type uranium deposits within the Athabasca Basin were formed after the deposition of the Athabasca sediments, or "Post- Athabasca". Uranium was concentrated and mobilized via hot, percolating hydrothermal solutions (around 250 degrees Celsius or 480 degrees Fahrenheit) into "structural traps". The uranium precipitated from solution when the oxidizing solutions from the Athabasca Basin came into contact and reacted with reducing solutions from the underlying basement rocks. The Athabasca sediments and the basement rocks were also affected by alteration from these hydrothermal solutions.

Dr. Boen Tan, Chief Geologist, and Rick Mazur, CEO, of Forum Development Corporation.

All large unconformity-type uranium deposits in the Athabasca Basin are fault-controlled. Structural interpretations have been strongly supported through geophysical exploration, utilizing magnetic, electromagnetic and gravity methods. The "Post-Athabasca" reactivated fault structures acted as the plumbing systems for the oxidizing and reducing solutions, which developed the rich and prolific uranium deposits of the Athabasca. Based on results from airborne magnetic surveys and geological mapping, several structural trends or "domains" have been outlined in the Athabasca Basin, each with their own structural characteristics. All of these domains have the potential for uranium mineralization. All current uranium production, however, is from the Wollaston domain in the eastern margin of the Athabasca Basin.

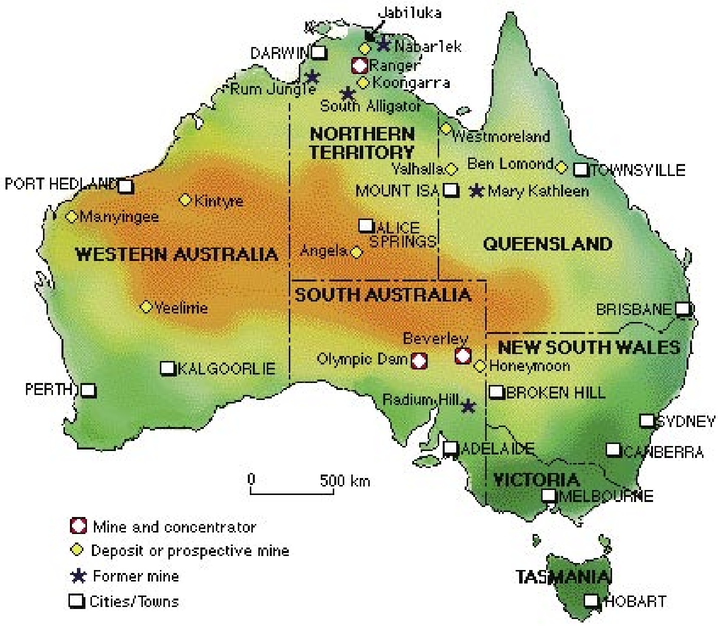
The metamorphosed black shales in the basement rocks formed a rock type called graphitic gneiss. This relatively soft rock is quite receptive to structural deformation. Almost all unconformity-type uranium deposits are located in fault zones associated with tectonized graphitic gneiss containing massive graphite and graphitic breccia. This is one of the reasons why most drilling is spotted on targets generated from electromagnetic surveys, which can outline the location of tectonized graphitic gneiss. There are some unconformity- type uranium deposits in the Athabasca Basin, such as the Rabbit Lake deposit discovered in 1968, which are not associated with graphitic faults. Additional potential for similar uranium deposits cannot be underestimated.

Most of Saskatchewan's unconformity-type uranium is located at or near the unconformity surface between the Athabasca sediments and the underlying basement rocks, such as the Key Lake, Cigar Lake and the Midwest deposits. These orebodies usually contain large amounts of nickel and arsenic. The world's richest uranium deposit, McArthur River occurs within sandstone and in the underlying basement to depths of over 100 m below the unconformity. The Eagle Point and Millennium deposits contain uranium only and are situated entirely in basement rocks up to 400 m and 250 m respectively below the unconformity.

Large hydrothermal clay alteration zones commonly envelop all unconformity-type uranium deposits, but the nature and chemical composition of the alteration can differ. Strongly silicified sandstone haloes characterize the McArthur River deposit. Fractures filled with druzy quartz and pyrite are quite common. Boron content is typical and varies in extent, depending on the degree of hydrothermal activity. As a result of the above chemical attributes, and in addition to the geophysical characteristics of unconformity-type uranium deposits in the Athabasca Basin, geochemical and mineralogical pathfinder exploration methods are also commonly used in the search for deposits beneath extensive Athabasca sandstone cover.

There are currently three uranium mines operating in the Athabasca Basin of northern Saskatchewan. The McArthur River Mine/Key Lake Mill, operated by Cameco Corporation and AREVA is an underground operation being mined at a grade of 24 percent U3O8 and at a depth of approximately 500 to 650 meters. The Eagle Point Mine/Rabbit Lake Mill, operated by Cameco Corporation is an underground operation being mined at a grade of 1.3 percent U3O8 to a depth of 400 meters. The McClean Lake Mill, operated by AREVA, Denison and OURD is currently processing stockpiled ore from an open pit, but will be processing ore grading 19 percent U3O8 at a depth of 430 meters from the Cigar Lake underground mine, scheduled for possible production in 2007.

Australia



Australia – the world's second largest uranium producer has the world's largest known recoverable uranium reserves.

On the other side of the world is the down-under Australian island continent. It hosts the world's largest known uranium reserves, but has no large-scale nuclear reactors (just a small research reactor outside the country's largest city, Sydney). Australian uranium mining is a bit of a curiosity. This country has a "Three Mines" policy, limiting the number of producing uranium mines. Yet at various times, Australia has had more. Another curiosity: Olympic Dam is the world's largest uranium resource, yet is classified as a copper mine. While the uranium mined at Olympic Dam is in far greater quantity than was produced from Kazakhstan (the world's 3rd largest producer), the uranium production is classified as a by-product of the underground copper mine.

The Ranger uranium mine is winding down. Olympic Dam is expanding capacity and production. The Beverly ISL operation produces about 2 million pounds per year, and should continue through the middle of the next decade. While there are more than 100 Australian uranium juniors, and some Canadian companies joint-venturing with those, Australia's uranium mining program is hampered by the country's anachronistic "Three Mines" policy. If this changes after the Labor Party's next national conference, which is being held in early 2007, then those who have locked up land, before then, will be celebrating. This is a political risk, which we can not accurately evaluate.

Recent Production from Australian Uranium Mines (tonnes of U_3O_8)

	1995-6	1996-7	1997-8	1998-9	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05
Ranger	3453	4237	4162	4375	4144	4612	3815	5312	4667	5544
Olympic Dam	1652	1758	1635	2021	4055	4814	3253	3075	3993	4356
Beverly	-	-	-	-	-	219	649	762	873	1064
Total	5105	5995	5797	6396	8199	9645	7717	9149	9533	10964

Calendar year 2005 production: 5910 t from Ranger, 4335 t from Olympic Dam, 977t from Beverley, total 11,222 tonnes.

The Honeymoon uranium project is now proceeding to obtain final environmental approval to start mining. Mining actually began in 1981, but was stopped by the South Australia government. We anticipate it will resume and benefit its mine owners and their shareholders. The Ranger mine may or may not expand beyond its first two orebodies into Jabiluka. Of immediate concern is that the Ranger mine is part of a national park system, which has become a major tourist attraction and is now a UNESCO World Heritage site. The Kakadu National Park is owned by the Mirarr aborigines. The Mirarr won the right to limit future uranium mining development in early 2005 and may remain resolute in banning the mining of new deposits.

We find Australian uranium mining very speculative until the Labor Party officially ends its mining policy. The country's future may be dominated by uranium production at Olympic Dam, which some believe may annually produce more than 30 million pounds. There may be insufficient room in this space for the smaller miners. We quote Julian Steyn, in the book he co-authored with U.S. Senator Pete Domenici and Blythe J. Lyons, ***A Brighter Tomorrow*** (Rowman & Littlefield: 2004), "If the past is any guide to the future, Australian supply potential must be tempered with the reality that the official party platform of the Australian Labor Party opposes nuclear power development. While current opposition could change as the environmental benefit of nuclear power is more widely accepted, this remains to be seen." On the flip side, should the Australian Labor Party renounce its stance, embrace uranium mining, then several Canadian-based uranium companies could become very big winners.

Countries to Watch

Behind Canada and Australia is the rest of the pack. Although we could have discussed several countries, there were few with plentiful, secure and stable investment opportunities at this time. We have ranked the three uranium-producing countries, which comprise this section, because there may be strong investment potential in uranium exploration and development companies. In order of safety, reliability and capacity to profitably produce uranium, we ranked Namibia, Niger and Kazakhstan in the sequence which follows.

Namibia

Namibian production may soon surpass 8 percent of the world's total uranium mining.

Namibia may not have the uranium reserves of the top three uranium producing countries, but it does have advantages. The country of Namibia, bordering South Africa, Botswana, Angola and the South Atlantic Ocean, is one of the world's key uranium producers – supplying global utilities with between six and eight percent of the uranium oxide.

Namibia is a uranium-friendly mining country. In October 2005, Mine and Energy Minister Erkki Nghimtina told the country's National Assembly, "Namibia should consider exploiting its uranium ore reserves in the light of rising world uranium prices." The country has already been doing so, through Rio Tinto Group's Rossing uranium mine for the past 25 years, which provides jobs to more than 800 employees. With the addition of the Paladin Resources' Langer Heinrich, even more uranium will be mined. The minister's comments were similar to a company's news release: he was soliciting uranium companies to come explore for new deposits.

The Rossing is one of the largest open pit uranium mines in the world and with solid reserves. According to the company's website, this mine "currently produces about 7.7 percent of the world's uranium." The Rossing uranium deposit is an intrusive deposit, with intrusive rocks in this category which include alaskite, granite, pegmatite and monzonites. Around the world similar type deposits include South Africa's Palabora and Greenland's Ilimausaq. In South Australia, a similar intrusive deposit – Radium Hill – was mined from 1954-1962.

We interviewed Graham Greenway, formerly the chief geologist at Rio Tinto's Rossing uranium mine, about developments in the country. Before becoming a resource evaluator for Snowden Mining Industry Consultants in Johannesburg, Greenway evaluated resource deposits for the Rossing Mine as the mine's chief geologist. Snowden is a highly respected international mining consultant firm with offices in Johannesburg, Perth, Brisbane, London and Vancouver.

Would it be possible Namibia will have four uranium mines before the decade ends? "It wouldn't surprise me," Greenway said. "When I look over at Rossing, they are also looking for alternative sources of uranium around the Rossing area." One of the uranium deposits Greenway evaluated for Rossing was Forsys Metals' Valencia deposit. "They and Rio Tinto have a wealth of information about the exploration done up to Valencia," Greenway told us. "There is quite a bit of interest in that area."

Is the Valencia an economic deposit or not? We asked because we wanted to know if this might be Namibia's third, or possibly fourth, uranium mine. "I would think so, yes," Greenway responded, "Under the right conditions, I think it could be economic under the current mining plan." For the record, in his technical report, Greenway wrote, "... the Valencia Project represents an advanced staged uranium project that has potential for development as an economically viable mining operation." He also wrote in his technical report, "Uranium mineralization has been identified over an area of 1,100 meters north-south by 500 meters east-west."

We also talked risk factors with Greenway about exploring for uranium in Africa. He outlined several key items as a starting point for an investor's checklist.

1. **Political Risk.** As with any "exotic" country or continent, such as Mongolia or Central Asia, there is the questionable political risk. Case in point, we asked Greenway if there were any African nations to avoid. "Zimbabwe has a lot of certainty as what's happening there at the moment," he responded. "Niger has political and water issues." From our analysis of news items, Namibia appears to be a politically stable.

2. **Infrastructure.** Unless the deposit is world-class, if there is no infrastructure in place, then the deposit will stay with Mother Nature a little while longer. Infrastructure can mean roads, a pipeline, or whatever transport system is required to move ore to a processing facility. If the project is sufficiently large, infrastructure will be built to service the deposit. In the case of Forsys Metals' Valencia Deposit, it is near the Rossing mine. Not so near that some additional infrastructure might be necessary, but not hundreds of miles away from a mill, either.

3. **Water.** Many parts of Africa are arid. The world's largest desert, the Sahara, is part of the African continent. Namibia's uranium deposits are in a desert. Therefore, there must be readily available water to explore and mine the deposit. "Niger has been having a drought." (Note: Greenway did, however, commend Niger for having developed infrastructure.)

Swakopmund water pipeline in the Namibian Desert

4. **Electricity.** "Namibia is very reliant upon South Africa for their electrical supply," said Greenway. "But they are talking about expanding their KUDU gas fields in the south, to build gas-fired electricity plants." Other countries may rely upon expensive diesel to generate electricity. Ironically, the cost of uranium mining may be dependent upon the price of crude oil, more so in Africa than a major coal-producing region, such as Wyoming.

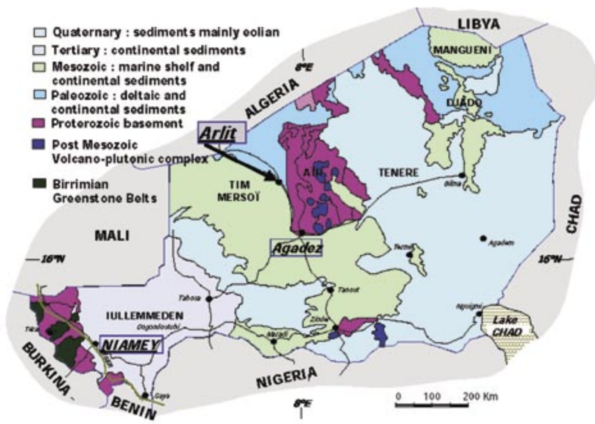
5. **Tenure of Ownership.** "Previously, Angola and Congo had issues with the tenure of ownership," said Greenway. "You'd find two companies owning the same piece of ground depending upon who got bribed the most." Greenway suggested this might still be found in the Democratic Republic of Congo (DRC). "Land ownership is pretty clear cut in Namibia," Greenway noted.

6. **Mining Code.** Basically, this defines how much the government gets to keep from the uranium mining. That's what a mining code is really all about: royalties. "South Africa has become a bit of problem with that," Greenway quietly stated. "Most of the other countries will let you get your money out of the country. Generally, the government will tax you 10 or 20 percent on your

project, and then allow you to get your money out of the country." He added in discussing South Africa, "There is a published code and there is a code that can be translated differently depending upon who you speak to." Greenway concluded, "I don't think you'll find the same problem within Namibia." He added that Burkina Faso had a pretty good mining code (formerly known as Upper Volta).

With any project, the maturity of an area strengthens the economic possibility of a worthy uranium project. The number of years it took for Rio Tinto to help develop relationships within Namibia may help smooth the way for Paladin, Forsys Metals and UraMin. Again, having a big guardian, such as the Rossing uranium mine, in the country where you wish to develop a mine, could expedite the mine development process. The downsides of Namibia are the low grades found in the country, the water problems and the potential of currency fluctuations, tied to any experienced by South Africa, upon which Namibia is dependent.

Niger

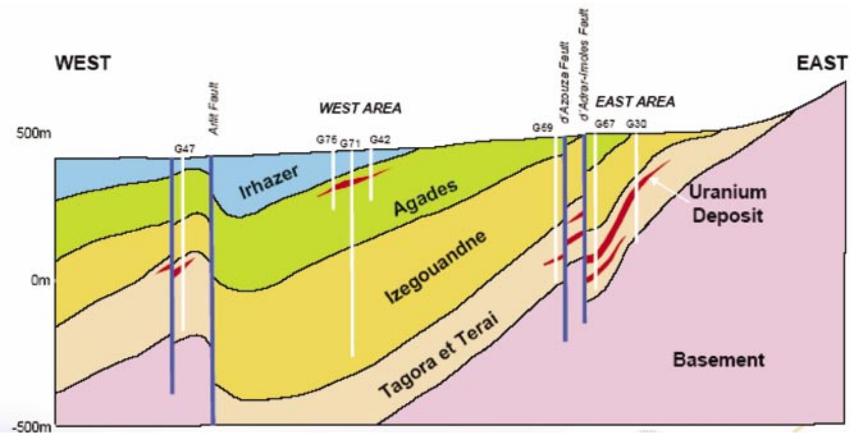


Until recently, few have paid attention to the Republic of Niger during the current uranium bull market.

Named after the river which runs through it, Niger produces nearly four times the uranium currently mined in the United States. More uranium is mined in Niger than in Russia, South Africa, India, China, Brazil, Ukraine Namibia or Uzbekistan. In fact, if you added up the total amount of uranium mined in South Africa, China, India, Brazil, Czech Republic and the Ukraine for 2004, Niger would trump the combined production of those six countries. Until Dr. Jon North came along, uranium mining was pretty much monopolized by Cogema and a consortium that includes Spanish and Japanese interests.

"This is the fourth largest uranium producer in the world," raved an excited Dr. North into his cell phone during our taped interview. "Niger has never had an entrepreneurial and nimble junior mining company ever explore for uranium. And this is the first one." North was talking about Northwestern Mineral Ventures. "Imagine if Australia, Canada and Kazakhstan never had a junior company looking for uranium. It's absolutely absurd to even consider the concept."

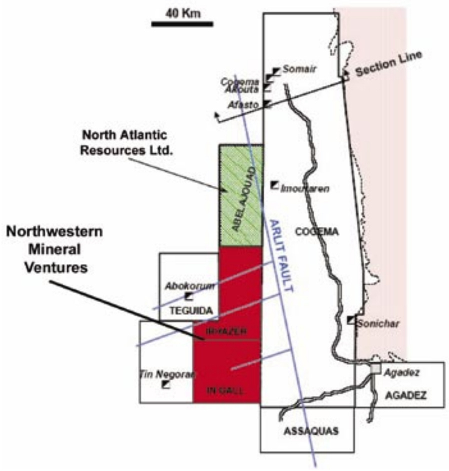
The Republic of Niger supplies about 9 percent of the world's annual production to meet the growing need for uranium to fuel the world's nuclear reactors. According to the IAEA-NEA Red Book of 2003, the sub-Saharan Niger ranked #4 behind Australia, Kazakhstan and Canada for total uranium reserves. In the 2005 update, it fell to seventh place. It could be this country is under-explored. In 1981, Niger produced a peak of 4366 tonnes of uranium. As with others, mining production plummeted with the spot uranium price plunge during the 1980s and 1990s. The slump hit the country hard because Niger depends upon uranium for more than 30 percent of its exports, more than $100 million. About five percent of the country's tax revenues come from uranium mining.



A schematic cross section of Niger's uranium geology

Exploration licenses are valid for a period of nine years, three-year licenses which are renewable three times. The country's mining act allows companies to apply for a mining license, which can be granted for between 25 and 70 years.

Uranium in the Republic of Niger is mined by open pit because of the sandstones. "These are redox deposits," North noted. "They tend to be associated with reduced layers



North Atlantic Resources obtained the Abelajouad concession while Northwestern Mineral Ventures was awarded the Irhazer and Ingall concessions, each 2,000 square km (772-sq. miles) in size. All three concessions border Cogema's concession in the Republic of Niger.

and structures, such as the former salt diapirs and faults in the stratigraphy. At the time, we didn't really understand why we were doing that. We just knew there was an association with uranium deposits and these structures in Niger."

At Cogema's seven open pit uranium mines which feed the Arlitt mill, the grades have run 0.3 percent with 2003 production at 1126 tonnes. At the two open pit uranium mines which feed the Akouta mill, grades have run at between 0.4 and 0.5 percent with 2003 production at 2017 tonnes.

Niger's geology is pretty straightforward, according to North. Salt is very common but it doesn't last very long in stratigraphy and it escapes, North explained. "When it escapes, it forms walls and diapirs (an anticlinal fold where the salt has pierced through the more brittle overlying rock)." Oil exploration geologists pay attention to these because they tend to form permeability barriers to oil and gas deposits. North is interested in them for a different reason, "We noticed that the salt diapirs, where they escaped through the sequence in Niger, coincided with the distribution of uranium deposits."

The Republic of Niger has North's vote on confidence. He has worked for the past few years as Chief Executive of North Atlantic Resources, which hopes to develop its Kantela gold property in Mali. Niger and Mali are demographically and geographical identical, he told us. North feels Niger is going to become more aggressive in developing its uranium properties. He talked about how the President of Niger told his minister of mines, "Get out there and advertise Niger as being open for business. We want people to come in here and invest. We want to give them mineral rights, and we want them to do what Mali is doing." From the looks of it, the first to jump on the Niger bandwagon were Northwestern Minerals and North Atlantic Resources, but they probably won't be the last.

Kazakhstan

Had we omitted Kazakhstan from this publication, which we considered at one time, many would have complained. There may be as many reasons to avoid investment in

Kazakhstan

companies exploring for uranium in this country as there are benefits. The world's largest uranium producer, Cameco, hopes to someday mine 30 million pounds per year in Kazakhstan. The state-controlled KazAtomProm, which controls uranium mining and the subsequent marketing of the product, recently announced the country's production targets would reach 30 million pounds by the year 2010.

There is no doubt Kazakhstan is rich in uranium. That is not the issue. Nearly everyone we interviewed did confirm Kazakhstan hosted one of the richest sources of uranium on earth, behind the Athabasca Basin. Its reserves might become the world's largest, perhaps someday to a lesser degree of the level of Saudi Arabia's oil fields. Those brave companies, which hope to develop uranium properties, must certainly be aware of doing business with the Kazaks. Some companies have had problems.

One chilling article we read, entitled, "The Reconstruction of the Uranium Industry in Kazakhstan," written by Paul A. Carroll of World Wide Minerals in 1999, made us ponder whether any investment in Kazakhstan was secure. He wrote, "A word to the wise - get everything that you want down on paper, up front, and get it signed by all of the right people. Even then you are not assured of success, but at least you know what the deal was supposed to be." Whether his remarks are warranted is uncertain. His company has filed litigation against the country's state-owned uranium company.

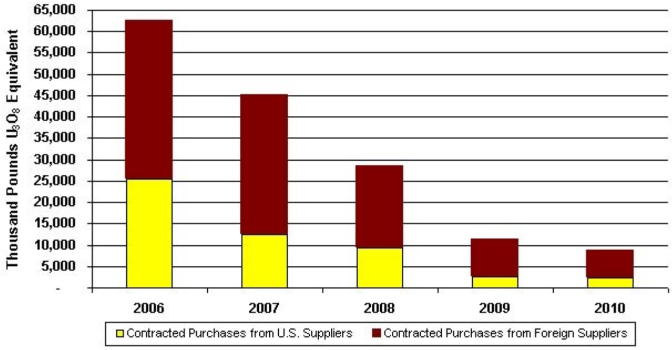
World Wide Minerals complained about the problems the company had selling its uranium outside the country, "Our inability to obtain an export licence for a straightforward sales contract should be a warning to all other foreign investors looking at Kazakhstan and wanting to export their production." The paper's author concluded, "Operating in Kazakhstan requires patience, flexibility and a temperament that can withstand the shifting sands of life in that country."

True, his paper was presented very close to the low point of the twenty-year uranium depression. From what we understand, litigation is ongoing, and we prefer to remain outsiders regarding their affairs. But what about ChevronTexaco? Between 1995 and 2003, the Chevron Corporation, which later merged with Texaco, was repeatedly stymied by the Kazaks. In September 1995, the ***New York Times*** reported Chevron was considering moving their oil through Iran, because it could not gain an export route through Russia. Eurasianet.org reported, "In November 2002, the energy conglomerate (ChevronTexaco) briefly pulled out of a $3.5 billion exploration deal in the Tengiz oil field over a dispute regarding how quickly it had to make payments to the government." Today, the relationship is more harmonious, as the U.S. oil giant projects up to 9 billion barrels of recoverable oil from Tengiz, one of the world's largest oil fields.

Oil is bigger money than uranium, and provides a great source of revenues than uranium mining may ever provide to Kazakhstan. We reviewed the Economist Intelligence Unit's assessment of Kazakhstan for an additional chilling of any strong interest we had about investing in this country. The internationally respected magazine warned of a danger of political in-fighting in the future. The country risk assessment cautioned the political outlook could be harsh over the coming years. As with most dictatorships, even one where the president was "elected," opposition forces vie to dethrone him. For now, the country's iron-fisted ruler has brushed off potential challengers and may be preparing his "dynastic successor." In May 2006, the ***Economist*** advised this may point to a rocky road ahead for Kazakhstan.

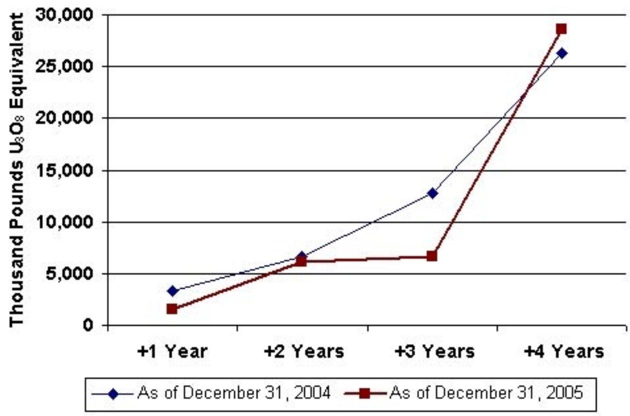
On the highly publicized production ramp up, there are more than a few industry skeptics. UxC president, Jeff Combs, whose consulting firm establishes the widely followed weekly spot uranium price, told us about Kazakhstan, "They definitely will continue to increase production, but perhaps not at the rates they are advertising. They've produced a lot in the past, in the old Soviet Union days. I think they can get back up to those production levels, but it's going to take some time." Combs explained the Kazak problem further, "One of the things that will slow them down is the infrastructure, including the skilled work force, needed to expand at that rate." He added, "A large part of it is just the time it takes to build the infrastructure, including training workers. You can have all of the investment in the world, but it still takes time to get things done, especially if the infrastructure isn't well developed in the first place."

Conclusion



Maximum Contracted Purchases of Uranium from Suppliers by Owners and Operators of U.S. Civilian Nuclear Power Reactors, in Effect at the End of 2005, by Delivery Year, 2006-2010. Source: Energy Information Administration: Form EIA-858 "Uranium Marketing Annual Survey" (2005).

While Americans complain about dependence upon foreign oil, the same can be said about uranium. The overwhelming amount of mined uranium, which powers U.S. nuclear reactors, comes from outside the United States. Except for Canada, we are wary of global uranium suppliers to U.S. utilities. As we mentioned, Australia's policy may change, or it may not. Kazakhstan has great uranium reserves, but is a political wild card. The African producers, Niger and Namibia, offer good hope, but we anticipate their supplies may likely to be locked-in by European, Middle Eastern and North African countries planning nuclear expansion programs. Mongolia, which we did not discuss, is early days, but would likely, if it becomes a significant uranium producer, supply China's growing nuclear energy ambitions.



Annual Unfilled Uranium Requirements of Owners and Operators of U.S. Civilian Nuclear Power Reactors, as of 12/31/2004 and 12/31/2005. Source: Energy Information Administration: Form EIA-858 "Uranium Marketing Annual Survey" (2004 - 2005).

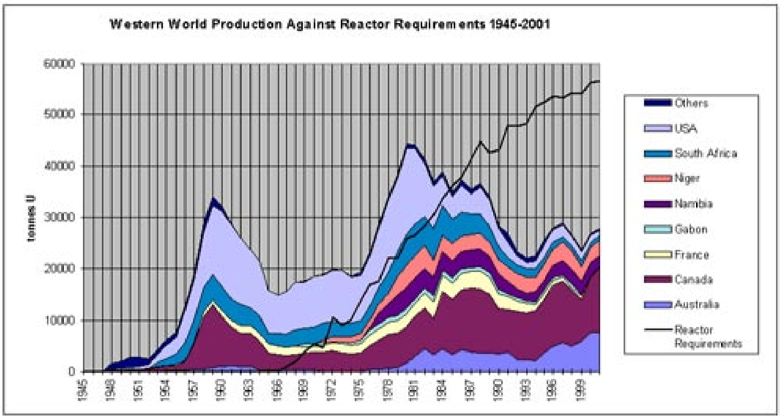
The safest mandate for the U.S. utility industry would be to cultivate the growing number of domestic uranium producers for the next two to three decades as a safeguard against potential supply disruptions. Conversations we had with industry insiders show a lackluster regard for the upcoming uranium supply crunch. U.S. utilities rest in a state of ennui, perhaps wondering whether they simply need to lobby the Department of Energy to release from its uranium inventories in the case of an emergency, or pursue their lobbying efforts through the Department of Commerce to eliminate trading restrictions with Russia. This may not be the healthiest course for the utilities. In the near future, we expect more utilities may begin discussions with domestic uranium development companies for a consistent supply of nuclear fuel as the decades progresses.

CHAPTER 6

The Great Uranium Shortage of 2012-2015

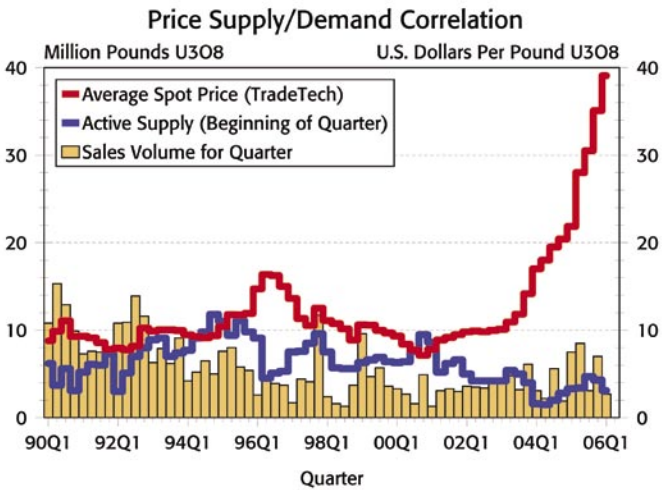
"It is not too much to expect that our children will enjoy electrical energy too cheap to meter....This is the forecast for an age of peace."

Lewis Strauss, Chairman of the Atomic Energy Commission
September 1954



Courtesy of World Nuclear Association

The basic premise of this book is that uranium stocks are probably an outstanding investment opportunity for the next ten years. In this chapter, we hope to explain why there will be continued explosive growth in the uranium mining sector. The current bull market is actually the third one over the past 60 years.. There were hundreds of uranium exploration companies in the early 1950s. The first bull market fizzled out, and those companies disintegrated, much in the same way we found with the Internet hopefuls in the year 2000. The second uranium bull market, during the 1970s, was dominated by the major oil companies. They wanted to expand beyond their oil and gas services, and provide nuclear fuel to the rapidly growing nuclear energy industry of that era. Both of the previous uranium bull markets ended because of single event. The former ended when the Atomic Energy Commission terminated its incentive program. The latter ended with the Three Mile Island episode.



Courtesy of TradeTech LLC

The current uranium bull market may provide greater longevity because it is no longer a U.S. phenomenon. This bull market has evolved because of a global explosion of demand for nuclear energy. We began this book on the premise there would be an inventory shortage, a supply discrepancy between what had been mined, or could be mined, in time to meet the demand for uranium. In a nutshell, we joined a chorus of others who foresaw a supply and demand imbalance, favoring sellers. As we pursued our in-depth research into this sector, it became crystal clear that the growth in demand has been grossly underestimated by the majority of insiders, analysts and consultants who follow this sector. Our research indicates the current bull market is going to last longer and become far more powerful than nearly any of the experts have calculated. It all began more than fifty years ago when seeds were planted in countries around the world.

Atoms for Peace

The shield of the Atomic Energy Commission

Once upon a time, in the 1950s, the Eisenhower administration created the world's first powerful campaign for civilian nuclear energy. The crusade sprang forth as President Eisenhower's "Atoms for Peace" program. The United States supplied dozens of countries around the world with hundreds of research reactors. These were small-scale nuclear reactors fueled by highly enriched uranium (HEU). Beneficiaries of the U.S. government's largesse included familiar names, such as Iraq, Iran, Vietnam, Korea, Indonesia, India, Israel, Pakistan, Argentina, Brazil, Taiwan and Yugoslavia. The widespread dissemination of nuclear reactors, nuclear research, nuclear fuel, and then-recently declassified documents about developing nuclear capabilities was the most aggressive PR campaign in history for nuclear energy.

It was not entirely an act of generosity on behalf of the United States. To understand this better, let's retrace the timeline of events which led up to the Atoms of Peace enthusiasm. According to Jonathan Helmreich's ***Gathering Rare Ores*** (Princeton University Press, 1986), the U.S. and Britain created the Combined Development Trust, in June 1944, to acquire all known foreign inventories of uranium and thorium. Brigadier General Leslie Groves, who was the director of the Manhattan Project, ran the Trust. America and England wanted to monopolize all the uranium assets before the Nazis or Soviets could get their hands on them. After a worldwide search, the project was dropped when the team discovered uranium and thorium were in plentiful abundance all over the globe.

By June of 1946, the U.S. Congress presented the Acheson-Lilienthal plan to contain the potentially explosive growth in atomic energy development. For the next seven years, the U.S. attempted to create an international body, which would control fissionable materials across the world, while maintaining a curtain of secrecy behind its own atomic research. That same year, the Atomic Energy Commission was created. All of the U.S. efforts were aimed to control nuclear research being done in the Soviet Union. The Soviets refused to budge. Thus, the arms race began. In 1946, the U.S. had manufactured but nine atomic bombs. The Soviets were racing ahead and detonated their first nuclear bomb in August 1949.

Four years later, again in August, the Soviet Union detonated their first thermonuclear weapon. In December of that year, Eisenhower addressed the UN General Assembly to promote the peaceful use of atomic energy. Again, he appealed for the creation of a fission bank, asking the governments with atomic weapons (namely, the Soviets) to "make joint contributions from their stockpiles of fissionable materials to an international atomic energy agency set up under the aegis of the United Nations." Again, the Soviets failed to participate.

Perhaps because it was worrisome the Soviet Union might provide other countries with nuclear technology, the Eisenhower administration launched its promotion of nuclear technology. By 1954, foreign scientists were being trained at the Argonne Laboratory's School of Nuclear Science and Engineering. The U.S. sponsored the first UN conference on the Peaceful Uses of Atomic Energy. In March 1955, Eisenhower approved NSC 5507/2, which promoted the international and regional interests of the United States through nuclear technology exports.

From this presidential directive, the Atoms for Peace movement energetically flooded the world markets with nuclear technology. The U.S. Agency for International Development, in late 1955, exhibited at the New Delhi Trade Fair, attended by two million Indians. On display were a 30-foot-high reactor diagram, several working models of reactors, and a "hot" laboratory. The secrecy surrounding nuclear technology, which had ruled for nearly a decade, had been replaced with wide-eyed optimism and the export of the budding nuclear technology.

As peace was being promoted through nuclear energy across the world, America's nuclear stockpile grew from nine atomic weapons in 1946 to more than 20,000 before Eisenhower finished his presidency. What the U.S. engendered in the 1950s, it began to regret by the early 1960s. Fears of a nuclear holocaust never materialized. In reality, the nuclear energy industry, instead, boomed. The first Atomic Energy Commission chairman David Lilienthal, whose doctrine had strictly contained the dissemination of atomic secrets and attempted to pool all uranium into one international agency which controlled it, recalled about that era of widespread dissemination of nuclear energy, "This prodigious effort was predicated on the belief and hope that this great new source of energy for mankind could produce results as dramatically and decisively beneficial to man as the bomb was dramatically destructive." Today, we have the International Atomic Energy Agency, under the auspices of the United Nations, which serves the function envisioned during the 1940s and 1950s.

What the wishful thinkers of the 1950s had hoped for may soon come to pass. The current Nuclear Renaissance has become the next stage of the original Atoms-for-Peace plan. Finally, after fits and starts, nuclear energy has evolved into a solution for the world's growing electricity needs. Nuclear energy is finally being recognized for what it is. As the world's leading environmentalist James Lovelock writes, "There is no sensible alternative to nuclear power if we are to sustain civilization."

A Shift in the Center of Gravity

The Center of Gravity has quickly been moving to China, India and the rest of Asia.

In Matthew Simmons' book ***Twilight in the Desert*** (John Wiley, 2005), he mentioned an observation made by Everett Lee DeGolyer, who was then one of the world's leading geologists. In 1943, President Franklin Delano Roosevelt ordered a senior delegation to investigate Saudi Arabia's potential oil resources. Only a few years earlier, in 1938, San Francisco-based SOCAL had made its first great oil discovery in Saudi Arabia. One oil field was already producing, having been followed by another discovery of oil. DeGolyer led this delegation, returning with astonishing news. In his report to Roosevelt, he predicted the "center of gravity for oil production would soon begin shifting from what he labeled the American-Caribbean area to the Middle East-Persian Gulf area."

The world did not realize until 1973, during the OPEC oil embargo, what DeGolyer had forecast 40 years earlier. The Middle East-Persian Gulf area ruled the oil world and became acknowledged as a center of power and wealth. Then, they began dictating prices we would all pay at the gasoline pump.

As we move deeper into the first decade of this millennium, the "center of gravity" for energy consumption, and especially for uranium consumption and nuclear energy, has already begun moving from the United States and European Union to the Pacific Rim countries. The major uranium-consuming countries are going to be the heavily populated ones whose electricity consumption will grow exponentially: China and India. Just as the centers of power moved from Europe to the United States during the 20th century, as the United States dominated the petroleum industry – both in terms of production and consumption, the growth of nuclear energy across Asia will move the center of power to this region. Wealth follows energy so it's time to start learning Chinese.

As was discussed in Chapter Three of this book, the Colorado Plateau experienced a series of minerals booms and busts. From the silver boom to radium, vanadium and finally uranium, scientific discoveries, technical advances or war led to aggressive minerals explorations. A single major event brought about a bull market into those metals. Madame Curie drove up radium prices because that element was in demand as a cancer treatment, and later as a means of surreptitiously lighting gun scopes during World War I. Vanadium was used by the shipping industry, and massive shipbuilding during World War II helped spur vanadium bull market higher.

Uranium enjoyed its first bull market because of the Manhattan Project and the subsequent nuclear arms race of the 1950s and 1960s. The uranium sector celebrated its second bull market in the 1970s because of the civilian nuclear energy buildup across the United States. Now, a third uranium bull market has begun. Some believe it has begun because of the threat of global warming, air emissions and other factors. Those are certainly practical reasons. Mainly, it has begun because China, India and many other countries want the cleaner, more efficient, less expensive and more reliable energy offered by nuclear power. Those seeds were planted by the U.S. and other world leaders in the 1950s. Now, those seeds have sprouted and taken root.

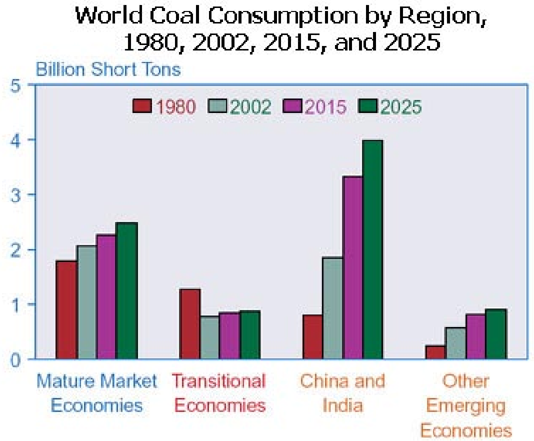
This shift in energy is also a signal that the Petroleum Age is waning while the Nuclear Age is waxing. Those who dominate this industry will hold the keys to wealth and power. For example, Russia foresees their return to superpower status by grabbing a large share of the ongoing nuclear renaissance. Hopefully, the United States won't miss the most powerful shift between energy sources of the past one hundred years. Again, wealth follows energy, into whichever energy source it may lead.

China's Economic Growth Will Prolong The Uranium Bull Market

Since early 2006, China has rocked Australian politics with its ambitions to buy into the country's uranium production. The Chinese have incessantly campaigned to secure a reliable source of uranium to fuel their country's aggressive nuclear energy program. The Chinese successfully negotiated a deal with the Australian Prime Minister to buy Aussie yellowcake. Of course, Australia may be required to change some laws, allowing uranium development outside of its two states. This remains to be seen.

The entire nuclear sector has been eyeballing China. Call it the China wild card, or consider their nuclear energy aspirations as a solid promise. Mainland China now has nine operating nuclear power reactors. Five are currently under construction. Start-up

Australian Prime Minister John Howard and Chinese Premier Wen Jiabao shake hands on their uranium deal

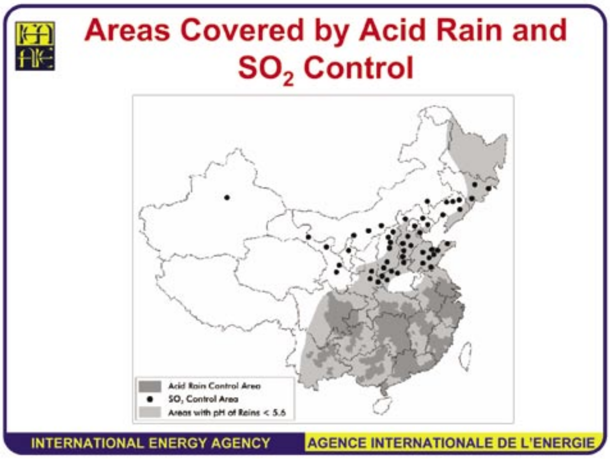


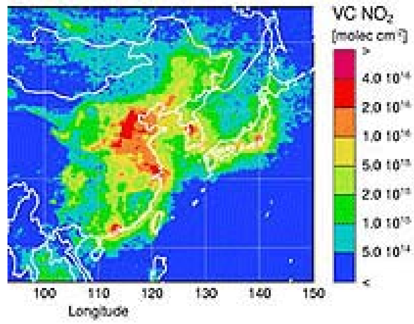
Sources: **1980 and 2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219 (2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **2015 and 2025:** EIA, System for the Analysis of Global Energy Markets (2005).

dates are between 2006 and 2011. At least eight more are seriously proposed. Reports suggest the Chinese may build another 69 nuclear power units within the next few decades. By the year 2020, China hopes to increase its nuclear energy operating capacity by five fold. To achieve their goal, about 40 new reactors, each capable of generating at least 1 million kilowatts of electricity, will need to be built.

Why are the Chinese aggressively pursuing nuclear energy? This country's economy is growing at an astonishing pace. Gene Clark, CEO of TradeTech LLC, told us that for every percent of GDP growth, a country would need one percent growth in electricity supply to sustain the economic momentum. China, India and other emerging economies are demanding a greater share of the world's electricity generation. Until now, China's solution has been to mine its coal. China is both the world's largest producer and consumer of coal.

China's dependence upon coal comes at a price. The NDRC reported nearly 6,000 died in coal mining accidents in 2005. The World Bank estimates about 400,000 Chinese die each year from air pollution-related illnesses, mainly heart and lung diseases. Not only does China export 24 percent of its coal to other Asian countries, it is exporting its pollution from coal emissions. "As much as 40 percent of air pollution in Japan and South Korea originates from China," said Dan Millison, an environment and energy specialist for the Asian Development Bank. Boo Kyung-Jin of the Korea Energy Economics Institute said, "South Koreans are increasingly concerned. In spring, everybody is coughing. It is getting worse in recent years." A report in Channel NewsAsia suggested, "There is also growing evidence that the pollution has reached North America."





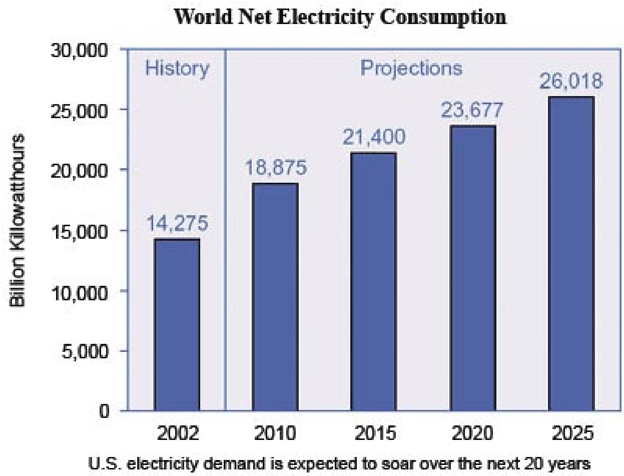
Envisat Photo of China's Nitrogen Dioxide levels, September 2005

According to a U.S. Congressional – Executive Commission on China, which held a series of Issues Roundtables in late 2004, it was estimated that 12 Chinese mine workers die for every million tons of coal produced. Most are killed by methane gas explosions while inside the coal mines. ***China Business Weekly*** reported in July 2000, "To prevent gas explosions, China emits 6 billion cubic meters of methane from mines annually, seriously polluting the environment..." Last year, instruments on the world's largest environment-monitoring satellite, the European Space Agency's Envisat, revealed the world's largest amount of nitrogen dioxide was hanging over Beijing and northeastern China. Because the country emits more methane from its coal mining than any other coal producing country, China pollutes the earth's atmosphere with about one-third of the total annual emissions of methane. According to the US Environmental Protection Agency, methane traps heat twenty times more than carbon dioxide, which impacts global warming.

Chinese Premier Wen Jiabao told the National People's Congress, in March 2006, that the country's growth rate would be reduced to 7.5 percent over the country's next five year plan. Economic growth reached nearly 10 percent in 2005. The strain imposed on China's natural resources and labor has been taking its toll. According to the next five-year plan, China's government policy will concentrate on building a resource-efficient and environment-friendly society. Their idea is to sustain the high output while reducing waste.

Because of the problems China has with coal mining accidents and environmental pollution, their turn to nuclear energy is sensible. This may, however, create supply concerns in the uranium mining sector. In May 2006, China's Ministry of Land Resources announced China plans to build up "sufficient reserves" of uranium and other minerals, in a new five-year government plan. The ministry said it would be stockpiling strategic reserves of uranium, copper, aluminum and other key minerals because of rising demand for those commodities. The Chinese also wish to avoid supply disruptions by hoarding uranium and other minerals, over the next few years.

This has been in the works for a while. A month before the Chinese Minister's announcement, we asked Kevin Bambrough, Market Strategist with Sprott Asset Management about China starting to build up strategic reserves of uranium. He answered, "Why shouldn't they have strategic uranium reserves to supply their nuclear reactors? It makes sense to have a good stockpile of uranium considering the relative cost of nuclear power versus anything else." And now, the Chinese plan to build up a strategic reserve of uranium for their aggressive nuclear program.



Sources: 2002: Energy Information Administration (EIA), International Energy Annual 2002, DOE/EIA-0219 (2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. Projections: EIA, System for the Analysis of Global Energy Markets (2005). Courtesy: Energy Information Administration, U.S. Department of Energy

How does China's buildup of a strategic uranium reserves affect utilities in the United States? In another interview, which we also published in April, Gene Clark, CEO of TradeTech LLC told us, "In reality, the U.S. utilities, which tend to wait longer to contract, may be the ones on the losing end because the Chinese and the Indians will contract early. The implication of current group-think is that the Chinese and Indians are not going to be able to find enough uranium for their new plants. But, they are committing for supplies way out into the future. When the U.S. utilities come to the market, they're going to look around say, 'Oh blankety- blank, what happened? Where's the uranium?' They'll be the ones that sat around. I think that is what's going to happen unless things really change in the way contracting is done in the United States."

At the root of the problem is a shortage of uranium inventory. In June 2004, we asked David Miller, a Wyoming legislator and a consultant to the International Atomic Energy Agency (IAEA), about the then-perceived supply shortage. He responded at the time, "In my opinion, no one has any extra uranium to sell on the spot market. There's just not excess inventory that people are unloading in the spot market." David Miller, who since then became president and chief operating officer of Strathmore Minerals, was right. He forecast the spot uranium price would double (then around $16/pound), which it did. In November 2005, we talked again with Miller, who said, "China is the future wild card... what they are planning for nuclear is probably the most aggressive program in the world."

Under an IAEA contract in 2003, Strathmore Minerals' President, David Miller (center of photo), consulted in China, at the Beijing Research Institute of Uranium Geology to teach Chinese geologists uranium exploration and in situ uranium recovery techniques. In 2006, Miller also presented to the World Nuclear Conference in Hong Kong updating the world's nuclear utilities of Strathmore's uranium production plans for the near future.

In talking about the spot uranium price, Miller said he wouldn't be surprised if it doubled again, adding, "All the new production is already factored into the future market for uranium. We're underwater right now without building one more nuclear power plant." Miller added, "Uranium exploration potential in China is excellent. But until China privatizes this sector, they will be coming to the world's uranium market to meet their uranium requirements." China's current requirements for uranium are modest now, but says Miller, "In ten to twenty years, China may become home to the world's strongest nuclear power growth."

According to the February 6th edition of ***Newsweek***, "In the past few years, Beijing has embarked on the boldest nuclear-energy plan since the one orchestrated by the United States in the 1970s...Nuclear power has thus become an essential part of their plan to prevent an energy and environmental crisis. China intends to increase its output of nuclear power at least fourfold by 2020, from 8,700 to 36,000 megawatts. That will require building up to three reactors a year until then. Already, China's enthusiasm for nuclear power is helping rekindle interest among countries that had abandoned their own programs."

Russia's New Nuclear Allliance

Presidents Putin (left) and Kazak president Nursultan Nazarbaev in one of many meetings. Reportedly, the closest of allies.

Was the day itself an omen? On a Friday the 13th in January 2006, ***The Moscow Times*** newspaper reported that Vladimir Putin announced Russia would be working with Ukraine and Kazakhstan to rebuild the nuclear energy ties which had existed under the old Soviet Union. In mid January, a Russian delegation visited Cairo (another former Soviet ally) to discuss civilian nuclear power reactors. Egypt had drafted a program in 2001 to construct 11 reactors, but abandoned the program in 2005. In late January, Russia's ***St. Petersburg Times*** announced, "Russia strengthened its commitment to atomic energy on Wednesday, as President Vladimir Putin welcomed Uzbekistan into an emerging nuclear alliance." Uzbekistan and Kazakhstan were major uranium producing states under the Soviet regime.

In his 2006 State of the Nation address on May 11th, Vladimir Putin addressed numerous issues, especially nuclear energy. He told his countrymen, *"We must also take steps to develop nuclear energy, a nuclear energy sector based on safe, new-generation reactors. We need to consolidate Russia's position on the world markets for nuclear energy sector technology and equipment and make full use here of our knowledge, experience, advanced technology, and of course, international cooperation. Restructuring in the nuclear energy industry itself also aims at enabling us to achieve these goals. We must, of course, also focus work on promising new directions in energy — hydrogen and thermonuclear energy."*

After the Soviet Union collapsed, breaking up into sovereign identities, Russia kept the nuclear assets, especially the warheads. The Central Asian republics kept the uranium-ore supply, not Russia. Two of those republics, Kazakhstan and Uzbekistan, delivered about 8 million pounds of U3O8 equivalent to U.S. civilian nuclear reactors in 2004. In total, there are now six countries in the benign-sounding Eurasian Economic Community: Russia, Kazakhstan, Uzbekistan, Kyrgyzstan, Belarus and Tajikistan.

While Kazakhstan has garnered the most publicity about its uranium deposits, each of the other ex-Soviet republics have played key roles in the old Soviet Union's nuclear program. Tajikistan helped supply yellowcake and the uranium used in Russia's first nuclear bomb in August 1949 was produced in Chkalovsk. Uranium ore produced in Kazakhstan, Uzbekistan and Tajikistan was milled at the Leninabad Mining and Chemical Combine in the Khodjent district of Tajikistan. It has since been renamed the Vostochnyy Rare Metals Industrial Association. The Argus nuclear reactor, a research reactor designed to run on 21 percent enriched uranium, was completed in 1991 in Dushanbe, but was never loaded with fuel. Tajikistani officials have expressed interest in obtaining fuel (enriched uranium, not ore) and operating the reactor.

Five of the six leaders of the countries, which comprise the Eurasian Economic Community.

Kyrgyzstan is acknowledged as a uranium-rich area as, but to a lesser degree than, Kazakhstan and Uzbekistan. Kyrgyzstan also has the Kara Balta uranium mill, which may be refurbished and operational in this decade.

Perhaps the most interesting country in the Eurasian Economic Community, which has become the umbrella for Russia's nuclear revival, is Belarus. This country had, perhaps, the Soviet Union's leading nuclear research institute. Here is one example of their scientific advances. The now-restructured Belarusian Institute of Nuclear Power Engineering (INPE) designed a mobile nuclear power reactor with a 700 kW capacity (according to Yermashkevich, 630 kW) and created a working model, called Pamir. This reactor was designed for military purposes and for territories, such as the desert or tundra, where it is difficult to connect to an electricity grid. This mobile plant was designed to work in conditions from -50 degrees Celsius to +50 degrees Celsius without any water resources. The project was scrapped in 1986 by a decision of the Belarusian government. Reportedly, the INPE also worked on a project to develop a fast-breeder reactor. This project was almost completed in 1985. A site had been chosen and construction was about to begin when the project was scrapped.

President Putin continues to astutely build his country's nuclear renaissance, for what many believe, as a way to service his country's neighbors: China, India and the Middle East. His chilling remarks in the May 11, 2006 State of the Nation address should also now be considered in the nuclear energy context of defending his country's territory. He said, *"Modern Russia needs an army that has every possibility for making an adequate response to all the modern threats we face. We need armed forces able to simultaneously fight in global, regional and — if necessary — also in several local conflicts. We need armed forces that guarantee Russia's security and territorial integrity no matter what the scenario."*

The HEU Program Will End in 2013

Logo of the HEU program, a joint uranium project between the United States and Russia

It has been nicknamed the "swords to plowshares" program. The HEU (Highly Enriched Uranium) program is called the "Megatons to Megawatts" program on the website of USEC, which is the agent for the U.S. government in this program. Uranium from Russia's decommissioned nuclear warheads has been providing 90 U.S. utilities in 31 states with about one-half of the front end of the nuclear fuel cycle. About 10 percent of America's electricity comes from uranium, which was meant, about forty years ago, to pulverize nearly all major U.S. cities. Now, Russian uranium provides the energy to keep America's lights on.

In 1993, the United States and Russia agreed to convert highly enriched uranium (HEU) taken from dismantled Russian nuclear warheads into low-enriched uranium (LEU) fuel. By September 2005, the HEU program had completed the elimination of weapons-grade uranium equal to 10,000 nuclear warheads. To date, the total fuel purchased from Russia has been enough to generate enough electricity to power the United States for one year.

The program expires in 2013. A major source of uranium to fuel U.S. utility-owned nuclear reactors could vanish. As China, India, and dozens of other countries scramble to secure uranium inventory for their burgeoning civilian nuclear energy programs, a guaranteed supply of uranium, from the HEU agreement, might well disappear. The key is whether or not Russia will renew their agreement. From the looks of it, Russia has its own nuclear energy aspirations. Many who closely follow developments in the uranium and nuclear energy sectors believe Russia will not renew. In the context of a stampeding bull market in uranium, this would be tantamount to fueling a runaway wild fire by hosing the area with gasoline.

Sprott Asset Management Market Strategist Kevin Bambrough doesn't foresee the uranium frenzy peaking until the years 2013 to 2015. What will happen then? "There's a good chance the HEU agreement won't be renewed," said Bambrough. "Russia may not be selling their uranium. The Russians may want to hold onto what they have." And if they do sell, they may not sell to the U.S. In 2004, U.S. utilities imported more than 80 percent of their uranium supplies from foreign sources. "It could be that the Russians are interested in trying to build nuclear plants for other countries and be in that business," he suggested. "That may go hand in hand with 'we're going to build you the facility and we can guarantee you supply.' And Russia would be using the balance of that uranium for their domestic needs."

Ux Consulting president Jeff Combs explained how things were different when the HEU agreement was signed in 1993. He said, "You need to consider how much things have changed from when the current HEU deal was signed. At that time, the Russian economy was struggling, as was Russia's nuclear power program. Now Russia's economy is much more robust, thanks to energy exports. Russia is experiencing a nuclear power renaissance of its own."

Combs concluded, "From this perspective, I think it's quite unlikely that the HEU deal will be renewed. When I say that, I'm referring to the deal between an agent acting for the Russian Government (Tekhsnabeksport [TENEX]) and an agent acting for the U.S. Government (USEC, Inc.) I don't think that necessarily means that there will not be any HEU blended down after the current deal is over, but that could be done for internal consumption in Russia or be used as supply for countries where Russia is exporting fuel for Russian-supplied reactors."

In attempting to determine how long the uranium bull market might last, one must factor in the HEU agreement. The U.S. is the largest consumer of uranium, at this time. It has the greatest number of nuclear reactors, nearly 25 percent of the global total. When its largest single supplier stops providing the uranium, there is cause for concern. In a discussion with the CEO of TradeTech LLC, Gene Clark, about the peak and trough of the current uranium bull market cycle, the year 2013 again materialized. In one his company's price models, he forecast, "Depending on the scenario, we see the peak possibly at 2008 or so. I would say we're looking at a trough around the timeframe of 2011 to 2013. Then back up after that."

How Fast Will the Middle East Convert to Nuclear Energy ?

One of the most unlikely places, where nuclear energy could see its strong expansion over the next two decades, is the Middle East. This region is instantly associated with petroleum, not uranium. North and northeast of the Middle East, in Central Asia, are the uranium-rich countries of Kazakhstan, Uzbekistan and Kyrgyzstan. Our research confirms major Middle Eastern countries have progressed far beyond the basics of establishing a civilian nuclear energy program. This may sound shocking, at first, perhaps incredulous, but there is adequate data found on the Internet, confirming our conclusions. (For example, in the next section of this chapter, we'll discuss Indonesia, which is not part of the Middle East aside from its ties to the Muslim religion. Did you know that Indonesia has quietly been developing its nuclear program for more than four decades?)

Will Iran Be the First?

Iran President Mahmoud Ahmadinejad

Iran has been the focus of controversy about its country's plans to launch a civilian nuclear energy program. The political and media tempest is about highly enriched uranium and bomb-making. Low-enriched uranium is used to power nuclear reactors. Highly enriched uranium is used in nuclear warheads. There is a breadth of background surrounding Iran's emerging nuclear industry. The country has been fiddling with starting a civilian nuclear energy program for more than four decades. We predict it will be the first Middle Eastern country with a civilian nuclear energy program, based upon all the events which transpired over the past three decades.

Iran signed a civil nuclear cooperation program with the United States in 1957 under President Eisenhower's Atoms for Peace program. The United States then equipped the Tehran Nuclear Research Center with a 5 megawatt nuclear research reactor in 1959. It was fueled with highly enriched uranium and began operations in 1967. In 1974, Iran's Shah Mohammad Pahlavi announced plans to construct 23 nuclear power stations throughout Iran by the year 2000, saying, "We envision producing, as soon as possible, 23,000 megawatts of electricity using nuclear plants."

Ironically, it was the Bushehr plant where Iran's nuclear energy program would begin, and around which the present-day controversy has focused. By 1975, a joint venture of Siemens AG and AEG Telefunken signed a contract worth up to $6 billion to build a pressurized water reactor nuclear power plant near Shiraz. Two 1,196 MWe nuclear generating units were subcontracted to ThyssenKrupp to build by 1981. After receiving $2.5 billion of the contract, the German joint venture withdrew from the Bushehr nuclear project in July 1979, convinced the Islamic Revolution would end their work in Iran. One reactor was 85 percent completed, while another reactor was half completed.

In August 1974, the Shah forecast the world's oil supply would run out and said, "Petroleum is a noble material, much too valuable to burn." He wanted nuclear energy to help his country grow. After the Shah fled the country during the Islamic Revolution, his successor declared nuclear energy the work of Satan. Iran's nuclear program lay dormant for more than a decade.

While the Shah of Iran was still in power, President Gerald Ford and Secretary of State Henry Kissinger were actively endorsing Iran's nuclear energy plans. In 1975, Kissinger had signed *National Security Memorandum 292*, entitled, "US-Iran Nuclear Cooperation." Kissinger tried to get Iran to buy nuclear energy equipment from Westinghouse and General Electric, which would have obtained about $6 billion in revenues for them. President Ford signed a 1976 directive offering Iran a US-built reprocessing facility with the capability of extracting plutonium from nuclear reactor fuel. The President's strategy paper stated, "... introduction of nuclear power will both provide for the growing needs of Iran's economy and free remaining oil reserves for export or conversion to petrochemicals."

Because of the Shah's efforts, Iran had been both an early and active participant in helping the nuclear industry move forward. In 1974, when Sweden withdrew from EURODIF (an acronym for European Gaseous Diffusion Uranium Enrichment Consortium), the Shah of Iran lent the joint stock company $1 billion for Sweden's 10 percent interest. Formed in 1973, the consortium was formed and jointly owned by France, Belgium, Spain and Sweden. Cogema, a French government subsidiary, formed Sofidif (Societe franco-iranienne pour l'enchrichissement de l'uranium par diffusion gazeuse) with Iran, which owned 40 percent of this venture. Sofidif acquired a 25 percent share in EURODIF, which meant Iran then owned Sweden's 10 percent interest. Iran chipped in another $180 million in 1977. Through the Shah's investment, Iran was reportedly entitled to buy 10 percent of the enriched uranium produced by EURODIF. That never happened.

After the Khomeini's rise to dominance in Iran, the French reneged on supplying enriched uranium. Iran wanted its billion dollars back plus interest. The French balked. French investigative journalist Dominique Lorentz wrote about the alleged multiple terrorist acts, which followed France's snubbing of Iran. These included the 1986 assassination of Georges Besse, who helped pioneer France's nuclear program and who was EURODIF's leader. On the day Besse was murdered, France paid back Iran $330 million. French hostages taken in Lebanon in 1985 were released in 1988 after French premier Jacques Chirac signed an accord with Iran, giving the country back its shareholder status in EURODIF. He also promised delivery of enriched uranium to Iran "without restrictions." On December 29, 1991, French president Francois Mitterand reportedly signed a secret accord concretely defining Iran's shareholder status in EURODIF, and again promising Iran the right to receive 10 percent of EURODIF'S enriched uranium.

Ironically, the factory now producing the enriched uranium was named after George Besse. Today, EURODIF supplies nearly 100 nuclear reactors in France and throughout the world. About 45 percent of EURODIF's sales revenues come from enriched uranium the consortium sells outside of France, including Brazil, Japan, Germany, Russia and the United States. How will the French-Iranian agreement change when EURODIF switches from gaseous diffusion to centrifugation enrichment over the next 15 years? That remains to be seen.

Iran should have no problems acquiring uranium for its nuclear facilities. If not EURODIF, then there is always one of the world's leading uranium mines in which they hold a minority share. Since 1975, Iran has owned a 15-percent share in Namibia's Rossing uranium mine, which produces about six percent of the world's supply of uranium. The majority owner, Anglo-Australian Rio Tinto, sells Rossing's uranium to utilities in the United States, Japan, South Korea and Sweden. For all we know, the electricity powering the White House may be generated from Rossing uranium in which Iran has a stake. (That's not too far-fetched. Dominion Power owns the nuclear power plant at Lake Anna, Virginia, which is northwest of Richmond. It's not uncommon for utilities to sell each other electricity. Ironically, it is less of a stretch to believe CIA headquarters in Langley, Virginia gets it electricity, at least in part, from the nuclear fuel provided by Iran.)

The entire Middle East is looking upon Iran as the test case for expansion of nuclear energy in the region. In late April, Yemen's Deputy Foreign Minister announced, "We hope that with sound judgment and prudence shown by Iranian officials, and taking into account the legitimate right of Iran to use peaceful nuclear technology, the issue will be resolved through diplomacy and negotiations." After Iran has overcome the international hurdles for establishing its civilian nuclear energy program, the remaining Middle Eastern countries might stampede into nuclear energy. Many countries such as Syria, Algeria, Morocco, Jordan and others have been laying the groundwork for civilian nuclear energy program for several decades.

Saudi Arabia's Gas & Water Problems Could Lead Them to Nuclear

An April 2006 UPI news item confirmed what many have long believed. It won't be long before Saudi Arabia launches a nuclear project. Kuwaiti researcher Abdullah al-Nufaisi told seminar attendees in Qatar that Saudi Arabia is preparing a nuclear program. He said the government was being urged to launch a nuclear project by Saudi scientists, but had not yet received the blessing by the royal family. Social, not energy, issues could

Saudi Arabia' desalination plants account for more than 20 percent of the world's total.

help the Saudi royals embark on a large-scale nuclear program.

Of the Kingdom of Saudi Arabia's 24 million subjects, more than 40 percent are under 18 years of age. While still manageable, the country's infrastructure is not prepared to deal with its explosive population growth. The two biggest problems facing Saudi Arabia are potential water and electricity shortages. True, its super oilfields may also have peaked in production and might move into tertiary recovery, but that remains an unknown. An Islamic revolution, similar to what Iran suffered in the 1970s is probably foremost on the King's mind. Civil unrest might come about should his subjects suffer from insufficient electricity and inadequate water supplies. One need only look at the widespread electricity shortages Syria experienced in the 1980s and early 1990s.

As reported in the October 14, 2004 issue of ***Arab Oil and Gas***, the Saudis lag well behind Bahrain, Kuwait, Qatar, and the United Arab Emirates in per capita energy consumption. The rate of natural gas consumption, which produces Saudi's electricity, increased less than Egypt and Syria. Total energy consumption dropped by 3.5 percent in 1999 and 2000.

The internationally heralded "Gas Initiative" of 1998 was the Kingdom's attempt to lure major western oil companies back into the country to help develop its natural gas reserves. After major oil companies spent $100 million in due diligence to evaluate the Saudi natural gas reserves, the initiative quietly dropped off the world's radar screen. A Shell Oil executive, whose company is exploring for gas in the country's Empty Quarter, told Bloomberg Daily Energy News that this was a high-risk venture with a low probability of finding sizeable reserves. In Matthew Simmons' ***Twilight of the Desert***, he repeated what he was told by an anonymous senior oil executive, "The reservoirs are crummy."

The Saudis need water and electricity to match their population growth. Nuclear energy could become the solution for both those problems. Continued dependence upon natural gas may prove a fatal economic and social error for the royal family. Our research forecasts the Saudis might announce a large-scale civilian nuclear energy program in the near future.

Let's discuss the water problem first. In a 2002 story reported in the ***Oil & Gas Journal***, Saudi Arabia's 30 desalination plants produce about 21 percent of the world's total desalinated water production. Nearly 70 percent of the local water drunk in cities comes from desalinated sea water. As the population grows, Saudi Arabia may spend another $40 billion to build more desalination plants.

Half of the world's desalination plants are in the Middle East. Most are powered by fossil fuels, especially natural gas. Converting sea water to potable water is energy intensive. The commonly used desalination method of multi-stage flash (MSF) distillation with steam requires heat at 70 to 130 degrees centigrade and consumes up to 200 kilowatt hours of electricity for every cubic meter of water (about 264 gallons). MSF is the most popular technology, but some are turning to reverse osmosis (RO). RO consumes about 6 kilowatt hours of electricity for every cubic meter of water.

Saudi Arabia's Jubail desalination plant is the largest in the world, daily converting 800 million gallons of seawater into much-needed fresh water.

Desalination is very expensive. The cost to generate this electricity through natural gas explains why Saudi Arabia spends about $4 billion in operating and annual maintenance costs.

There are numerous precedents in combining water desalination with nuclear energy for electrical generation. The World Nuclear Association highlights the BN-350 fast reactor in Kazakhstan, which has produced 135 MWe of electricity and 80,000 cubic meters per day of potable water for nearly 30 years. In Japan, ten desalination facilities are linked to pressurized water reactors producing electricity. The International Atomic Energy Agency is working closely with about 20 countries to implement dual-use nuclear reactors, which would also desalinate water.

According to the World Nuclear Association's website, *"Small and medium sized nuclear reactors are suitable for desalination, often with cogeneration of electricity using low-pressure steam from the turbine and hot sea water feed from the final cooling system. The main opportunities for nuclear plants have been identified as the 80-100,000 m3/day and 200-500,000 m3/day ranges."*

There are numerous examples of nuclear desalination being considered. In 1977, Iran's Bushehr nuclear facility was to also have a 200,000 cubic meter/day MSF desalination plant. Construction delays, and the subsequent Islamic revolution, prevented this from occurring. Perhaps when Iran commences its civilian nuclear program, the desalination plant will be revived. China is reviewing the feasibility of a nuclear seawater desalination plant in the Yantai area. Russia has advanced a nuclear desalination project with barge-mounted marine reactors using Canadian reverse-osmosis technology. India has begun operating a nuclear desalination demonstration plant at the Madras Atomic Power Station in southeast India. Another one may soon follow in the southern Indian state of Tamil Nadu, which perpetually suffers from water shortages. Pakistan continues its efforts to set up a demonstration desalination plant. South Korea has developed a small nuclear reactor design for cogeneration of electricity and water. It may first be tested on Madura Island in Indonesia. Argentina has also developed a small nuclear reactor design for electricity cogeneration or solely for desalination.

The Saudis have investigated dual use for nearly thirty years. Since 1978, Saudi scientists have studied nuclear desalination plants in Kazakhstan and Japan. Both studies positively assessed the feasibility of bringing the first dual-use nuclear reactor in Saudi Arabia. Since the mid 1980s, scientists and researchers at the Saudi's Nuclear Engineering Department at King Abdulaziz University, the College of Engineering at the University of Riyadh, the Chemical Engineering Department of King Saud University, and the Atomic Energy Research Institute have researched and evaluated nuclear desalination. Saudi scientists presented their paper, entitled, 'Role of Nuclear Desalination in the Kingdom of Saudi Arabia,' at the First International Conference on Nuclear Desalination in Morocco in October 2002.

The country possesses a tandetron accelerator and a cyclotron capable of isotope production for medical purposes. Saudi's nuclear scientists have been involved with many countries to help their country develop a bonafide nuclear energy program. In late March 2006, a German magazine reported Saudi Arabia has been secretly working on a nuclear program with help from Pakistani scientists. Ironically, many believe Saudi Arabia helped finance Pakistan's nuclear program. Because Saudi scientists lack the proven experience of the entire nuclear fuel cycle, Pakistan's expertise, over the past decade, could help accelerate the Kingdom's pursuit of a civilian nuclear program.

While lacking proven uranium deposits, the country's Tabuk region has low-grade amounts of uranium and thorium. However, Saudi Arabia has significant phosphate deposits, which some believe could be exploited. The country's two largest deposits reportedly measure about 750 million metric tons, averaging between 19 and 21 percent P2O5. Mined by the Saudi Arabian Mining Company and the Saudi Basic Industrial Corporation, fertilizer plants at the Al Jubail Industrial City produce about 4.5 metric tons of P2O5 annually. While extraction of uranium from phosphates can be an expensive proposition, the phosphates could provide a ready supply or uranium for the country's nuclear desalination plants. Then, it would be a matter of uranium enrichment, of which both the Russians and the French would be scrambling to provide the Kingdom.

While the Saudi program many not directly impact world uranium prices, the Kingdom's decision to advance its nuclear program, beyond the research and medical stage, would signal to the entire world that nuclear energy programs will be a primary growth sector for the next fifty to one hundred years. Should the Saudis also commence desalination projects using dual-use nuclear reactors, this could change the entire landscape of the water situation for the Middle East, and also impact Africa. It would most likely spark a significant stampede of the Kingdom's neighbors into the global nuclear renaissance.

Other Middle Eastern Countries

Turkey

If Iran continues to be delayed in launching its nuclear program, then perhaps Turkey may be the first Middle Eastern country to build a series of civilian nuclear power plants. In the late 1990s, Turkey had planned to build up to 20 nuclear reactors by 2020. Again, politics interfered when a pro-Islamic government took office. This country's goal was revived in early February 2006 when Turkish Energy Minister Hilmi Guler met U.S. Energy Secretary Samuel Bodman in Washington to move forward. Together, they toured a nuclear reactor in Virginia after their discussions.

Egypt has also been in the running for a civilian nuclear reactor program for many years. Since the 1950s, Egypt has been in the development stages for the entire nuclear fuel cycle. The IAEA has helped this country with uranium exploration and milling techniques. Egypt's Nuclear Research Center and Atomic Energy Authority have covered nearly all the bases in establishing a full-fledged nuclear program. But, until now, it has all of Egypt's efforts have been in the experimental and research phase. The country's Nuclear Material Authority has explored for, to develop, uranium deposits in Egypt's Eastern Desert area, and discovered new deposits in the West Sinai and Gabal Kadabora regions. Russia and China may both compete to help bring Egypt's nuclear program to fruition.

For thirty years, Syria has had an Atomic Energy Commission, and a feasibility study for nuclear power options for electricity generation was begun in 1979. Since the early 1980s, the country has tried to construct a nuclear reactor, hoping to have one in operation by 1991. In fact, the country envisioned having six 600-megawatt reactors functioning by the mid-1990s. By 1991, all Syria had to show for their efforts was a Chinese built SRR-1 miniature neutron source reactor, but no nuclear program to resolve its frustrating battle to power its country with reliable electricity. Russia may someday make good on its promise to build a nuclear facility and nuclear desalination plant for Syria.

Middle East Summary

Fears of water and electricity shortages, anxiety about depleting oil reserves, and the desire to bring their countries into a more modern lifestyle is driving Middle Eastern countries to pursue the civilian nuclear path. What many Americans and Europeans may not understand is that China, Japan, Korea, Russia and Argentina will pursue business with the Middle Eastern countries without the political concerns of terrorist threats to their countries. Many of tomorrow's nuclear engineers, who would bring their countries into the Nuclear Age, will have been trained in Western Universities. Many already have, and many are being, trained now.

Take for example, Rensselaer Polytechnic Institute (RPI). RPI has granted more undergraduate degrees in nuclear engineering, over the past three years, than any other university in the United States. One of the leading students in the Class of 2006 was Rian Bahran, president of Rensselaer's American Nuclear Society (ANS) student chapter. As part of his leadership, Bahran recruited top leaders in industry, government and academia to speak at the 2006 ANS national student conference.

Among those who came to talk to tomorrow's nuclear engineers were Admiral Bowman, who heads the Nuclear Energy Institute; Gregory Jaczko, U.S. Nuclear Regulatory Commissioner; Joseph Indusi, senior scientist and chairman of the national security department at Brookhaven National Laboratory; and Moustafa Bahran, chairman of Yemen's National Atomic Energy Commission, who is also the science and technical advisor to the president of Yemen. The latter is also Rian's father. Rian plans to pursue his PhD in nuclear engineering, hoping to later engage in the international dialogue about nuclear issues. He announced in an RPI news release, "There are not enough people with technical backgrounds making policy decisions about nuclear energy, nonproliferation, and science in general."

It is through tomorrow's nuclear scientists, such as Rian Bahran, that the Middle East will grow its civilian nuclear energy program. This region of the world is yet another reason why the nuclear energy renaissance is still in its infancy, with decades more to mature. When it begins to mature, uranium miners will then have new buyers for their yellowcake.

Sleeping Giants: Africa, South America and Asia

Most of the growth in nuclear energy will grow, not in the mature economies, but in the emerging countries. As demand for electricity soars, demand to have nuclear reactors will follow. Environmentalists will continue to hinder growth in the mature economies around the world, with their hyperbole about wind farms, solar energy and tidal waves. Following such advice might decelerate GDP growth in the United States and Europe. Predictably, the greatest percentage of economic growth for the rest of this century is likely to occur in Asia, South America and Africa.

The number of countries, which announced in the first half of 2006 a strong interest in developing a nuclear program, jumped higher by any other timeframe in history. Some have been more widely publicized than others. Rather than discuss all of the candidates for nuclear energy expansion, we will outline plans announced by some in each of the three world's regions of this section: Asia, Africa and South America.

Asia: The Prime Mover

Having previously discussed China, our focus is with relatively smaller, but still highly populated, countries where nuclear energy could quickly expand. India has been omitted in this section because it is evident India will emerge as major player in the nuclear energy picture. Much of what has been reported about China will also hold true for India. When India's nuclear program unfolds, and as this populous nation tries to catch up to China, the uranium shortage could greatly accelerate.

Indonesia is a country, where we could expect strong growth in nuclear energy. With more than 231 million people, the world's fourth most populous country, Indonesia, has had nuclear ambitions for about fifty years. The archipelago nation has announced plans to commence construction of a nuclear power plant in 2010 and have it operational by 2016. Indonesia hopes to build up to 12 facilities. The first location is reportedly the island of Java, which is about the size of New York State and has about 110 million residents.

Indonesia has a well established nuclear research program spanning nearly five decades. With four nuclear research facilities in operation (located in Jakarta, Bandung, Yogyakarta, and Serpong), a cadre of trained professionals and ties to the IAEA, foreign capitals, universities, and research labs, BATAN has long conducted research projects and published papers on sundry nuclear development related matters. The country also has indigenous uranium assets, which could be economically mined for domestic use. However, should nuclear demand expand to meet its population's needs, Indonesia will probably have to import uranium to fuel its reactors.

Vietnam may have its first nuclear reactor operational by 2020. Vietnam's Ministry of Industry and Electricity has been carrying out a pre-feasibility study for the construction of its first nuclear power plant. According to the country's news service, "Atomic energy would be crucial to meeting the country's energy demands in the coming century, particularly as the number of coal, oil and hydro-power options begin to diminish."

South Korea

The Republic of Korea has relied upon nuclear energy to fuel its thirty-year economic growth of about 8.6 percent per annum. Electricity demand from 1978 to 2005 increased by ten fold to 365 TWh. It imports about 97 percent of its energy sources. The country has 20 nuclear power plants in operation. Nuclear power supplies South Korea with about 40 percent of its electricity. Eight more nuclear reactors are to be constructed over the next decade. South Korea's reactor capacities run at one of the highest capacities in the world at 96.5 percent. The country also has two research reactors, which are used for production of radioisotopes, medicine and agricultural research.

Korea would be adversely affected by a continued rise in uranium prices, or a scarcity of supply. It has investigated black shale deposits, containing uranium, but those are low grade. Uranium extraction would be expensive. Because it is deficient in a uranium resource, and highly dependent upon nuclear energy to power its electricity grid, Korea is a high-traffic importer of enriched uranium. Most of the country's uranium originates from Australia, which now being pursued by China.

Korea will likely play an integral role in the nuclear/uranium renaissance as an exporter of nuclear technology. It may provide both Indonesia and Vietnam with its OPR-1000 (Optimized Power Reactor). However, what could make Korea invaluable to the Middle East is its SMART reactor, a 330MWt pressurized water reactor. It is being developed by the Korean Atomic Energy Research Institute and is said to have advanced safety features. It may be able to generate electricity up to 100 MWe and also utilized in seawater desalination. It reportedly will have a three-year refueling cycle and work for up to 60 years. A demonstration plant may be ready for 2007.

Africa's Great Potential

Africa is a great land of mineralization and natural resources. Uranium from Africa helps power the world's nuclear reactors. But the continent hardly benefits from the resources it provides the rest of the world. South Africa is the only country in Africa with a nuclear power plant. Crippling electricity blackouts have led the country to consider building a second nuclear plant. The country's Vaal River mine, owned by Anglogold, is the world's tenth most productive uranium mine, producing nearly 2 percent of the global uranium mined. Ironically, four of the world's top ten uranium mines are located in Africa. Each of the three mines located in Niger and Namibia produce more uranium than the Vaal River mine.

Africa

While there are other countries in Africa planning to turn to nuclear energy, Algeria is the most interesting example to review. For example, Morocco plans to invest in its nuclear program. The head of the country's electricity service announced in April 2006, "The nuclear option is now part of our investment programme. The decision has been taken." The IAEA has already approved a site south of Casablanca for the construction of a power site. Libya signed an agreement with France to proceed with peaceful nuclear research. Clearly, North Africa will become a major consumer of uranium. This brings us back to Algeria.

Algeria is one of several countries which once had close ties to France. The country also possesses about 56,000 tons of uranium in an area called the Targui Shield. There are four main deposits, which have not been exploited. The promising Tahaggart deposit, near the Niger border, was discovered in the 1970s, but has yet to be mined. The country, like Indonesia, is also a top natural gas producer. Comparable of the suspicions surrounding Syria's ambitions to launch a nuclear energy program, mistrust of Algeria in the international community has put it on the watch list. But, as with Libya, political climates could change.

Since the 1980s, China has supplied Algeria with nuclear technology. A secret accord, signed in 1983, included the construction of a nuclear complex to house the Es Salam nuclear reactor, a hot cell laboratory and a reactor for producing radioisotopes. Argentina sold Algeria the Nur research reactor and planned to build a fuel fabrication plant, but this deal fell through. Should Algeria capitulate its military ambitions, it might be possible for the country to become a significant player in all aspects of the nuclear fuel cycle over the next two decades.

How long will Africa's great potential remain unrealized? With the possibility of extended droughts, the expansion of deserts and epidemics throughout Africa, turning to nuclear energy may be what the continent needs to save it. Imagine nuclear desalination plants across the continent? It would change Africa forever.

South America: An Undiscovered Giant

Brazil could be regarded as the biggest of the world's sleeping giants with regards to the nuclear renaissance. Its nuclear research program pre-dates nearly every other country. Brazil had discovered enormous uranium reserves in the 1930s. In 1940, Brazil and the United States signed a cooperative mining of uranium and monazite. Through the 1940s, the United States transferred nuclear technology to Brazil in exchange for monazite. Brazil benefited from the Atoms for Peace program in the 1950s, and two research reactors were built.

During the 1970s uranium bull market, more than $150 million was spent exploring Brazil's uranium deposits. It reportedly hosts four percent of the world's known uranium reserves. Brazilian uranium powers its two nuclear reactors, which provide about four percent of the country's electricity, but about 40 percent of this energy used in Rio de

Janeiro. The first reactor was designed by Westinghouse. An additional eight were to be built by West Germany, using Siemens equipment, but economic problems prevented completion of the plan.

In May 2006, Brazil launched a full-scale uranium enrichment facility, outside of Rio de Janeiro. This facility will reportedly produce 60 percent of the enriched uranium for its two power plants. By enriching its own uranium, Brazil will save about US$11 million per year. Previously, the country had shipped its uranium overseas for enrichment. Brazil's Science and Technology Minister Sergio Rezende announced upon the completion of this facility, "Wind and solar power were not viable on a large scale in Brazil. Studies have shown that nuclear energy is the alternative way to respond to large-scale energy demands in a clear and safe way."

South America

Brazil's neightbor, Argentina has two nuclear reactors generating less than nine percent of the country's electricity. Lack of funds in the 1980s prevented another four more reactors from being constructed. This country's small nuclear program may expand should the country attract outside financing. Argentina's questionable financial problems prevent any significant expansion for the time being.

Uranium mining in Argentina is minimal. The country's cumulative production since the 1950s totals a little more than 2500 tons of uranium. In 2003, there was about 20 tons of uranium production. Most of the uranium would come from the Sierra Pintada mine and Cerro Solo. Combined the reserves are less than 8000 tons.

Argentina's nuclear energy program appears stalled, but there is hope. In Chapter 7 we explore nuclear reactors and the Generation IV forum, of which both Argentina and Brazil participated. Argentina's nuclear future may depend upon its engineers. If they successfully produce an advanced reactor design, this could become a boon to the country's nuclear program. Then again, they are competing against the likes of General Electric, Toshiba and others for reactor designs and the billions of dollars these conglomerates attract, when building nuclear power plants.

Conclusion

Unfilled Uranium Requirements of Owners and Operators of U.S. Civilian Nuclear Power Reactors, 2005-2015 (Thousand Pounds U3O8 Equivalent)

Year	As of December 31, 2004		As of December 31, 2005	
	Annual	Cumulative	Annual	Cumulative
2005	3,302	3,302	NR	--
2006	6,641	9,942	1,585	1,585
2007	12,823	22,765	6,093	7,678
2008	26,303	49,068	6,636	14,313
2009	W	W	28,631	42,944
2010	W	W	41,847	84,791
2011	W	W	38,418	123,210
2012	57,941	262,669	54,942	178,152
2013	53,822	316,491	49,845	227,997
2014	48,969	365,460	44,888	272,885
2015	NR	--	55,137	328,023

W = Data withheld to avoid disclosure.
NR = Not Reported.
-- = Not available.

Note: Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration: Form EIA-858 "Uranium Marketing Annual Survey" (2004-2005).

Globally, there is a scramble by emerging economies to secure uranium supplies. China, India, Korea, Japan, Russia and others have begun the long process of developing relationships with significant uranium-producing countries, such as Australia, Canada and Kazakhstan. Some foreign utilities have progressed with uranium development companies, which are presently mining uranium in the United States or plan to do so. To a very large degree, as described by the table, preceding these remarks, and the chart, which follows, U.S. utilities are not prepared for the worldwide expansion in nuclear energy. Mostly, from our discussions with industry insiders, U.S. utilities are asleep at the wheel. Complacency has lulled U.S. utilities into believing there will be no scarcity of uranium for their nuclear reactors. Because U.S. utilities are giants among the world's nuclear members, it appears they collectively believe uranium will be at their doorstep, when they really do need it for their reactors. Environmental groups needle utilities at every step, offering unlikely schemes such as wind farms and solar panels, making it harder for utilities to move forward.

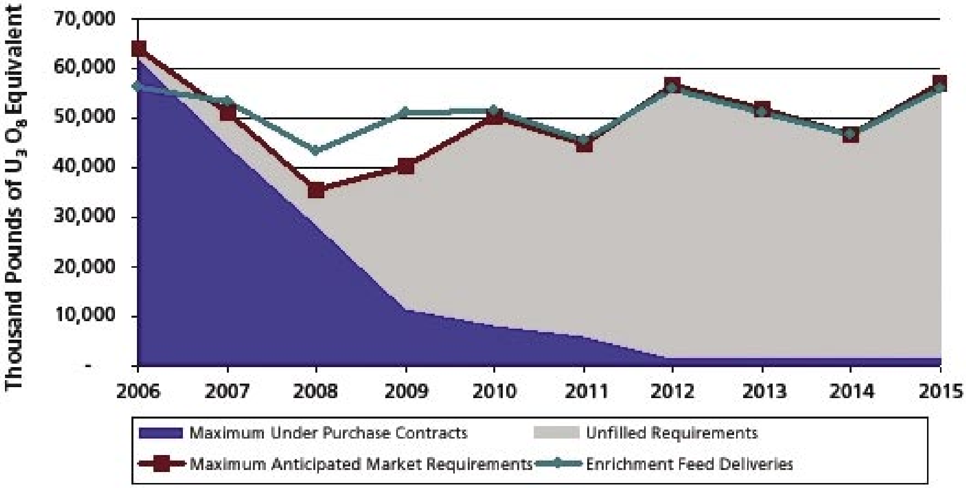
Was it prescience or propaganda? Optimists might view the Atoms for Peace program of the 1950s as a blessing, which was years ahead of its time. By planting the seeds of nuclear energy for medical and research purposes, and training foreign scientists, the nuclear energy cheerleaders of fifty years ago helped prepare an energy-starved world for the calamity which lays ahead. Cynics will scream back that the Atoms for Peace propaganda gave birth to widespread abuse and weapons of mass destruction. It should be noted here that a nuclear bomb has not been used in military warfare since World War II. Over the course of the past five decades, there have been a few close calls. There were times when nuclear weaponry was nearly used to resolve territorial issues. Fortunately, clear-thinking political leaders settled each one with diplomacy.

We side with the optimists. They forecast a world where nuclear energy can and will solve social issues, such as war, poverty, famine and disease. All four of these key problems have been positively impacted by nuclear energy. Because of the horrifying power of the nuclear bomb, it has not been used to solve a petty land squabble. Atomic research has helped preserve food longer and make it more widespread in areas of the world, where it would not have been possible. Nuclear research, since the time of Mme Curie, has helped advanced medicine. Widespread nuclear power might help eliminate poverty by bringing affordable energy to locations where there is not now electricity.

Skeptics will disagree. But, there will always be the naysayer. Such pessimists have populated all cultures through the timeline of history, especially the Dark Ages. After numerous investigations into the environmental movement, we concluded the stereotypical environmentalist would be happiest living in a cave in the Stone Age, warming himself by the fire of deadwood. What we now call the "environmentalist" was once called an anarchist, a rabble rouser, and a disturber of the peace. He or she is someone who can not observe, who parrots someone else's dogma without a second thought and who has no scientific background. Today's true environmentalists are the nuclear engineers and geologists who do want a better world. They are taking the actions to carefully preserve nature, while feeding the hungry masses the electricity those peoples loudly demand.

The problem ahead, in this century, is the explosive population growth. By 2050, the number peopling this earth will have jumped from about 6 billion to perhaps 10 billion. There is plenty of room for all of us to live happily, but will there be enough energy to go around? And to what degree would you, yourself, agree to have your quality of life reduced to? Would you be willing to sit in darkness, every other night, without a television? Be rationed "computer time" thrice weekly, because there is insufficient power at certain times of the day? Few would readily agree to such sanctions. The ones who would later scream the loudest against such supposed tyranny would today's environmentalists.

Maximum Anticipated Uranium Market Requirements of Owners and Operators of U.S. Civilian Nuclear Power Reactors, 2006-2015, as of December 31, 2005



Source: Energy Information Administration: Form EIA-858 "Uranium Marketing Annual Survey" (2005).

How many Chinese will want iPods, personal computers, camcorders, laptops, DVDs and sub-zeros refrigerators? Who will settle for less than a luxury sedan? China's middle class is now reportedly larger than the adult population of the United States. They number 300 million. And another billion are slaving away trying to become part of that middle class. India, Vietnam, Indonesia, Korea, Brazil and Russia all want more. Just as the Eisenhower conservatives flooded dozens of countries with nuclear reactors, liberal Hollywood has swarmed the world with the glories of technology. Asia, Africa, South America and every indigent country wants to be just like the Americans in some ways!

As technology advances, the world becomes more reliant upon electricity-based products: computers, cable television, satellite dishes and the Internet. Perhaps it was simpler when there were just televisions, washer/dryers and radios. But, then we had VCRs, mobile phones, camcorders and laptops. More gadgets enter the marketplace every year. Now we have MP3 players, satellite radios, portable gaming devices and PDAs. When will it stop? Probably never. The entire 1990s was a decade of change for North America and Europe. Technology swept through our cultures and forever changed the way we worked, the food we ate, and the ways with which we entertained ourselves. Would you, for one minute, believe that someone in Marrakech, Beijing or Sao Paolo doesn't want the very same luxuries you are now enjoying?

It's not just the newer things. Every consumer wants bigger and better, as their purchasing power increases. As the middle class of each country grows, they want bigger automobiles, bigger homes, and bigger TV screen or plasma televisions. Many have become more energy-efficient, but collectively still consume more electricity. The number of people with purchasing power will grow as the population increases. Greater purchasing power means consumers can buy more things. Whichever things those are, they consume energy to produce. And often require energy to use them. As the world's productive classes grow, more electricity will be consumed.

Subsequently, because of rising electricity demand, there are few options remarkably capable of providing clean and reliable electricity across the world. The confluence of expansionary policies, which began throughout the last century, the concern over cleaner air and global warming, which are increasingly bearing down on the minds of environmentalists, and the soaring demand of global electricity, have all caught the world unprepared for the upcoming uranium supply crunch.

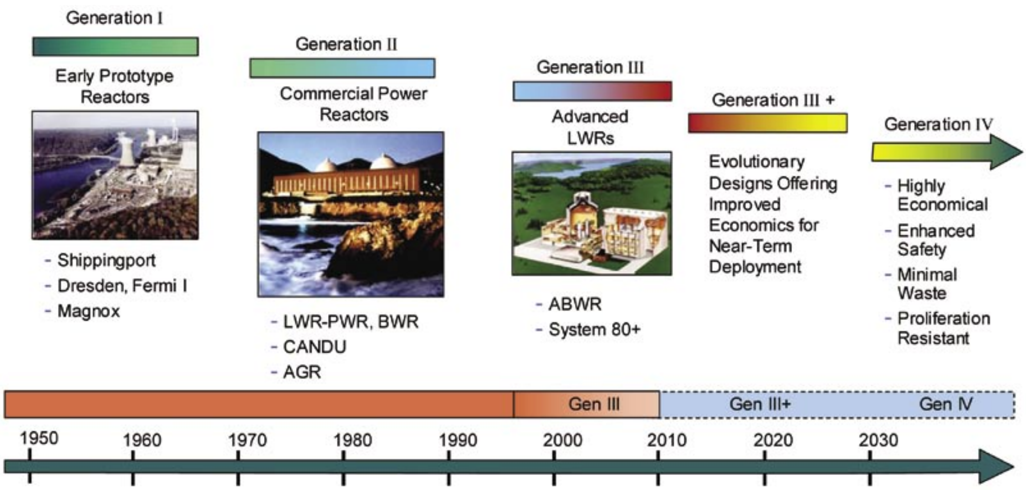
Two of the primary concerns about nuclear energy are its abuse as a terrorist threat or the safety of nuclear reactors. A new generation of nuclear reactors is now being planned with that in mind: advanced safety controls to prevent another Chernobyl or Three Mile Island. Nuclear engineers around the world are ensuring they will also be terrorist-resistant. We have devoted Chapter 7 of this book to previewing what some of the world's leading scientists have in store for us. Critics will announce these safeguards are not possible. Instead, they will remind us about renewable energy sources, such as wind and solar. Have they ever understood the concept of baseload electricity? Baseload is the portion of electricity generated, which remains continuous and does not vary over 24 hours. To date, none of the proposed renewable energy sources meet the "baseload electricity" acid test, aside from hydroelectric. None are envisioned to reach that critical phase for several decades.

Growth in nuclear energy will accelerate through the rest of this decade. It may very well grow exponentially in the second decade of this century. After that, depending upon electricity requirements, GDP growth and population growth, nuclear energy may well expand beyond providing less than 20 percent of the world's electricity. Should it remain consistently at 16 percent, the growth of electricity demand over the next four decades will require a great deal more uranium than is currently being mined. There may come a time, during the next decade, when the construction of nuclear reactors may decelerate because of a lack available uranium to fuel them.

Until then, we believe a uranium supply crunch is coming for all of the reasons explained in this chapter. By the beginning of the second decade, it should be widely felt.

CHAPTER 7

Tomorrow's Reactors Could Strengthen the Uranium Bull Market



The Timeline of Each Nuclear Reactor Generation

The next generation of nuclear reactors will help set the stage for what may become the greatest run in uranium prices. Consequently, this will be reflected in the share prices of those companies who are developing uranium properties for production. It is not just

Experimental Breeder Reactor-I made history when on Dec. 20, 1951, it produced usable amounts of electricity from nuclear power for the first time. It is now a National Historic Landmark where visitors can see early nuclear reactors. Courtesy: Idaho National Laboratory

Installing the reactor vessel into Experimental Breeder Reactor-I .

a case of newer reactors replacing older ones, but the first series of new ones are expected to have 60 to 100 percent more capacity than current ones. Old reactors will be decommissioned, and new ones will replace those in many cases.

A great number of countries are vying to commence a civilian nuclear energy program before 2020 to meet the soaring demand for electricity. One forecast by the U.S. Department of Energy indicated the U.S. will need about 335 billion watts of new generating capacity by 2025. To meet this demand through nuclear energy alone, the U.S. would need to more than double its current fleet of reactors, or build many more reactors which would generate twice the electricity of those now operational.

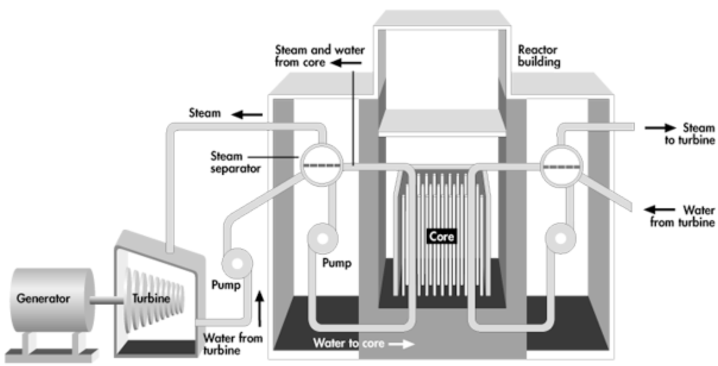
The combination of new reactors and non-nuclear countries commencing operations could quickly send the long-term uranium price to record levels. First, let's address the idea of nuclear safety, especially those two episodes in the history of nuclear energy, which previously stymied growth in this sector, during the past two decades.

How comfortable would you be driving daily to work in an automobile manufactured in 1969? Would your computer be as efficient if it was the same computer used in 1975? Imagine if your television viewing habits were restricted to a handful of channels, while often adjusting "rabbit ears" atop your TV's console? Technology has advanced over the past thirty years, but a large part of the electricity powering your home and office may today be generated by a nuclear reactor built in the 1960s or 1970s. Most U.S. nuclear reactors are running at nearly 90 percent capacity to ensure you enjoy continuous electrical service. How well would your thirty-five-year-old car perform under those circumstances?

Since the two worldwide nuclear energy disasters of Three Mile Island and Chernobyl, the world's leading nuclear engineers have begun designing future reactors to safeguard against another disastrous event. Both nuclear accidents involved human error and nuclear design factors. Both have been addressed to prevent similar episodes.

The accident at Three Mile Island Unit 2 reactor began when the vital cooling water was blocked from entering the unit's steam generators, because of a closed valve that was supposed to remain opened. The operators did not understand what was going on with their controls, during the episode.

Gene Clark, CEO of TradeTech LLC, remarked the accident was caused by "high-school-graduate operators at the Three Mile Island (TMI) plant (who) totally misread the instruments there in 1979." Clark added they "consequently, took exactly the only steps that could have made the situation worse. In spite of their ineptitude, there was still no significant release of radioactive contamination off-site." Clark pointed out, "In the aftermath of Three Mile Island, the Nuclear Regulatory Commission (NRC) instituted a stringent series of safety retrofits to address the 'lessons learned' from the accident. Since then, the industry has learned that 'a safe plant is an economical plant.' Consequently, the nuclear power industry now operates plants more efficiently and, thus, at lower cost."



Those who have actually studied the Chernobyl nuclear accident, which occurred about seven years after TMI, have unanimously agreed the trouble began because of a very bad reactor design. Called the RBMK reactor, an acronym for Reactor Bolshoi Moschnosti Kanalyni, it grew out of the Soviet military weapons reactors. Significant design errors included (a) the water was boiled in each of the reactor's 1600 pressure tubes, which accelerated the steam explosion and (b) the RBMK had a positive void coefficient. The United States Nuclear Regulatory Commission would never license a commercial

U.S. nuclear reactor with a positive void coefficient. A negative void coefficient means you are reducing power as you are losing coolant. That is what is used in all large-scale U.S. commercial reactors. A positive void coefficient means that as you lose coolant, you are increasing power. The Soviet scientists thought they could overcome this dangerous obstacle. History proved them wrong.

At the Chernobyl Unit #4, the positive void coefficient caused the power to surge one thousand fold in the blink of an eye. The Soviet scientists were testing the unit that day in April 1986 to determine how well the nuclear reactor's own electricity generation could drive its coolant pumps. The operators violated their very exact safety procedures. The explosion worsened because the Soviets were being thrifty and failed to build a containment building for this reactor. To prolong and amplify the catastrophe, the reactor's moderator was graphite. Burning graphite turned the entire area into a giant blaze. Firefighters and others trying to extinguish the blaze were the primary casualties of Chernobyl.

Everything that could go wrong that day did go wrong. It took that many mistakes for Chernobyl to become the rallying cry for the European and world's environmentalists. From this reactor accident, less than 100 people died as a direct result. Despite the environmentalist movement's claims, probably less then 10,000 died indirectly from this accident. It may be likely the more accurate amount is less than 4,000. With the disfavor of nuclear energy, coal mining and coal-fired power plants began to expand across the world to replace the energy source for electricity, which a growing world demanded.

Since Chernobyl and TMI, mining coal has caused at least 100,000 direct deaths. Indirectly, through Black Lung, coal mining has easily impacted more than 1 million. Air pollution from coal mining has affected tens of millions of people across the world. Since TMI, more than 500 Americans have died as a direct result of natural gas. Where are the protests against natural gas? There are none. No one died at TMI, but U.S. utilities were driven by public opinion to expand their coal-fired and gas-fired power plants. Environmentalists may wildly and loudly rage about nuclear energy's safety, but they still want electricity to power their laptops so they can spew their rhetoric.

By contrast, nuclear engineers, politicians and scientists have sought to prevent a reoccurrence of those two widely publicized catastrophes. From our research, we have discovered the truest environmentalists are the scientists – the nuclear design engineers, the researchers, and even the uranium geologists and engineers who look to provide more nuclear energy for the world's electricity grids. They, too, would like to smell better air and preserve the earth's resources while still meeting the energy demands you, yourself, demand every day. Because of those two accidents, nuclear reactor safety has emerged as the number one concern for all reactor engineering designs. The transition in reactor designs has been evolving from active operations to passive operations. The accent is most definitely on passive operations, allowing for less moving parts and far less of the "human error" factor in operating them. As we progress through this century, all commercial nuclear reactors will reportedly have the most stringent safety features to appease the worst skeptics.

For enlightening reading written by a professional nuclear engineer, we strongly recommend Scott W. Heaberlin's book, ***A Case for Nuclear-Generated Electricity*** (Battelle Press, 2004). His explanation of nuclear energy, reactor designs and nuclear chemistry should help you better understand and appreciate why nuclear energy is the most important solution for the first half of this century.

The Great Transition

Four light bulbs were lit with America's first civilian nuclear reactor in 1951, capable of producing electricity. Courtesy: Idaho National Laboratory

Nearly 80 percent of the world's operating commercial reactors were built more than 15 years ago. The nuclear renaissance, since 2002, has been driven by the anticipated evolutionary shift from one reactor design to a later generation. Most of the world's nuclear reactors are the second generation. In 1996, Japan became the first country to begin using the third generation of reactors. This transitory third generation could dominate nuclear reactor designs for the next two to three decades. But, one exception, the Pebble Bed Modular Reactor (PBMR), could revolutionize the entire nuclear energy field and accelerate the global demand for uranium. More on the PBMR later in this chapter.

Newer, more high-tech designs have been selected to launch the Generation IV nuclear reactors as early as by 2020. The preponderance of such reactors would not likely arrive until after 2030. Subsequently, our forecasts of a sustained bull market in uranium, one which might last through 2015, could become an understatement. As nuclear countries convert over to the next generation of reactors, during the coming two decades, there should be several significant growth spurts, within this super bull uranium cycle.

> ***FACT: For those who wonder why America's power stations are called the "nuclear fleet," it is because 85 percent of the world's electricity is produced by nuclear reactors, which were initially developed for use by the U.S. Navy for use as naval propulsion reactors. Under President Eisenhower's direction, Navy Captain Rickover built and oversaw the first civilian nuclear plant in Shippingport, Pennsylvania, using the pressurized water reactor (PWR) design. This had been earlier used in the first prototype submarine thermal reactor for its nuclear propulsion plant. The PWR design became the prototype for most commercial U.S. reactors.***

Several countries are building new reactors to replace their aged fleet. New reactors will have to replace decommissioned ones, the International Energy Agency reported. The hope is to maintain nuclear energy's percentage in the overall energy source mix. Otherwise, air-polluting coal will fill the gap. Ontario's Bruce Power plans to rebuild two nuclear reactors, which have remained idle for the past decade. Canada's Ontario Power Authority announced plans to build twelve new plants in place of electricity-generating coal plants. More importantly, as many as 20 of Ontario's AECL-designed CANDU reactors may be retired. This opens the door for nuclear reactor vendors to replace the CANDU with a third generation reactor.

Finland's Teoliisuuden Voima' (TVO) utility company should have its third reactor powered up on Olkiluoto island in western Finland by 2010. The 1600 MW pressurized water reactor, aptly named Olkiluoto 3, will join two reactors built in the 1970s. With the addition of the third, much larger reactor, Finland will derive about 30 percent of its electricity from nuclear energy. Finland moved forward in building Europe's first nuclear reactor since 1991 because of worries about energy supplies. They depend upon Russia for 100 percent of their natural gas supplies. Many Finns are concerned about rising natural gas prices and the availability of supply. This will be the world debut of the EPR (European Pressurized Reactor), which is being built by a joint venture of Areva's Framatome and Siemens AG.

A second EPR is expected to be operational by 2012. France is adding more nuclear to its existing infrastructure by constructing its 1600 MW reactor for the power utility Electricite de France in western France at Flamanville. As we were going to press, the French Prime Minister had approved a plan to build the country's second nuclear plant using third generation technology.

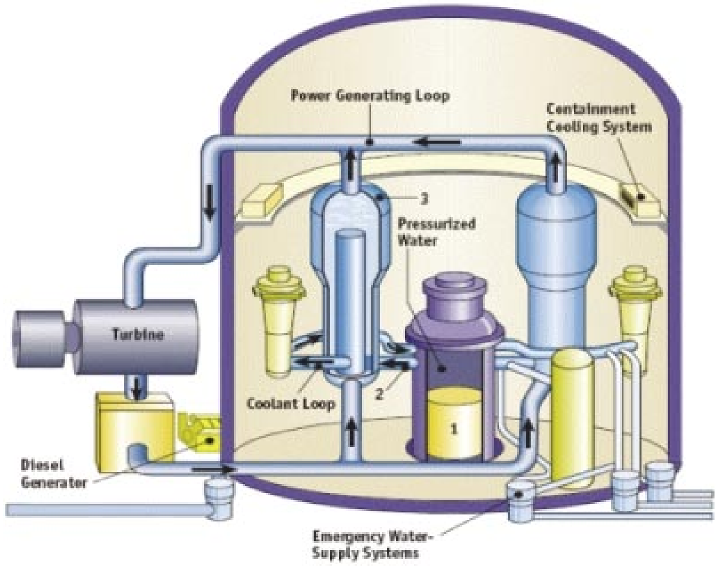
By the end of the second decade, China, India, Pakistan, Iran, Russia, Argentina, Brazil, Bulgaria, Chile Turkey, the Czech Republic, South Korea, Taiwan and South Africa each hope to have built one or more reactors to keep up with electricity growth in their countries. For example, South Korea currently has four reactors under construction and a further eight planned by 2015. By then, the country hopes to have boosted its total capacity of nuclear energy production to 13,000 MW. Korea's electric company, KEPCO, maintains some of the world's operational ratios with its twelve reactors. Russia is constructing six nuclear plants and hopes to build eight more. China, India, Japan, South Korea and Taiwan combined could account for another 85 to 100 new nuclear plants over the next two to three decades.

There could be many surprises, especially in South America. During the last uranium bull market, several southern hemisphere countries had announced great expectations. Brazil hoped to build as many as 30 new reactors, Argentina aimed for six, Venezuela for as many as three, Mexico for between two and ten, and Chile, Peru and Colombia for as many as two. Those are the wild cards, which might benefit from the more advanced smaller scale commercial reactors, such as the Pebble Bed Modular Reactor. New engineering designs will spur demand for nuclear energy as fossil-based energy prices continue to remain high.

Generation III Reactors

Aside from the reactor safety issue, a major worry for utilities and governments are the enormous construction costs required to build and bring a new reactor online. Unless you have personally reviewed the transcripts of an NRC hearing, in this case with General Electric's Generation III+ design, you may not appreciate how heavily impenetrable the bureaucratic walls appear to be. The Construction and Licensing submission process forced upon utilities, the number of years a manufacturer expends to design its reactor and a thousand other obstacles along the way pile onto the final price tag for a nuclear reactor. Westinghouse's staff cumulatively spent 1300 man-years and expended $440 million for the design and testing program of its Generation 3 AP-1000 reactor. It takes an average of 12 years to build a nuclear power plant.

In general, the capital costs for a large-scale commercial reactor are about $2000 per kilowatt. By comparison, a coal-fired plants capital costs are $1200 per kilowatt installed. Combined-cycle gas turbine cost only $500 per kilowatt to build. No wonder the world's financial centers give pause to financing the nuclear renaissance. Capital costs for some of the Generation 3 reactors may come down to approach the costs for a gas-fired plant. Westinghouse believes its overnight capital costs could arrive at $1200 per kilowatt. The IRIS pressurized water reactor might be constructed for as little as between $1000 and $2000 per kilowatt. Others we researched may drop to as low as $1400 to $1700 per kilowatt. The IAEA estimates capital costs are between 60 and 75 percent of the total generating cost for a nuclear power plant. Operations and fuel cost are the remaining expenses required to generate electricity. Price is a key concern reactor manufacturers hope to address in the next generation of reactor designs.



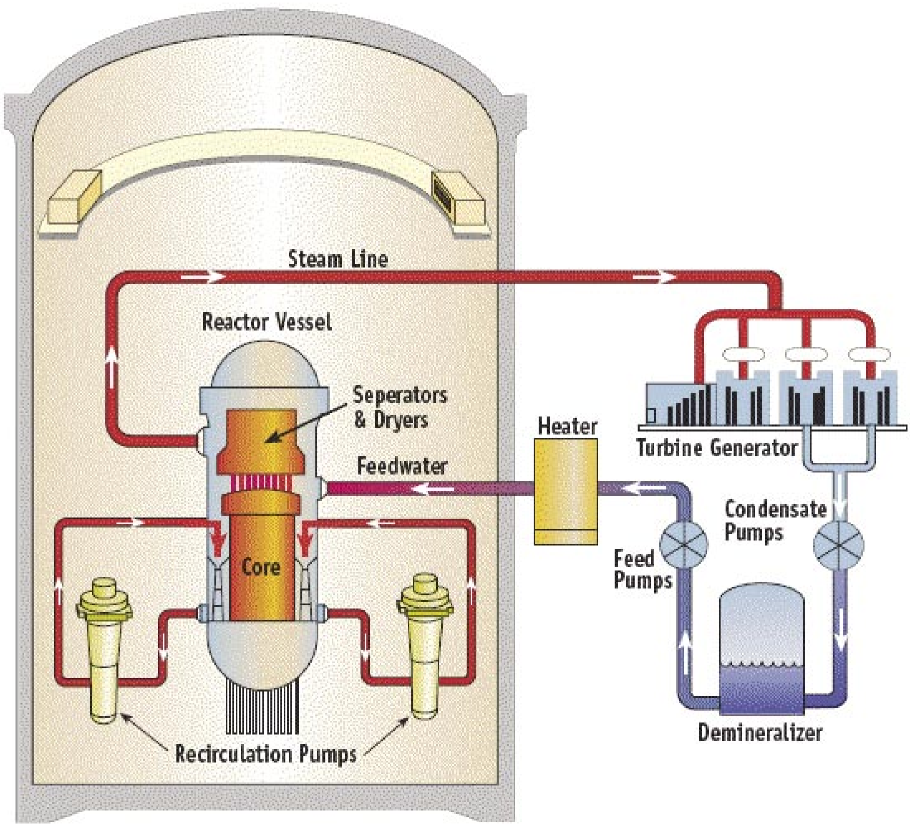
Pressurized Water Reactors use nuclear fission to heat water with pressure inside the reactor. The heated helps generate steam to produce electricity. Sources: U.S. Nuclear Regulatory Commission

There are several third generation reactors being designed, certified or on course for certification. Light water reactors will dominate the third generation of nuclear reactors. They are called light water because the coolant is the same tap water we drink. These will be in the 1000 to 1300 MW range. There are several designs which we should briefly discuss. For a good number of us, these will be the reactors used to generate nuclear energy in our lifetimes. Light water reactors are split into two categories: Pressurized Water Reactors (PWR) and Boiling Water Reactors (BWR). Sixty-nine of the licensed U.S. commercial reactors are PWR, the remaining 35 are BWR.

According to the World Nuclear Association, the Generation III reactors are significantly different from the second generation designs because they incorporate passive safety features. Specifically, these would require no active controls or operational intervention in the event of malfunction. Many rely on gravity, natural convection or resistance to high temperatures. As we discussed earlier, both the TMI and Chernobyl accidents were worsened by the operators miscalculating the event and making the wrong decisions during that event. Other new features include a longer operating life, about 60 years, simpler designs and easier to operate, more rugged and less vulnerable to operational upsets, higher burn-up to reduce fuel use, among others.

According to Westinghouse, the manufacturer of the AP 1000 nuclear power plant, it is an advanced 1117 to 1154 MWe plant that uses the forces of nature and simplicity of design to enhance plant safety and operations and reduce construction costs. It is expected to have a 60-year life. The AP1000 is an advanced passive (AP is an acronym for advanced passive) system, which would reportedly reduce the actions required by its operators. The plant has 50 percent fewer valves, 83 percent less piping, 87 percent less control cable, 35 percent fewer pumps and 50 percent less seismic building volume than a similarly sized conventional plant. It can also be built faster because of a modularization construction technique. The site construction schedule is expected to be 36 months from first concrete to fuel loading.

In September 2004, the U.S. NRC granted a final design approval on this reactor. The 1100 MWe AP-1000 should generate electricity below 3.5 cents per kWh. Westinghouse received NRC approval for its smaller AP-600 MWe reactor in 1999. The AP-1000 is said to be the front runner among reactors for U.S. utilities. It might also be under consideration to replace some or many of Canada's AECL-designed CANDU reactors over the next decade or more.



A Boiling Water Reactor's (BWR) fission-based heat from the core boils the reactor's coolant water into steam, which then generates electricity. Sources: U.S. Nuclear Regulatory Commission

The U.S. NRC certified General Electric's Advanced Boiling Water Reactor (ABWR) in 1997. Its design was based upon previous designs, but also incorporated new technologies. The ABWR is reportedly simpler to operate and requires less maintenance. Several studies demonstrated its design was almost 100 times safer than the current nuclear plants operating in the United States. It is easier to build because the buildings holding the reactors are about one-third smaller than those currently housing other boiling water reactors. Two ABWRs were built in Japan, Kashiwazaki Kariwa-6 and -7 have been operating since 1996. A third unit went online two years ago. More of these reactors are being constructed in Japan and Taiwan.

General Electric is also marketing its 1500 MWe ESBWR (Economic & Simplified Boiling Water Reactor), which some view as an extension of the European Simplified Boiling Water Reactor, developed by Framatome ANP. The European boiling water reactors will be the reactors reportedly debuting in Finland (2010) and France (2012). Areva's Framatome ANP describes these new reactors on the company's website, "Not only will they contribute to further perfecting measures for accident prevention, but they will also be designed to control the most severe, although highly improbable, accidents - right up to and including core melt." The company is also developing two advanced third generation designs called the European Pressurized Water Reactor (EPR) and a newer boiling water reactor d called the SWR 1000 (SWR = Siedewasser Reactor). The former is rated for 1500 to 1800 MW, the latter for 1000 MW. Both are said to incorporate highly innovative safety systems.

GE's ESBWR falls into the Generation III+ category. It is undergoing the design certification process, and a full safety evaluation report is expected by late 2007. General Electric hopes to complete the report in time for the utilities, which are filing Construction and Operating License (COL) submissions. On GE's website, the company announced plans to have the ESBWRs in operation by 2014 or 2015. On General Electric's Internet feature page for the ESBWR, the company highlights the passive safety feature for this reactor, by waxing poetic, "It is 11 times more likely for the largest asteroid near the earth to impact the earth over the next 100 years than for an ESBWR operational event to result in the release of fission products to the environment." Its modular design can help accelerate the construction schedule, according to GE press materials, announcing, "...construction times for first concrete to first core load in as little as 36 months."

Other reactor manufacturers are not sitting idly by. South Korea's Advanced Pressurized Reactor (APR) design came from the US System 80+ and reportedly has enhanced safety features. Design certification was awarded by that country's Institute of Nuclear safety in 2003. Korea hopes to have two of the 1450 MWe reactors operational by 2012. Korea also plans a one-fifth scale plant using its SMART design (system-integrated modular advanced reactor) for smaller applications, such as seawater desalination.

Mitsubishi Heavy Industries announced it would enter the nuclear reactor design business in 2002, with a view to producing an advanced model of PWR (APWR). Mitsubishi has been working with Westinghouse and four Japanese utilities to develop a large

1500 MWe reactor in central Japan at a power plant in Tsuruga. Since that announcement, two have been planned. Mitsubishi announced, at the time, it also planned to export the APWR to the United States.

Russia is aggressively expanding its nuclear energy program to meet an increasing demand for energy. Electricity is rising about three percent per year. By 2010, about 50 GWe in the European part of Russia will come to the end of its design life. Because Gazprom can make five times the money exporting its natural gas to Finland, Germany and much of Western Europe, they have cut domestic gas supplies by 12 percent for the next two years. This natural gas would have been used for electricity generation, and perhaps the Russians hope to replace the lost electricity generation through nuclear energy. While quickly playing catch up, Russia has been active in the APWR design field with several advanced reactor designs.

According to the World Nuclear Association, the Gildopress 1000 MWe is being built in India for Novovoronezh, an area in southern Russia which presently has five aging reactors. Another two Russian reactors are being built in China. Gildopress is developing replacement plants for Leningrad and Krusk. Designs for the 1500 MW reactors should be finished by 2007, and the first reactors commissioned by 2013. Smaller PWR reactors have also been developed.

Once implemented, the Generation III reactors should provide an additional safety buffer for utilities whose present reactors have been over-taxed. For the average person who wonders about the safety of nuclear energy, the Generation III reactors may very well increase the general confidence in expanding a country's nuclear program. Many of the soon-to-be-decommissioned reactors are running on their last legs. Some countries are facing tough decisions right now about their nuclear energy policy because of the aging issue. In the UK, the British are phasing out all but one of their nuclear power plants by 2023. The country depends upon nuclear energy for more than 20 percent of its electricity generation. Across the channel, France's Areva announced it could quickly solve Britain's nuclear energy dilemma, "We believe that we can have one of our third-generation reactors ready within five years of the first concrete being poured." That would be in 2017, which is a very tight deadline.

In summary, there may be 16 types of nuclear reactor designs from which utilities may choose, over the next decade, depending on certification, acceptance and construction timetables. There are variations within these five basic reactor designs, among the Generation III reactors. These include:

1. **Advanced Boiling Water Reactors,** such as the ESBWR (European Simplified Boiling Water Reactor), the SWR 1000 (Siedewasser Reactor 1000) or the High Conversion Boiling Water Reactors

2. **Advanced Pressurized Water Reactors,** such as the AP1000, the APR1400, the APWR+ or the EPR (European Pressurized Reactor).

3. **Modular High Temperature Gas Cooled Reactors**, such as GT-MHR (Gas Turbine Modular High Temperature Reactor) or the PBMR (Pebble Bed Modular Reactor).

4. **Integral Primary System Reactors,** such as SMART (System-Integrated Modular Advanced Reactor) or IRIS (International Reactor Innovative and Secure).

5. **Advanced Pressure Tube Reactors,** such as the ACR-700 (Advanced CANDU Reactor 700).

The Next Frontier: Generation IV Reactors

The Generation IV reactors are still on the drawing boards. Six design selections were made in early 2005 by the Generation IV scientists and engineers. This group is still growing. As we were going to press, the European Atomic Energy Community (EURATOM) formally joined the other ten members of GIF – short for Generation IV International Forum. EURATOM joined the current members: Argentina, Brazil, Canada, France, Japan, South Africa, Switzerland, United Kingdom and the United States. Russia is not part of GIF, but one of their reactor designs, a sodium-cooled fast reactor, is one of the six designs found in this section. India is not participating and is probably going to develop a way to use its abundant thorium reserves as a nuclear fuel, but this decision could flip flop over the next few years. Also not a GIF member, China appears focused on the Pebble Bed Modular Reactor, which has some similarities to one of those six designs.

These will be the "next frontier" of nuclear reactors, which may help solve more than just a growing and alarming electricity scarcity problem. All would be operated at higher temperatures than today's reactors. Four of the six reactor designs will also produce hydrogen. These designs also address the issues of nuclear fuel recycling and waste disposal. Because the "recycling" feature is questionable at this point in time, we believe rising uranium prices and depleted inventories of uranium could someday make this feasible. Consequently, we expect a peak point during the course of this super bull market in uranium, when world governments collectively agree the once-through use of uranium was a very bad idea. When uranium fuel is again reprocessed in the United States, utilizing the new nuclear reactor technologies, this would signal the end of the Great Uranium Bull Market.. Our best guess would be in those years approaching 2030. Ironically, the excitement over new reactor designs, and their enhanced safety features, should launch a new wave of advance uranium purchasing, but ultimately the new reactors will bring the bull market to a close.

Understanding Once-Through

One strong reason behind the acceleration of this uranium bull market higher is the "once-through" use of uranium. U.S. utilities are the world's largest commercial consumers of U3O8. Because of government policies established thirty years ago, U.S.utilities may no longer reprocess uranium in their commercial nuclear reactors. Each spent control rod contains about 95 to 97 percent of unused uranium. Imagine if you were only allowed to use 5 percent of the gasoline in your tank to power your automobile. You would be legally bound to drain the remaining 95 percent of the gasoline from your car, store it and then refresh your tank with new gasoline. Again, you could only use 5 percent of that gasoline. All the while, environmentalists would incessantly hound you about where and how you are storing your unused gasoline. Tens of millions of tax dollars would be spent studying how your gasoline would be stored, whether it is stored safely and how long your gasoline can be safely stored, and not impact the environment one thousand to one million years from now. Why not just re-use the rest of the uranium?

Under these political circumstances, U.S. utilities are bound to constantly acquire fresh supplies of uranium. A large-scale Generation III nuclear power plant will reportedly consume 30 million pounds of uranium oxide over its proposed sixty-year operating life. When the 104 licensed Generation II nuclear reactors are replaced with the next generation of reactors, U.S. utilities can look forward to acquiring more than 3 billion pounds of uranium to operating those plants. To aggravate the uranium supply issue, these same utilities will be competing with other country's utilities across the globe, which also want uranium to power their aggressively growing nuclear energy programs.

The Generation IV nuclear reactor designs could help solve the reprocessing issue. The problem of reprocessing stemmed from worries about plutonium falling into the hands of terrorists. In May 1974, India detonated a nuclear device. The device was constructed from plutonium separated at its reprocessing facility. The Indians had obtained plutonium from an insecure Canadian research reactor.

Then-presidential candidate James Earl Carter was opposed to recycling plutonium. He debated then-President Gerald Ford about the evils of reprocessing. This presidential election also took place during the high point of the 1970s uranium bull market. President Ford blinked and issued a 1976 policy statement, "The avoidance of proliferation must take precedence over economic interests." He didn't ban reprocessing, but changed the domestic policies of the "commercialization of chemical reprocessing of nuclear fuel which results in the separation of plutonium."

By April 1977, President Carter issued his edict indefinitely "deferring" the commercial reprocessing of uranium. Carter wanted to bury the nuclear waste, but never studied how much it would cost the taxpayer. This has brought us the present day dilemma of where, and for how long, to entomb about 30 years of nuclear waste. Instead of recycling the nuclear fuel rods, we are now faced with decisions about where to safely dump this nuclear waste. President Reagan lifted the ban in 1981, but in the post-TMI years, few got excited about reprocessing. Many have given up on the nuclear industry; some believed it would eventually go away and we would get our electricity from wind farms and solar panels. President Clinton in 1995 proceeded in a joint venture with Russian government to dispose of plutonium from surplus nuclear weapons, called the HEU program, which again brought up the reprocessing issue.

Ironically, France, Japan and the United Kingdom reprocess their used nuclear fuel by utilizing the technology developed in the United States. Over the past forty years, more than 75,000 metric tons of used nuclear fuels have been reprocessed. France has reprocessed more than 10,000 metric tons of used reactor fuel. The United Kingdom has reprocessed more than 15,000 metric tons. Reprocessing extends the life of the uranium as a nuclear fuel, or more accurately more fully uses the energy uranium generates. After five or six cycles, the remaining plutonium can no longer be used. By recycling the uranium and plutonium within a metric ton of used reactor fuel, utilities are getting the equivalent energy of 100,000 barrels of oil.

Instead of simply reprocessing the fuel rods, U.S. utilities are given a bizarre alternative. Spent fuel rods are stored in nuclear fuel storage pools of water. Instead of reprocessing the used nuclear fuel, it must now be "safely" stored. We presently endure a national debate about nuclear waste disposal. The safe haven for nuclear waste disposal is Yucca Mountain, but the disposal site has yet to be utilized. Whether or not to utilize Yucca Mountain can also find its roots in the political decision made during the 1976 U.S. presidential election. This is a 30-year problem awaiting a sensible solution.

U.S. utilities are currently held hostage from all sides: (a) provide a cleaner source of energy to a growing appetite for electricity; (b) don't reprocess spent fuel rods, but instead burden the uranium miners to obtain a fresh supply of uranium for their re-fueling cycles; (c) dispose of the nuclear waste in new and inventive ways (dry cask shortage to alleviate the rising storage pools); (d) build newer and safer nuclear reactors. Once-through has created numerous problems for U.S. utilities, and ultimately for every American. Meanwhile, U.S. utilities provide about one-fifth of your electricity with nuclear energy.

Reviewing the Next Generation

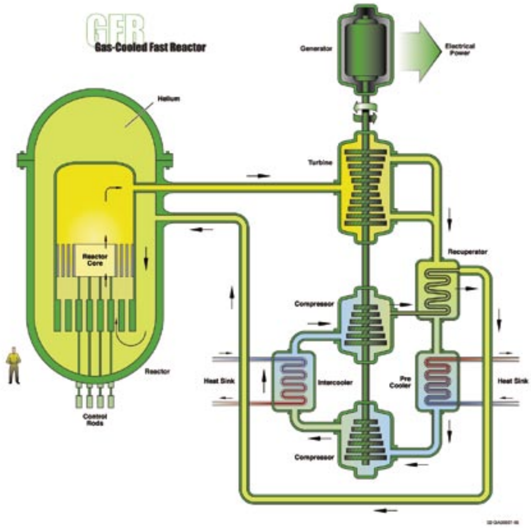
More than 100 top scientists and engineers from more than a dozen countries reviewed about 100 different nuclear energy design concepts to identify which would be the most effective nuclear reactor designs for deployment after 2030. Key issues such as safety, reprocessing and proliferation concerns, minimizing nuclear waste, hydrogen production and additional uses from nuclear energy were discussed and evaluated.

The Generation IV Forum was spearheaded by the U.S. Department of Energy and has gained traction since its inception. There is reason for their concern. The United States and France account for about 45 percent of the world's nuclear power capacity. Five countries, when you include Japan, Germany and Russia, comprise about two-thirds of the world's nuclear energy capacity. The top ten countries, using nuclear energy, make up more than 80 percent of the world's nuclear energy capacity. About 80 percent of the world's countries have no civilian nuclear energy program. Clearly, there is plenty of room for exponential growth in the use of nuclear energy across the world.

Generation IV reactors and other advanced reactor designs, such as the Pebble Bed Modular Reactor, may make it possible for the rapid public acceptance of nuclear energy. With acceptance comes the expansion. The most major public concerns, safety, disposal and cost issues, are being addressed by the Generation IV Forum participants. Let's review the six designs proposed by the Generation IV group.

Gas-Cooled Fast Reactor

The Gas-Cooled Fast Reactor (GFR) system is designed as a fast-spectrum reactor cooled by helium. It uses a closed fuel cycle, allowing the reactor to reprocess the nuclear waste. This technology comes from several thermal spectrum gas reactor plants and fast-spectrum gas- cooled reactor designs.



Positives

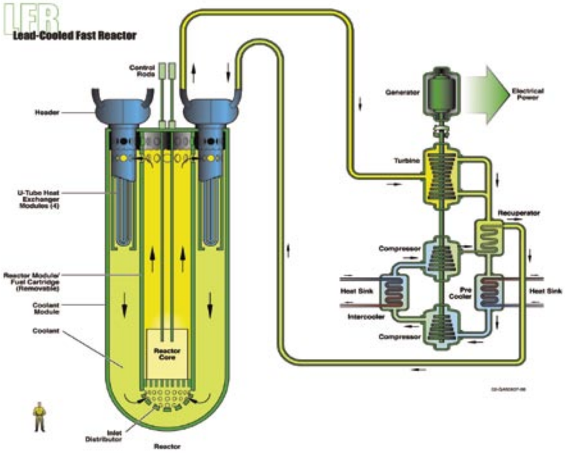
1. Minimizes the production of long-lived radioactive waste isotopes.
2. Makes it possible to utilize depleted uranium from enrichment plants, about two orders of magnitude better than thermal spectrum gas reactors with once-through fuel cycles.
3. Has an integrated, on-site spent fuel treatment and refabrication plant.
4. Net plant efficiency of 48 percent

Negatives

1. Need to first develop materials with superior resistance to fast-neutron fluence under very high temperatures.
2. Need to develop a high-performance helium turbine for efficient electricity generation.
3. Need to develop efficient coupling technologies for process heat applications and the GFR's high temperature nuclear heat.

Scientists hope to have a conceptual design of the GFR prototype system by 2019. They hope the prototype system could be operational in 2025.

Lead-Cooled Fast Reactor



The Lead-Cooled Fast Reactor (LFR) system is designed as a fast-neutron spectrum, using lead or a lead-plus-alloy as the coolant. This reactor design also provides a closed fuel cycle, equipped for reprocessing nuclear waste. The LFR borrows from the Russian BREST fast reactor system, which were used the Soviet navy. Russia's Alpha class submarines were powered by a lead-bismuth eutectic cooling system in their naval propulsion reactors.

<u>Positives</u>

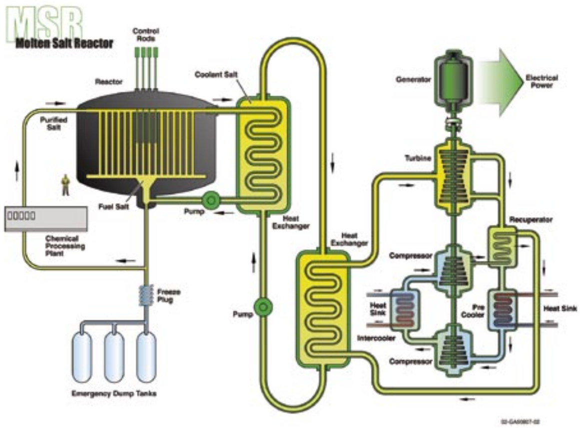
1. Options include a long refueling interval battery, which might only require refueling every 15 to 20 years.
2. Smaller size can fill the gap for developing countries which need electricity production on smaller grids.
3. Full support fuel cycle services.
4. Reduced cost because of its smaller size.
5. May be able to produce hydrogen

<u>Negatives</u>

1. Technology gaps for the high-temperature structural materials
2. Environmental issues with lead
3. Need to develop nitride fuels and find out compatibility and performance
4. Need to determine coolant chemistry control
5. Longest development time to market
6. Largest R & D needs

Molten Salt Reactor

The Molten Salt Reactor (MSR) system produces fission power through a circulating molten salt mixture, which are fueled with uranium or plutonium fluorides dissolved in a mixture of molten fluorides. The MSR was developed for aircraft propulsion in the late 1940s and 1950s. An Air Force experiment in 1954 established the performance benchmarks for a circulating fluoride molten salt system at high temperatures (814 degrees Celsius).



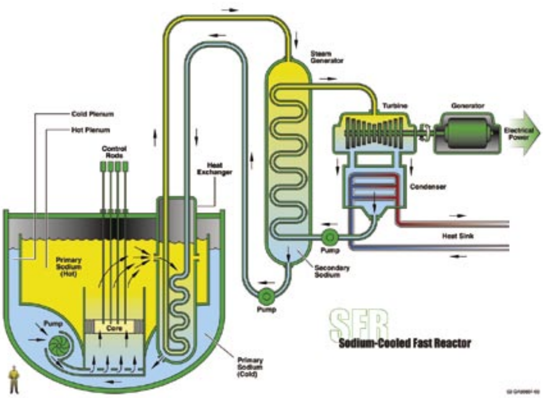
Positives

1. Actinides burning with continuous recycling during electricity production
2. Have good neutron economy
3. High-temperature operation could produce thermochemical hydrogen
4. Molten fluoride salts have very low vapor pressure, reducing stresses on the reactor vessel and the piping
5. Refueling, processing and fission product removal can be performed online

Negatives

1. Need to find out the compatibility of irradiated molten salt fuel with structural materials and graphite.
2. Need to find out the lifetime behavior of molten salt fuel chemistry.
3. Need to resolve potential metal clustering in the heat exchangers.
4. Corrosion and embrittlement studies need to determine lifetimes of materials and reliability
5. Need to develop tritium control technology
6. Graphite moderator will need to be replaced every four to ten years
7. Need to develop the fuel and determine the molten salt composition

Sodium-Cooled Fast Reactor



As with the gas- and lead-cooled fast reactors, the Sodium-Cooled Fast Reactor (SFR) is designed as a fast-spectrum reactor with a closed fuel recycling system. It may be favored because of its envisioned capability of managing high-level wastes, especially the management of plutonium and actinides. The SFR is more technologically developed than the other five design concepts. SFRs have been built and operated in Germany, Russian, Japan, the United Kingdom and the United States. Most of the latest design studies are occurring in the Japan.

Positives

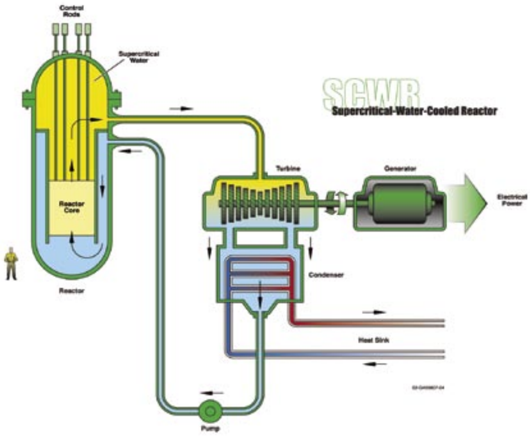
1. Wide range of plant sizes, from a few hundred MWe to 1700 MWe.
2. Relatively large thermal inertia of the primary coolant; a large margin to coolant boiling.
3. Primary system operates at atmospheric pressure, only requiring pressure to move fluid.
4. If a sodium-water reaction occurs, it does not involve a radioactive release.

Negatives

1. Need to reduce capital costs for it to be competitive with other plants
2. None of the SFRs already constructed have been economical to build or operate.
3. Need to determine passive safe response to all design basis initiators.
4. Need to develop an oxide fuel fabrication technology with remote operation and maintenance.
5. To ensure bounding events can be sustained with loss of fuel coolability or containment function.

Supercritical-Water-Cooled Reactor

The Supercritical-Water-Cooled Reactor (SCWR) is designed for high-temperature and high-pressure performance. The water-cooled reactors operate above the thermodynamic critical point of water. Depending upon the core design, the SCWRs could be thermal or fast neutron systems. Japan has been working to develop the supercritical light water reactor (SCLWR) over the past 10 to 15 years. The overnight capital costs may be about one-half that of the current Advanced Light Water Reactors (ALWR) with operating costs about 35 percent less than the current LWRs.



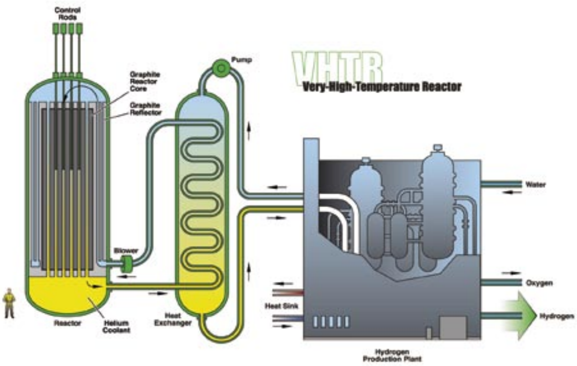
Positives

1. Increases thermal efficiency, approaching 44 percent compared to the 35 percent of current light water reactors.
2. Reduced reactor coolant pumps, piping and associated equipment.
3. Lower coolant mass inventory could mean smaller containment buildings.
4. No boiling crisis.
5. A simpler plant with fewer major components.
6. Lower capital and operating costs.

Negatives

1. Possible corrosion and stress corrosion cracking.
2. No candidate alloy has been confirmed for us as either the cladding or structure material in thermal or fast-spectrum SCWRs.
3. Fast-spectrum design would require five times (or more) cladding and structural materials than the thermal design.
4. Need to research strength, creep rates and rupture mechanisms, and embrittlement.

Very-High-Temperature Reactor



The Very-High-Temperature Reactor (VHTR) is an evolution of high-temperature gas-cooled reactors. The VTHR system comes from experience with High Temperature Gas Reactor technology. The basic technology was developed in the United States. The Pebble Bed Modular Reactor further develops this concept. High Temperature Reactor technology has also been researched in Japan and Europe.

Positives

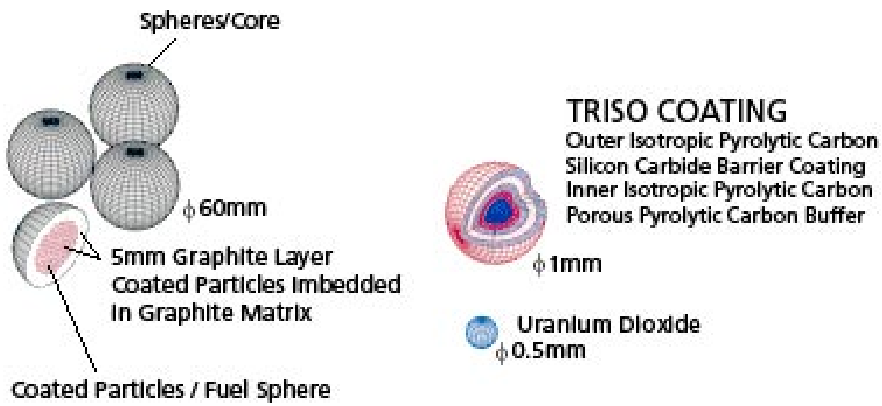
1. Can produce hydrogen from only heat and water by using thermochemical iodine-sulfur process or with natural gas by applying steam reformer technology to core outlet temperatures greater than 1000 degrees Celsius.
2. A 600 MWth VHTR can yield over 2 million normal cubic meters per day of hydrogen.
3. Can generate electricity at 1000 degrees Celsius at greater than 50 percent.
4. Could become a heat source for large industrial complexes.
5. Could be used by the petroleum industry for hydrogen generation to upgrade heavy and sour crude oil.
6. Could use nuclear heat application in steel, aluminum oxide and aluminum production.

Negatives

1. Novel fuels and new metallic alloys must be developed to withstand high temperatures.
2. Avoid power peaks, temperatures gradients in the core, and hot streaks in the coolant gas.
3. Need to develop a high-performance helium turbine for efficient electricity generation.
4. Need to modularize the reactor for commercial deployment.
5. Need to develop an optimized approach for dealing with graphite disposal.

Generation IV reactors plan to address the key issues surrounding nuclear power. The goals are to provide sustainable energy generation, which meets clear air objectives and minimizes the managing of nuclear wastes. Generation IV reactors are being designed with the highest goals of reliability and safety in mind. Such systems are envisioned to have a very low likelihood of reactor core damage. Economically, the Generation IV reactors plan to be competitive with, or have a lower life-cycle cost advantage over, other energy sources. Finally, scientists and engineers are designing the reactors to become proliferation-resistant and terrorist-resistant. As you can see, the experts have quite a task ahead to provide all of us with electricity in the coming decades.

Pebble Bed Modular Reactors



The Pebble Bed Modular Reactor (PBMR) technology has the potential to trump the Generation III designs on a smaller, but widespread scale. It could possibly compete with Generation IV head-to-head in some countries. PBMR is a High Temperature Reactor (HTR) technology conceived in the 1950s, and developed by German scientists in the 1970s. It was abandoned in Germany because of "green" politics. The basic reactor design is unusual, but simple. It is a smaller reactor, making it quite flexible. Consequently, the PBMR may become ideally suited for "mass marketing" across the globe. Don't laugh because this might very well come to pass.

The Pebble Bed Modular reactor provides heat to the coolant gas, which then turns a generator. The uranium, and other nuclear fuels, are formed inside ceramic balls, comprised of pyrolytic graphite. The "pebbles" look like billiard balls, about the size of a tennis ball. Each pebble is a 60 millimeter hollow sphere, weighing 210 grams filled with 9 grams of uranium inside. The pebbles are stacked in a steel-cased, bin-shaped reactor.

Fuel Pebbles

These balls are continuously fed, gumball machine-style, through the helium-cooled reactor, which is lined with graphite, from the bottom to the top. This rotating process repeats over a few years until the fuel inside the ceramic balls is expended.

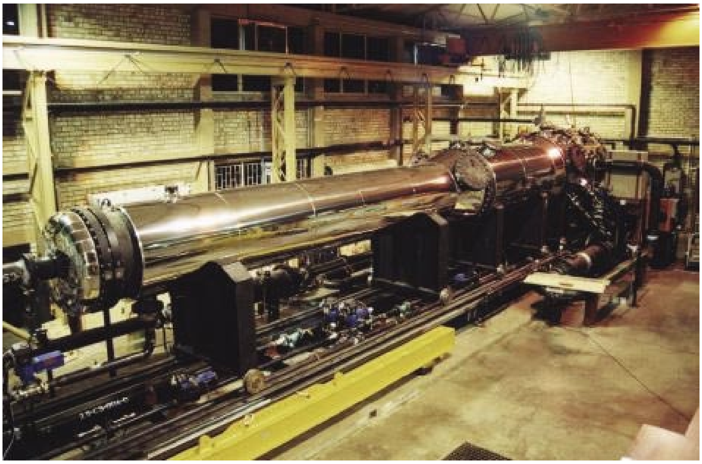
There are about 360,000 of the graphitic-encapsulated pebbles in the core, depending upon the power of the reactor. For example, a 120 MWe reactor would hold about 380,000 pebbles. About 3,000 pebbles are passed through the core every day. About 350 are discarded daily. The average pebble cycles through the core about 10 to 15 times. Inside the hollow sphere are some 15,000 small seeds surrounding a kernel of fissionables. The pyrolytic graphite, which is the main material of the pebbles, won't melt until the temperature reaches 3000 degrees Celsius – more than double the design temperature of most reactors.

Graphite also has a long history of being used in nuclear reactors For example, pyroltic graphite is what space engineers use in constructing the missile re-entry nose cones. While traveling at about 17,000 mph, a space shuttle hits air molecules while re-entering the earth's atmosphere and builds up heat from this friction. Temperatures rise to approximately 1650 degrees Celsius. Pyrolitic graphic helps prevent this high temperature from burning up the shuttle. The ceramic plays a key role in preventing a core meltdown within the reactor.

According to the PBMR website, "The current schedule is to start construction in 2007 and for the demonstration plant to be completed by 2011. The fist commercial PBMR modules are planned for 2013." The South Africans may be leading the way in bringing the PBMR technology to market. However, the Chinese also licensed the AVR technology (Arbeitsgemeinschaft Versuchsreaktor) and are developing it further at Tsinghua University in Beijing. Competition between the two countries should help widely advance the implementation of this design.

The Chinese plan a 200 megawatt production plant by 2007 and have firm plants for thirty PBMR plants by 2020, providing 6 gigawatts. Reports have also been made that China hopes to deploy up to 300 gigawatts of reactors by 2050. By comparison, the world's entire nuclear energy capacity in 2002 was about 363 gigawatts. The world's two largest civilian nuclear programs, the United States and France, amounted to about 160 gigawatts. Subsequently, the PBMR may help accelerate the world's most aggressive nuclear energy expansion, possibly double the size of the U.S. nuclear expansion of the 1970s. The Pebble Bed Modular Reactor is another reason why many analysts are underestimating the size and duration of the great uranium bull market.

The PBMR has attractive safety features. The coolant has no transition phases. The helium coolant remains as a gas, which is inert and fireproof. Few neutrons are absorbed so the coolant remains less radioactive. The moderator is solid carbon, does not act as a



Micro Model of a PBMR

coolant and does not have transitions as found with light water in a conventional reactor. In an actual test, a pebble bed reactor was designed to have all of its supporting machinery fail. The reactor did not crack, melt, explode or discharge hazardous wastes. The reactor kicked into idle. Some were encouraged to call the PBMR an "idiot-proof" reactor, as a result, which means even idiots could operate the reactor without a critical episode. The continuous refueling prevents excess reactivity in the core, and allows for the ongoing inspection of the fuel elements.

The major roadblock thrown up by PBMR critics refers to a small accident in 1986 in Germany, which came about when reactor operators attempted to dislodge a jammed pebble in a feeder tube. The accident released small amounts of radiation in the surrounding area. Consequently, the West German government shut down the PBMR research program. It has never been revived in that country.

The major advantages of the PBMR include (a) being small and easier to construct than the larger reactors, and (b) they are relatively cost-effective for mass manufacturer. Industry insiders told us the Chinese hope, in the future, to mass market the PBMR for export around the world. The South Africans plan to export their reactor after first building a model PBMR at Koeberg, South Africa (on the Atlantic coast about 18 miles from Cape Town). France announced plans to have its first PBMR operational by 2020. Others may have one before then.We believe many other countries could order their first PBMR before 2010.

Because the PBMR is a small reactor, it is reportedly versatile and flexible. Scientists publicize the reactor as capable of producing 110 MW. This amounts to only 7 to 10 percent of the power of many of the Generation 3 reactors. Because of the PBMR materials and design, its efficiency may run as high as 40 percent compared to the 33 percent thermal efficiency of the light water reactors. Manufacturers hope to increase its efficiency toward 50 percent. With an ease and speed to construct, a lower cost to build and operate, safe and reliable and versatile, the PBMR might become the ideal candidate for many undeveloped countries across the world. Of the 80 percent of the world's countries, which do not now have nuclear energy in their mix, the PBMR may become the entry-level reactor from which to build their civilian nuclear program.

Conclusion

One of the early driving forces behind the uranium bull market was the expectation that many nuclear reactors across the world would be decommissioned. Because new reactors would replace the aging fleet, a fresh supply of uranium would be needed to start them up. Global recognition that China planned to aggressively quadruple the gigawatts of their nuclear reactors stimulated stronger interest. Insiders remembered the impact upon the price of uranium caused by the first aggressive nuclear energy expansion, in the United States during the 1970s.

Since then, insider, analysts and commentators have searched for comparative models upon which to base a future price of uranium. There isn't a price model one can actually draw upon. In reality, the sky is the limit, depending upon how quickly countries can finance their new reactors, how rapidly engineers can design the latest reactor technology, and how effectively the public can be persuaded that nuclear is safer, cleaner and more efficient than alternative energy sources. Nothing like this has happened, to this extent, with regards to an energy source, where one can not fully envision how strong growth can be anticipated and how much longevity the energy source might have.

The closest parallel would be the petroleum industry, where hundreds of billions of dollars in wealth have been created over the past century. The same may come to pass in the nuclear fuel industry. Imagine if nuclear energy were used by 80 percent of the world's countries to fuel their electricity generation? As more countries replace their aging reactors with Generation 3 reactors, and as more countries embark on starting a nuclear energy program, because of the newer, safer and less expensive reactors, the uranium bull market could then become a worldwide phenomenon of ever increasing expectations.

Let's consider a recent example of the gravity with which countries are viewing nuclear energy. Generally, when a minerals deal between two advanced countries is negotiated, it is signed off by those lower on the political food chain. The fact that Australia's Prime Minister and China's Premier signed a landmark uranium deal sent a message to the markets: Uranium is a very important commodity. At some point, uranium might become more important than natural gas or oil, perhaps later in this century. This is not as reckless a statement as you might think. Imagine if nuclear energy were used to produce hydrogen, as is envisioned in some of the Generation IV reactor designs. Nuclear-produced hydrogen could power your automobile and replace fossil fuels to a significant degree.

For the time being, the new reactor designs are going to continue attracting new entrants to civilian nuclear energy. Top scientists in every major and minor developed country have already considered, and are pondering, nuclear energy as an alternative to their current energy source, or in addition to that source, for electrical generation. They are advising their leaders to move forward or are further studying how far along these reactor designs are coming. Once the PBMR and other reactors move past the demonstration stage, we anticipate a flood of new plans and proposals to build more nuclear power plants. This will continue increasing the price tag on uranium for another decade or longer.

CHAPTER 8

How to Choose a Uranium Stock

A sign at a Wyoming crossroads reminds us that only the strongest uranium companies survive.

Now that the uranium bull market has gone to a new level, it's time to choose your stocks more carefully. For assistance, we turned to Kevin Bambrough, Market Strategist, and Jean-Francois Tardif, Portfolio Manager, at one of the world's top money management firms, Sprott Asset Management. These two market-savvy financiers, and others, helped us craft a simple guide of tips as advice on how to navigate through the hundreds of companies, which are engaged in uranium exploration, development and/or production. Who better to ask than specialists at a firm, which has heavily invested in the uranium sector? Sprott Asset Management was the first major fund to foresee the renaissance in uranium mining stocks, and their advice may be worth following.

Jean-François Tardif, CFA
Senior Portfolio Manager, Sprott Asset Management

Jean-Francois Tardif joined Sprott Asset Management (SAM) in November 2001 as co-manager to the Sprott Long/Short Funds and Sprott Canadian Equity Fund. Since joining the Firm, he has played an important role in generating new and exciting investment ideas that have contributed to the Fund's impressive performance results. Jean-Francois was recruited to SAM based on his notable stock picking abilities and portfolio management successes which were demonstrated throughout his 11 years in the financial industry and as a Portfolio Manager for various funds at ING Investment Management and Montreal-based Cote 100. Jean-Francois has a Bachelor of Business Administration from Sherbrooke University as well as the CFA Charter. He is the Lead Portfolio Manager for the Sprott Opportunities Hedge Fund LP.

Kevin Bambrough
Market Strategist, Sprott Asset Management

Kevin Bambrough joined Sprott Asset Management Inc. as a Research Analyst in August 2002. He has worked in the investment industry for over 5 years and adds greater depth and analysis to the investment team due to his diverse background and experience across various industries. Prior to joining SAM, Kevin worked as a Microsoft Systems Engineer for five years. Since 2003, Kevin has focused his analysis in the coal and uranium mining sectors for the Sprott Investment Team.

Ten Golden Rules for Yellowcake Investors

Kevin Bambrough prefaced his advice by saying, "We would like to make the point about some incredible gains that have been had in the uranium sector. The list is growing, but not the quality, so investors should use extreme caution. As the uranium price rises, and money pours into exploration, we can expect to see some sizeable discoveries coming down the road. It should be exciting times."

1. **A current project's potential success may be determined by its past ownership.** Look for companies that acquired properties, which were heavily explored and developed by major companies, during the last bull market. After the uranium boom of the 1970's ended, many major companies decided to completely exit the uranium sector – at the bottom of the twenty-year drought in uranium prices. Many major companies spent tens of millions of dollars exploring and drilling for uranium on those properties. They delineated orebodies, which became uneconomic during the uranium depression. With the uranium price trading more than 500 percent higher, many of these orebodies might be economically mined.

2. **What is the property's value per ton?** The average grade of the orebody will determine its value. Every one percent of uranium per ton yields 20 pounds of uranium. How much uranium can be recovered from an orebody? For example, in an In Situ uranium recovery operation, about 70 percent can be economically recovered. Determine the value of the ore body with regards to its recoverable metal, not how many "pounds in the ground" a company claims.

3. **Look for proven management, which has been successful in the past.** Find out if the geological team has had previous uranium mining experience, not just mining experience. Were they exploration or project geologists? The former explores for deposits; the latter develops the discovery. Some geologists have experience in both, and their share of exploration failures. Find out if management has proven experience in actual mining or In Situ recovery operations. Many companies are lacking in this department.

4. **What is the property's infrastructure like?** Find out about the electricity and water costs required for exploration, development and production. Find out about roads, rail, trucking, access and proximity to a mill. Developing infrastructure can be quite expensive in remote parts of the world. If the average grade is high, this can more easily attract funding for capital costs. If infrastructure is lacking, a modest project might fail to commence operations.

Uranium mining companies require electricity and other infrastructure in order to produce yellowcake.

5. **Is there hidden value in the company?** Consider the value of the property's existing infrastructure. Before the uranium bull market took hold, some companies acquired existing facilities, perhaps a mill or shafts, which more than justified the company's entire market capitalization. Previous drilling for uranium will save a company money the burden of exploration costs. Some companies have properties with very expensive shafts and/or mills. Other companies, such as Energy Metals Corporation (TSX: EMC) and Strathmore Minerals (TSX: STM), acquired large databases of past drilling on various properties. These databases are goldmines, which can be used to acquire good prospects as well as sold in pieces to other companies who might wish to participate in the Great Uranium Bull Market.

Strathmore MINERALS CORP.

ENERGYMETALS CORPORATION

Bambrough and Tardif are bullish about Strathmore Minerals and Energy Metals. Sprott Asset Management has invested tens of millions in these two companies because the firm believes in their business plans.

6. **Is the property in a pro-mining environment?** A company will eventually mine its property or not. Properties in jurisdictions, where government is pro-mining, will more quickly move into the production stage than in those areas where a government is ambivalent. At this time, Australia is a case in point because of the Australian's Labor Party's policy opposing the widespread expansion of uranium mining in that country. Other countries are hungry for investment by uranium companies that they will offer favorable tax rates and other incentives. Permitting and licensing a facility can be costly and can take a long time in many developed countries. This is a very important factor, which has been overlooked by many investors. A stock's price will show this discount if there is political or environmental risk.

Investors will encounter less of these signs as more environmentalists endorse nuclear energy as a means to reduce air pollution and global warming. Some of the more rabid groups prey upon backward aboriginal or indigneous peoples, slowing down the uranium mining process.

7. **Look for solid shareholders.** Find out if management has a large stake in the company. Often, this makes them value their stock more highly and will discourage them from reckless stock issuance. Other good signs include large holdings by successful fund managers or institutions, and interest by a major company in a related industry, such as a utility. Companies with strong business plans, accompanying the previous 'golden rules' are more likely to attract future interest by funds, institutions, major uranium companies and utilities.

8. **Study the capital costs for the project and the currency in the country where the project is located.** Typically, the lower the capital costs, the less risk there is in the project. The less a company risks, in time and money, to find out if the mine is economic, the greater its chance of success. Risks-to-reward doesn't favor pure exploration, which is a far riskier proposition than developing a previously drilled uranium property. Larger capital intensive projects usually take longer to bring on so you could risk missing an important part of the cycle in this bull market. Consider currency moves and their possible impact. A strengthening local currency can drive up costs and destroy margins. A falling currency can dramatically improve the economics of the project.

9. **Can the company sell its story?** Funding can improve the story or outlook. How well can the Chief Executive and his geological team attract financing to explore and develop a property's potential? Study how much cash the company has to determine how much more it might need to raise. Funding can dilute the shares, but it is an important element for every company in this sector. Both major uranium producers and the developers/explorers will need to continue selling their stories to attract future financing.

10. **Buy emerging stories**. New stories will come out during this bull market. Mergers, acquisitions and new uranium discoveries will continue to alter the community of uranium companies. There will be successes, but more failures, which is why we helped create this list of cautions and advices.

A Conversation with Kevin Bambrough and Jean-Francois Tardif

To further clarify some of Mr. Bambrough's and Mr. Tardif's tips, StockInterview.com discussed their advice in greater detail.

StockInterview: How do you feel about uranium, which fuels nuclear reactors and generates electricity, and for the uranium bull market that we're in right now?

J-F Tardif: We are very bullish. We're extremely bullish on uranium as a firm, not only for uranium, but we're also very bullish on energy. Everything is inter-connected because we believe in the peak oil theory. That means the production of oil around the world will eventually peak, yet the demand will continue to increase. That puts a tremendous pressure on oil. With oil going up and natural gas price going up, then this has an effect on coal and uranium prices as well. So that's why we're very bullish on uranium.

StockInterview: Isn't there a special situation, though, with uranium?

J-F Tardif: In the business of uranium, you have a huge shortage of production versus demand. Very close to half of the annual demand is produced from mining. The other half is coming from above ground inventories. Eventually, those inventories go down. Eventually, they go to zero. Obviously, you can not have a zero inventory. So that puts an additional pressure on the uranium price. The fact is we don't produce enough uranium versus the demand. Rising oil prices puts pressure on the cost of energy so people are looking at alternatives. A lot of the growth in Asia, for example, is in terms of nuclear energy. So there are many reasons to be bullish.

StockInterview: How you determine the quality of a uranium stock?

J-F Tardif: The first thing is a high quality resource in the ground or in production. If somebody is already producing, obviously we know they have it. If a company is not producing, but they have a resource, it has to be a high quality resource. This can be done by engineering work and drill holes and experts. I'm not a geologist so I cannot be a technician myself, but other people can. They can say there is X amount of uranium in the ground with X amount of certainty. Those, then, would be the type of stocks in which we would be interested.

Kevin Bambrough: And at a grade that we feel is in economic concentrations at various prices.

StockInterview: But there is such a spread on those concentrations, or grades. It can't always be the high-grade uranium found in Athabasca. What grades make you comfortable?

J-F Tardif: It's very different if you have an ore body or a deposit that is very deep in the ground. Obviously, it will be at a different cost than if it's an open pit. You have to understand how it's going to eventually be mined. Depending on the grade, let's say it costs $100/ton to mine somewhere. Your value in the ground is $200/ton. To value the uranium, you then have a $100/ton of gross margin potential. You then figure out the cost per ton and the revenue per ton. Revenue per ton obviously is driven by the grade. Then, you try to figure out who has the best gross margin out there. Then you look at the gross margin versus the market cap and you compare. It's a lot of analysis and thinking about numbers and guessing. It's a guessing game as well. Finally, you try to guess the best you can, make an opinion, and make a decision.

StockInterview: When you say a good management team, are you referring to the geological team?

Kevin Bambrough: Typically yes. I get more comfort from guys that have worked for some of the larger companies. For example, some of them have been employed with a larger company for a long period of time in a prominent role. Then, they decide to go on their own because they feel that they can. They're excited to go and try to develop their own company. They think that they can go and hopefully strike it rich.

J-F Tardif: We certainly prefer people that have been involved in uranium for a long time – people that were actually involved in uranium in the 1970s. A guy with 40 years of experience in mining, and 10 years of that in uranium is certainly better than another type of guy who has never dealt with uranium. Management is important, but the deposit is more important. Either they have it or they don't, right? Obviously we don't want to go with a company that has management that we don't like and with no deposit.

Kevin Bambrough: Early on, when we first started looking at uranium, and the land grab phase was on, we valued management a little more highly then. We were talking to people who were saying things like, "Give us some money, we're going to go and try and stake some things." Or they'd say, "We've bought a database so we know people who know where these deposits are, and we're going to get them." Back then, we were in an early stage. Now, a lot of the most prospective properties have been snatched up. So, now it becomes more about the mining team than it was in the early stage, during the acquiring phase.

StockInterview: What do you look for in an exploration play before you even consider it?

Kevin Bambrough: There are different things you could do. With some exploration plays, you focus on management history. A lot of it is a belief in management. Sometimes you're looking at your belief in a region, the success of a region, what is called "closeology." Somebody's staked around an area where there was a recent strike by another. Or, a major dropped a bunch of land that was prospected around an existing deposit, which another company picked up that land during a market low and is now going to explore.

StockInterview: Aren't there, however, a lot of failures in that area?

Kevin Bambrough: A lot of successes, too. It's a risk-to-reward ratio.

StockInterview: Because the last uranium boom was thirty years ago, aren't many of the exploration companies having a tough time finding talented experts?

Kevin Bambrough: There are not a lot of people out there. There are some people who have been trained. The Altius (TSX: ALS) people were fortunate enough to work with Cameco (NYSE: CCJ) and have access to their lab back, over last decade and are very close in that area. A lot of different people out there have skills, and people are developing them. There's a lot of new interest moving into this sector.

Cameco Corp is the world's largest uranium producer. Altius Minerals has enjoyed a connection with this major company.

StockInterview: How do you uncover the "hidden value" during a company in which you consider investing?

Kevin Bambrough: When we first started look at uranium companies at the start of this bull market, we looked at different things they had. With a company like Western Prospector (TSX: WNP), it had a mine shaft. An existing shaft costs huge dollars to build today. Their market cap was less than the value of the shaft when we first started investing in it. Another company might have a database with drill data they can use. They just have to drill a few holes to be able to qualify their resources and bring things forward. So, it's a huge considerable cost and time savings. When you have access to that data, it's a type of hidden value. Sometimes, there are companies which have a mill that can be rehabilitated. In comparing the value of an explorer, in terms of one who's got a very little bit of drilling done on their property, you find out what it costs for the average drill hole. Depending upon where you are, it can be quite expensive. That also helps put a baseline value in the company.

Bambrough likes Western Prospector because its previous tenant built a mine shaft, therefore reducing this company's expense in mining its property.

StockInterview: What about exploring in a remote area, such as Namibia, where Paladin Resources (TSE: PDN) has had success?

Kevin Bambrough: It really depends upon your distance from infrastructure. In Namibia, there is a real shortage of water. It can be an extreme problem. It can be an extreme cost to get access to water that's required in the mining process. It doesn't kill the exploration. It just means you're going to have to find a lot more uranium in order to justify the capital costs. If you believe there's some uranium in this remote area, well there better be a lot of uranium. That's because the cost to build a mine there is extreme. It's not like you can truck the ore out, because it's out in the middle of nowhere. So you're going to have to build a mine and a mill, and it becomes a lot more difficult. You also have to make sure there is a long enough reserve life so you can spread the capital cost of the infrastructure out over time.

Paladin Resources hopes to commence its uranium operations in Namibia this year. It has reported pre-selling its uranium production to a U.S. utility. Others are now following Paladin in Namibia, such as Forsys Metals and UraMin.

StockInterview: You mentioned that "access to capital was easy right now in the sector"?

Kevin Bambrough: The money is just pouring into this sector with all of the financings. In some ways, it's good for the industry as a whole. It may not be the best thing for the uranium price long term, but the investments that have come in recent months are going to help find, or might find, new deposits and solve the (supply) deficit at some point. We're talking way off here, because it still takes a long time to find new deposits.

StockInterview: Sprott Asset Management has invested heavily in the uranium exploration sector, and many have done well. Will you continue to support these companies?

Kevin Bambrough: What we have been doing is basically sticking with our winners and helping to finance them to take their project forward. We still believe we were fortunate enough that most of the projects we found and invested in early are the ones that are still the most likely to come on in the future. We feel we're backing the right horses, and we're going to sort of stick with that philosophy.

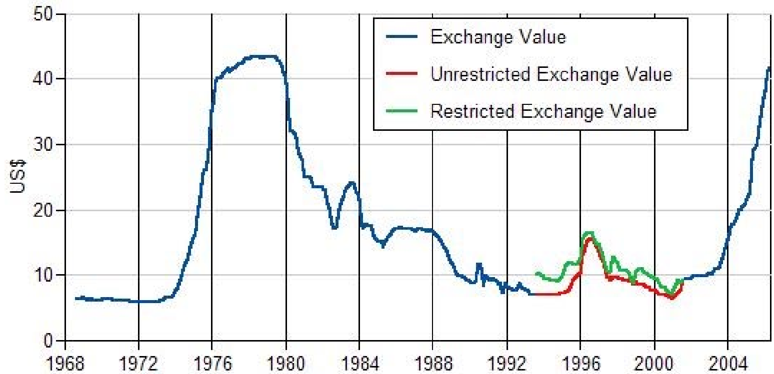
StockInterview: Are uranium stocks still to be held at this time, or is time to circulate money elsewhere?

J-F Tardif: It depends on your view. Our view is to redeem in the long term because we have a bullish view on energy, and uranium. We're comfortable owning uranium here even though they've gone up. But, short term? Who knows the short term? The short term is probably the toughest thing to predict.

Kevin Bambrough: I think a lot of these stocks have run a lot in the short term so that makes us more cautious. There are not as many stocks that have a significant upside like we saw a couple of years ago. It's not the same picture out there, but there are still a few select companies that have a lot of potential. A lot of companies have gone up. Companies, which we think may not be as good, have also gone up. Perhaps, now is a better time to really focus on the companies we believe are better than others. That is actually something we've done here. We've started selling those we're not as confident in as others and have bought other uranium stocks we actually feel more confident in the quality.

StockInterview: Do you believe we're still going to see a uranium shortage?

Kevin Bambrough: I think it's clear that there is a uranium shortage right now. I think it's going to continue for some time.



At this writing, spot uranium is now trading at $45/pound, the highest recorded spot price, but not in constant 2006 US dollars. Courtesy of TradeTech LLC

StockInterview: What pricing do you see in the spot uranium market?

Kevin Bambrough: I think that prices may be more than $50 as a sustainable level. Again, I'm looking at a few years, and it's really hard to even make these predictions. Look at the cost of mining inflation, the costs keep going up. There does seem to be quite a lot of low cost uranium production that's available to come on in the world given the passage of time. But, because of the excessive demand we believe that's going to be out there in the nuclear industry, it's going to require more than just the low cost mines coming on. We're going to need a lot of these higher cost mines, those that need the $40 or $50 spot uranium prices in order to justify the investment required to bring these properties on.

Experts Forecast A Major Uranium Supply Crunch

"The problem is the one to two decades that will be needed to expand [production] capacity and build the flow of nuclear fuel that meet the expanding requirements horizon."

Thomas L. Neff, MIT's Center for International Studies

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Kevin Bambrough, Market Strategist, Sprott Asset Management

Kevin Bambrough joined Sprott Asset Management Inc. as a Research Analyst in August 2002. He has worked in the investment industry for over 5 years and adds greater depth and analysis to the investment team due to his diverse background and experience across various industries. Prior to joining SAM, Kevin worked as a Microsoft Systems Engineer for five years. Since 2003, Kevin has focused his analysis in the coal and uranium mining sectors for the Sprott Investment Team.

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