The First New Conventional Uranium Mill in the U.S. in 30 Years – Status of the Piñon Ridge Project, Colorado- 11438

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ABSTRACT

Energy Fuels Resources Corporation (EFR) is intending to license, construct and operate a conventional acid leach uranium and vanadium mill at the Piñon Ridge Mill site in western Montrose County, Colorado. Site facilities will include an administration building, a 17- acre mill, three tailing cells totaling 90 acres, a 40-acre evaporation pond (expandable capacity to 80 acres), a 6-acre ore storage pad, and an access road. The mill will process ore produced from mines within a reasonable truck-hauling distance, mostly from the historical Uravan mineral belt of the Colorado Plateau (western Colorado and eastern Utah). The ore to be processed at the mill contains elevated concentrations of natural uranium and its decay products. The average uranium content in the blended ore which will be fed to the mill is 0.23 percent U_3O_8 equivalent which is approximately 600 pCi (20 Bq) U-238/g ore).. The Piñon Ridge Mill is expected to produce about 770,000 lbs (350,000 kg) of yellowcake (uranium oxide) product / year. Vanadium concentrations are, on the average, four to five times greater than uranium concentrations in the Uravan mineral belt resulting in correspondingly greater recoveries of vanadium The mill will initially process 500 tons (about 450,000 kg)of ore per day and is designed for future expansion to a production capacity of 1,000 tons (about 900,000 kg) per day (tpd). The projected operating life of the Facility is 40 years, operating 24 hours per day, 350 days per year at 500 tpd. The Facility is expected to employ 85 people directly.

The Piñon Ridge mill is subject to regulation by the state of Colorado as an Agreement State under the Atomic Energy Act. Accordingly, the mill license (radioactive source material license) will be issued and administered by the Colorado Department of Public Health and Environment (CDPHE). A source material license application has been submitted to CDPHE and is currently under detailed technical review. This paper will present a summary of design and environmental work accomplished to date, the status of the licensing and permitting process and some of the challenges faced as the first new conventional uranium mill in the US in decades.

INTRODUCTION AND PROJECT BACKGROUND

Energy Fuels Resources Corporation (EFR) is intending to license, construct and operate a conventional acid leach uranium and vanadium mill at the Piñon Ridge Mill site in western Montrose County, Colorado. Site facilities will include an administration building, a 17- acre mill, three tailing cells totaling 90 acres, a 40-acre evaporation pond (expandable capacity to 80 acres), a 6-acre ore storage pad, and an access road. The mill will process ore produced from mines within a reasonable truck-hauling distance, mostly from the historical Uravan mineral belt of the Colorado Plateau (western Colorado and eastern Utah). The ore to be processed at the mill contains elevated concentrations of natural uranium and its decay products. The average uranium content in the blended ore which will be fed to the mill is 0.23 percent U_3O_8 equivalent which is approximately 600 pCi (20 Bq) U-238/g ore).. The Piñon Ridge Mill is expected to produce about 770,000 lbs (350,000 kg) of yellowcake (uranium oxide) product / year. Vanadium concentrations are, on the average, four to five times greater than uranium concentrations in the Uravan mineral belt resulting in correspondingly greater recoveries of vanadium The mill will initially process 500 tons (about 450,000 kg) of ore per day and is designed for future expansion to a production capacity of 1,000 tons (about 900,000 kg) per day (tpd). The projected operating life of the Facility is 40 years, operating 24 hours per day, 350 days per year at 500 tpd. The Facility is expected to employ 85 people directly.

Currently, the US fleet of 104 nuclear power plants produce approximately 20 % of the US's base load electricity* and consumes about 60 million pounds of yellowcake per year. In 2010, the US produced < 5 million pounds. Accordingly, we must currently import > 90 % of the uranium needed for U.S. fuel requirements. The last section of this paper will discuss circumstances of supply and demand in the global uranium market. Figure 1 presents a simple schematic of the commercial nuclear fuel cycle in the US.

* "Baseload " refers to electricity that can be produced and is available 24 hours/day, 7 days/week since availability is not depended on environmental factors.

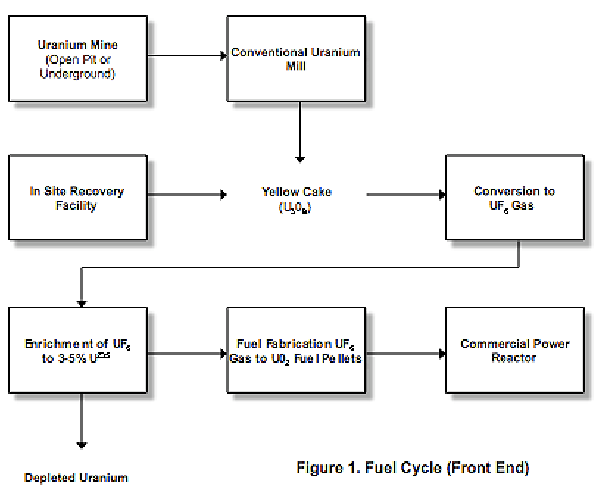

Fig.1: US Commercial Nuclear Fuel Cycle Schemati

The Piñon Ridge project site covers approximately 880 acres in the southeastern portion of Paradox Valley. The proposed Piñon Ridge Mill Facility is located on Highway 90, approximately 7 miles east of Bedrock, Colorado and 12 miles west of Naturita, Colorado. Figure ***2*** presents the general location of the project and Figure 3, depicts the property boundary within the Paradox Valley region. Figure 4 shows the site today with a superimposed artist rendering of the facility when construction is complete.

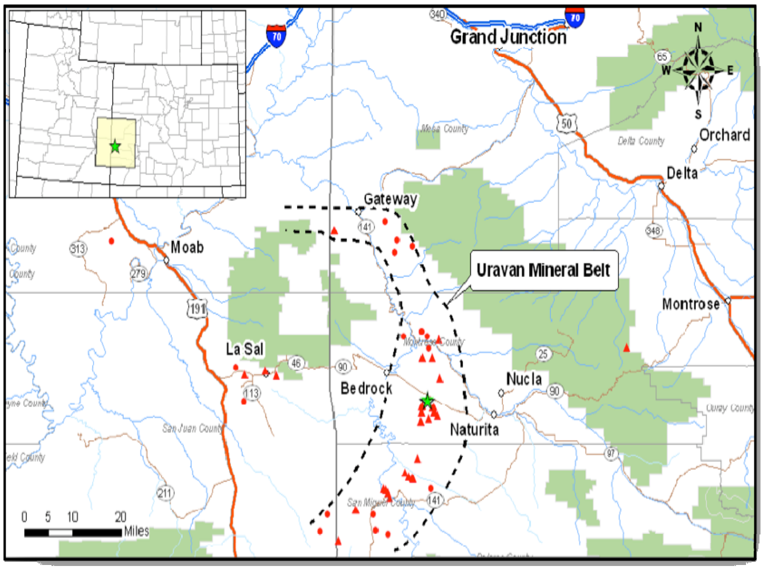

Fig. 2: General Location – Piñon Ridge Project

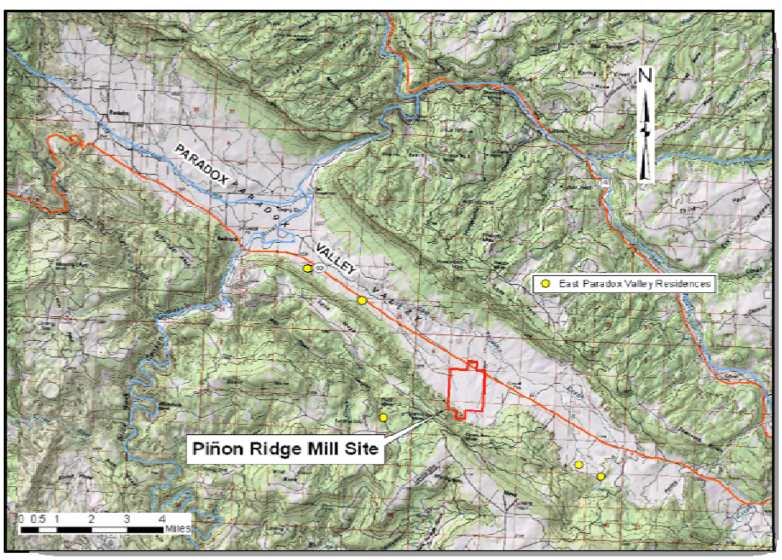

Fig. 3: Project Boundary within ParadoxValley

Fig. 4: View of Site With Superimposed Artist Rendering

Regulatory Background and Licensing Process

The Piñon Ridge mill is subject to regulation by the state of Colorado as an Agreement State under the Atomic Energy Act. Accordingly, the mill license (radioactive source material license) will be issued and administered by the Colorado Department of Public Health and Environment (CDPHE). A source material license application has been submitted to CDPHE and is currently under detailed technical review. Table 1 presents the status of key milestones associated with the Piñon Ridge source material license application process. The multi - volume application package is shown in Figure 5.

Fig. 5: Source Material License Application for the Pinon Ridge Uranium Mill – Submitted to the Colorado Department of Health and Environment, November 2009

As an Agreement State, Colorado has the responsibility for licensing the possession and use of radioactive materials under the State's Radiation Control Act. As of January 2006, thirty-three states have entered into agreements with the US Nuclear Regulatory Commission (NRC), under which regulatory authority has been delegated to the state over most radioactive materials used in non-federal facilities, pending that the state program is compatible with NRC requirements. (Note: New Mexico, although an "Agreement State" in most other circumstances, had relegated its licensing and regulatory authority for uranium mills and related source material facilities back to the NRC some years ago.)

Per agreement between the NRC and the Governor of Colorado, CDPHE is the sole regulator of radioactive materials in Colorado under the Colorado Radiation Control Act (CRS 25-11-101, et seq). The implementing regulations for the management and control of radioactive materials are detailed under the Colorado Rules and Regulations Pertaining to Radiation Control (6 CCR 1007-1). Examples of some of the specific CDPHE regulations under 6 CCR 1007-1 that are applicable to the licensing of a uranium mill in Colorado include:

- Part 1 - *General Provisions*
- Part 3 - *Licensing of Radioactive Material*
- Part 4 - *Standards for Protection Against Radiation*
- Part 17 - *Transportation of Radioactive Materials*
- Part 18 - *Licensing Requirements for Uranium and Thorium Processing"* and its Appendix A, *Criteria Relating to the Operation of Mills and the Disposition of the Tailings or Wastes from these Operations*

Additionally, CDPHE has the option of incorporating relevant NRC guidance into the State's license review process including use of the following (for example):

- NRC NUREG 1620 *Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act of 1978* (1)
- NRC Regulatory Guide 3.5 *Standard Format and Content of License Applications for Uranium Mills.* Under revision as Draft Guide 3024. (2)
- NRC Regulatory Guide 3.8 *Preparation of Environmental Reports for Uranium Mills* (3)
- NRC Regulatory Guide 4.14 *Radiological Effluent and Environmental Monitoring at Uranium Mills* (4)
- NRC Regulatory Guide 8.30 *Health Physics Surveys in Uranium Recovery Facilities* (5)
- NRC Regulatory Guide 8.31 *Information Relevant To Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Is Reasonably Achievable* (6)

At least nine months prior to anticipated construction, an applicant must submit the mill license application to CDPHE (construction is prohibited until a license is issued). At least 12 months of pre-operational environmental characterization and monitoring data will have been collected prior to license submittal. Initially, CDPHE must review the application package for completeness and has 30 days to determine this. The application package for the Piñon Ridge Project was determined by CDPHE to be substantially complete in mid-December 2009 (See Table 1).

The first public meeting/hearing must be conducted by CDPHE within 45 days of the completeness determination, with a second meeting within 30 days of the first. The County Commissioners review of the Environmental Report (submitted as part of the license package) is requested within 90 days of the first public meeting. CDPHE must approve or deny the application within 270 days of response from the County Commissioners, or within 360 days of the second public meeting if there is no County Commissioner response.

TABLE I: Piñon Ridge Key Regulatory Milestones

Milestone	**Date Achieved**
Submittal of radioactive material license application to Colorado (CDPHE)	11/18/09
CDPHE determination of completeness	12/18/09
First public meeting	1/21/10
Second Public Meeting	2/17/10
County Commissioners response	4/19/10
CDPHE issues first Request for Additional Information (RFI)	2/26/10
CDPHE issues second RFI	5/25/10
CDPHE issues third RFI	8/19/10
CDPHE issues fourth and final RFI	9/21/10
Application package preliminary approval and draft license issuance	Expected 1/17/11
Final approval and license issuance following 60-day public comment period	Expected 3/18/11
Potential administrative appeals by NGOs, 9-12 months	

The remainder of this paper will present an overview of the history of the uranium recovery (mining and milling) industry in the U.S., a summary of the design and uranium recovery processes of Piñon Ridge mill, and will then conclude with some perspectives on how projects like Piñon Ridge fit into the national and global energy picture today and in the near future.

History and Current Circumstances of Uranium Recovery in the United States

In the United States, the mining of ore that contains uranium goes back to the early part of the 20th century. At that time the interest was not in uranium per se, but in other minerals associated with it, namely vanadium and radium. Interest in uranium began in earnest in the years immediately following World War II with the passage by the U.S. Congress of the McMahon Act (more commonly known as the Atomic Energy Act [AEA], signed by President Truman in August 1946), which created the United States Atomic Energy Commission (AEC) and established the U.S. government as the sole buyer of uranium (for the nuclear weapons program). The government's uranium ore procurement program sent thousands of prospectors crawling over the "Colorado Plateau" (the four corners area of Utah, New Mexico, Arizona, and Colorado). The AEC developed publications to assist prospectors in this regard (Figure 6). This ore was processed at a number of sites—collectively known as the "MED (Manhattan Engineering District) Sites"—and remediated decades later under the Formerly Utilized Sites Remedial Action Programs still ongoing today. AEC incentives ceased in 1962, (although the purchase program continued until 1970) and mining and milling operations on a much larger scale than those early efforts were established by private companies.

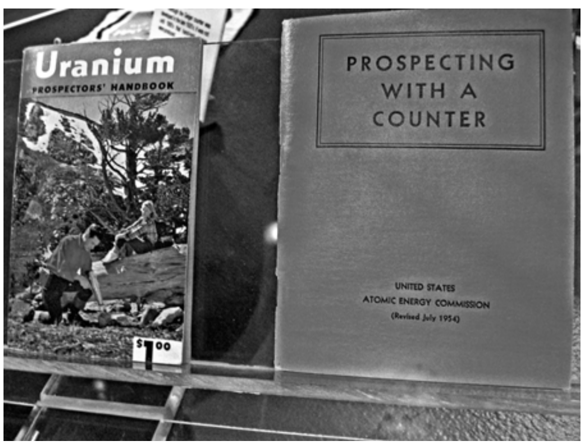

Fig. 6: US Atomic Energy Commission Uranium Prospector Booklets – Circa 1955

As the commercial nuclear power industry developed in the late 1960s and early 1970s, the federal government was no longer the exclusive buyer of domestically produced uranium. U.S. production and uranium prices peaked in the early 1980s. Shortly thereafter, domestic demand for uranium ore declined as the commercial nuclear power industry fell far short of its expected growth and in response to, and low cost of, much higher-grade Canadian and Australian deposits that began to dominate world markets and supplies provided from agreements with states of the former Soviet Union to convert and down blend uranium from nuclear weapons into power reactor fuel. Planning and construction of new U.S. commercial nuclear power plants came to a halt and the domestic price of uranium dropped dramatically as the nation faced an oversupply of uranium despite the fact that demand remained fairly constant through 2003.

Over the past 4 - 5 years, several factors have contributed to driving up market price of uranium in direct response to increasing demand. These factors of course include national and international interest in reduction of dependence on fossil fuels, climate change and related environmental issues. However, more fundamentally, "exploding economies" such as China and India are building large numbers of nuclear plants in the coming decades to support the energy and quality of life needs of their populations. This major factor has resulted in demand today being greater than supplies and this differential is expected to widen in the immediate future.

As a result of these market conditions, the uranium recovery industry is benefiting directly from the "nuclear renaissance" of today and into the near future. The U.S. Nuclear Regulatory Commission (NRC) Uranium Recovery Branch has recently issued several new licenses for in – situ uranium recovery facilities* and estimates that over the next few years, it expects to receive over 20 additional source material license applications for new and/or upgraded uranium recovery facilities (7). Similar new project development is also taking place in the historical uranium recovery districts in NRC Agreement States (e.g., Texas and Colorado).

* In contrast to the Piñon Ridge "conventional" uranium mill, "In Situ Recovery" (ISR) plants recover uranium by circulating groundwater; fortified with oxygen, carbon dioxide and/or sodium bicarbonate (in US designs - acids are used in Asia) thereby recovering the uranium " in situ". The uranium bearing solutions are pumped to the surface for ion exchange and otherwise conventional processing. They typically have an annual production of about 50% of that of a conventional mill.

The Piñon Ridge Milling Operation

The Piñon Ridge operation will be a conventional milling process with significant modern design and equipment upgrades relative to the technology of conventional mills > 30 years ago. Milling involves grinding the ore into a fine slurry and then leaching it with sulfuric acid to separate the uranium and vanadium from the remaining rock. Uranium and vanadium are then recovered from solution and precipitated as uranium oxide ("U_3O_8") concentrate (called yellowcake) and vanadium oxide ("V_2O_5") concentrate, respectively. These dry concentrates are sealed in 55-gallon, steel drums and transported off site for further processing by others. The primary uranium milling and process stages include:

- Grinding;
- Pre-leaching and thickening;
- Leaching;
- Separation and purification;
- Uranium recovery and precipitation
- Yellowcake drying and packaging

The vanadium recovery process is not addressed here but is very similar to the uranium recovery process except that after drying, the vanadium oxide is run through a fusion furnace to create a metallic product that is then packaged and shipped off site for further processing

Following is a brief description of each primary component of the uranium milling process. Figure 7 illustrates the entire milling process including vanadium recovery.

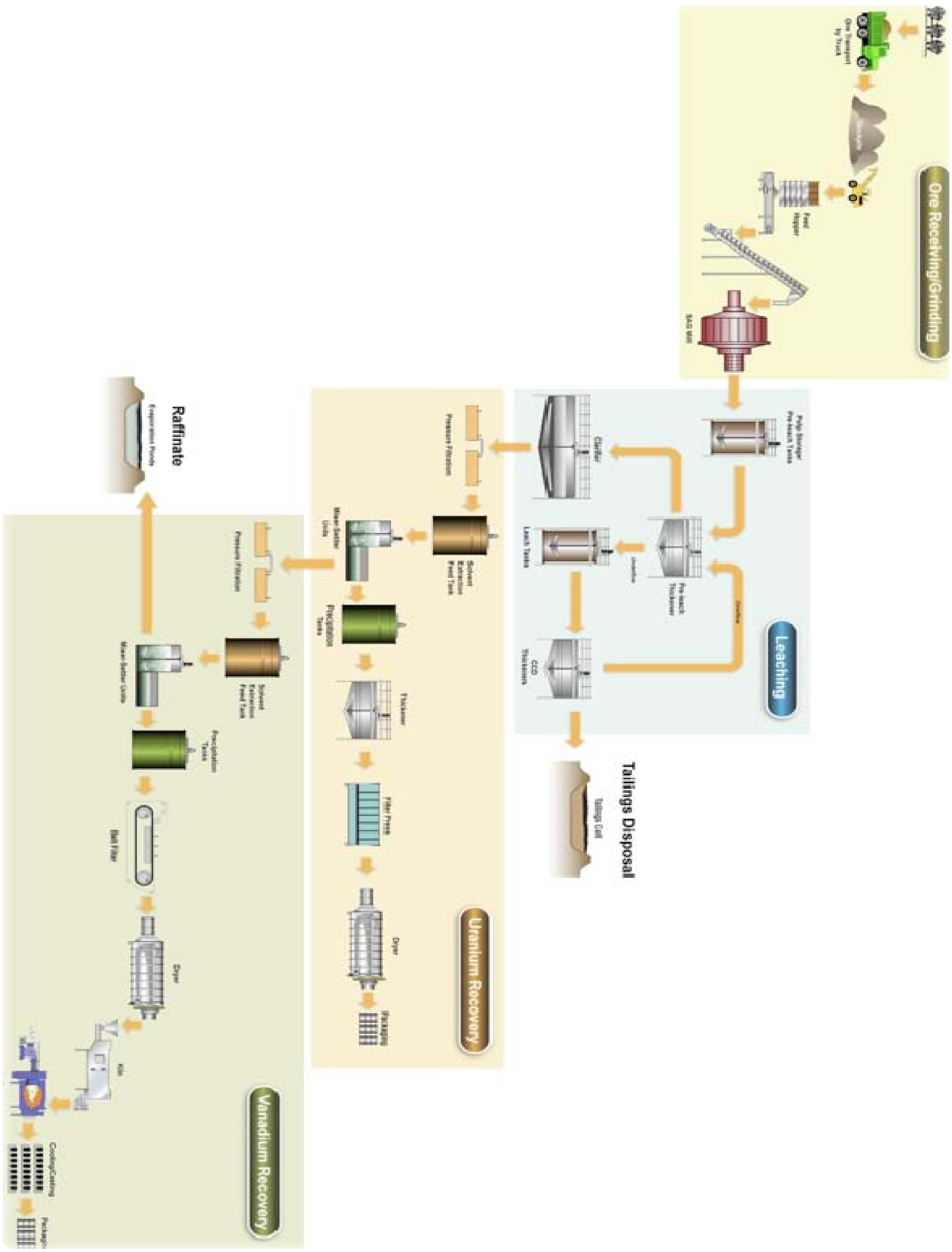

Fig. 7: Milling Process Flow Sheet

Grinding

Ore is fed into the mill from onsite stockpiles using a front-end loader and/or trucks. The ore is dumped into a feed hopper and delivered by belt conveyor to a semi-autogenous grinding ("SAG") mill. In the SAG Mill, the ore is combined with water and tumbled with steel balls. The tumbling action causes the larger ore pieces and steel balls to grind the ore into fine powder, exposing the uranium and vanadium mineral surfaces from the host rock.

Pre-leaching and Thickening

The resulting slurry from the SAG Mill, consisting of 0.03-inch sized particles and water, is distributed to one of two large, steel pulp storage tanks. The slurry is pumped from the storage tanks to two rubber-lined, steel pre-leach tanks where the pulp reacts with sulfuric acid reducing the pulp density to approximately 25 percent solids. The pulp then reports to a rubber-lined, steel thickener tank. The overflow from the thickener is clarified, filtered and sent to a feed tank for use in the uranium recovery circuit. The partially dewatered underflow from the thickener is pumped to the leaching circuit.

Leaching

The leach circuit consists of eight rubber-lined steel tanks with agitators. The tanks are arranged in a cascading and staggered configuration so that individual tanks can be bypassed if necessary. In the leaching circuit, the pulp pumped from the pre-leach thickener tank is heated with steam and then leached with sulfuric acid to dissolve the uranium and vanadium minerals. Sodium chlorate is also added as an oxidant, as necessary.

Liquid/Solid Separation and Purification

The leached pulp is pumped to a series of 40-foot diameter counter current decantation ("CCD") thickeners, where liquids and solids are separated. The uranium- and vanadium-bearing (or pregnant) solution is separated from the remaining solids, called tailings, which consist of a variety of other minerals that were present in the ore. The pregnant solution is pumped to the pre-leach tanks and subsequently to the uranium recovery feed tank while the tailings are pumped to the tailings cell.

Uranium Recovery and Precipitation

A solvent extraction ("SX") process is used to concentrate and recover the uranium from the pregnant solution. In the SX process, the pregnant solution is filtered and the uranium separated and purified using a kerosene-based solvent. The result is a pure, but weak, uranium solution, which is washed with sulfuric acid and water to remove impurities. Following washing, the uranium is stripped from the solvent using a sodium carbonate solution. The uranium is continuously precipitated from the stripping fluid by adding hydrogen peroxide to the solution, which precipitates a bright yellow powder (or slurry) referred to as yellowcake. See Figure 8.

Fig. 8: About 700 pounds of Yellowcake (Uranium Oxide)

Yellowcake Drying and Packaging

The powder is then partially dewatered, washed, filtered and dried in a vacuum dryer. Finally, the dried yellowcake is packed, weighed, and sealed in 55-gallon, steel drums for shipment. Each packed drum weighs approximately 700 pounds.

At an ore processing rate of 500 tpd, an average ore grade of 0.23 percent U_3O_8 equivalent, and a 96 percent recovery rate, approximately 2,200 pounds of yellowcake (or 2½ drums) are produced per day. The drums of yellowcake are shipped to a conversion plant where the uranium is converted from an oxide * to uranium hexafluoride, which can be enriched for use in nuclear power plants (See Figure 1). Conversion plants currently in operation in North America are the Honeywell facility in Metropolis, Illinois and the Cameco facility in Port Hope, Ontario. Typically, a transport truck can carry 25 to 27 tons of cargo, or up to approximately 55 to 60 drums of yellowcake. Approximately 15 truckloads of yellowcake will be shipped from the Piñon Ridge mill per year.

* In modern uranium recovery facility designs, the final “yellowcake product” is typically a combination of UO_3, UO_4 and their hydrates (8)

The Current and Near Future Global Uranium Market – Supply and Demand

Concurrent with the recognition that nuclear-generated electricity must play an increasing role in worldwide energy supply and in consideration of the new nuclear power plants world wide ordered, planned or under construction, the demand for uranium needed to fuel these reactors has already outpaced supplies. Accordingly, the price of uranium (typically expressed as $ per pound U_3O_8 equivalent) had increased from approximately 10 $ per pound in 2002 to over 120 $ per pound by mid 2007**,** although market factors have balanced the price to about 60 $ per pound at the end of 2010. As a result, numerous new and reconstituted uranium recovery projects are being developed in the United States and in other countries around the world. Table 2 presents uranium ore production figures for the world’s top ten uranium producers. Note that in 2009, Kazakhstan surpassed Canada and Australia and is now the world's leading producer of uranium ore and that country's production is expected to continue to increase over the next few years.

Table II: World's Top Ten Uranium Ore Producers - from mines (tonnes U) *

Country	2003	2004	2005	2006	2007	2008	2009
Kazakhstan	3300	3719	4357	5279	6637	8521	14 020
Canada	10457	11597	11628	9862	9476	9000	10173
Australia	7572	8982	9516	7593	8611	8430	7982
Namibia	2036	3038	3147	3067	2879	4366	4626
Russia	3150	3200	3431	3262	3413	3521	3564
Niger	3143	3282	3093	3434	3153	3032	3243
Uzbekistan	1598	2016	2300	2260	2320	2338	2429
USA	779	878	1039	1672	1654	1430	1453
Ukraine (est)	800	800	800	800	846	800	840
China (est)	750	750	750	750	712	769	750

* World Nuclear Association @ http://www.world-nuclear.org/info/inf23.html

This recent imbalance between supply and demand is depicted in Figure 9. It should be noted that in the United States, our current reactor fleet of 104 operating units, which generate 20 percent of our base-load electricity, requires approximately 55 million pounds of U_3O_8 per year, but only about 5 million pounds per year is produced domestically. That is, about 90 percent of our current demand, ignoring anticipated increase in requirements in the near future as new nuclear plants come online must come from foreign sources without additional development of existing U.S. reserves. Domestic uranium production over the last 10 years reached a low of about two million pounds in 2003 and has been increasing steadily since then.

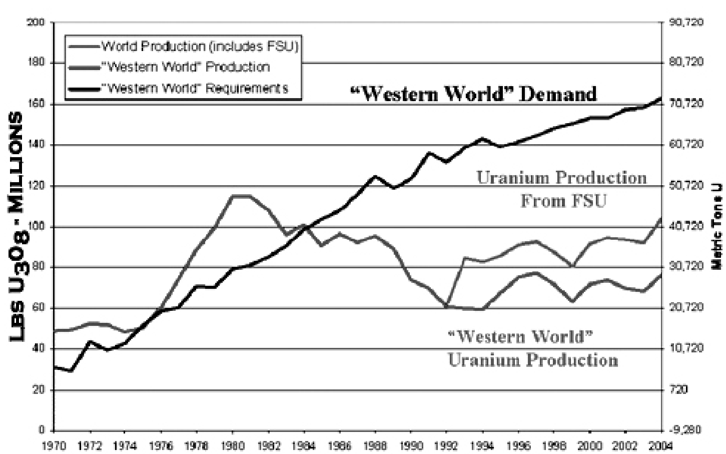

Fig. 9: Uranium Demand Outpaces Supply and is Expected To Continue Over Next Decade or More

The US Department of Energy, Energy Information Agency reported in July 2010, (http://www.eia.doe.gov/cneaf/nuclear/page/reserves/ures.html) that at the end of 2008, U.S. uranium reserves totaled 1,227 million pounds of U_3O_8 equivalent at a maximum forward cost (MFC) of up to $100 per pound U_30_8. At up to $50 per pound U_3O_8, estimated reserves were 539 million pounds of U_3O_8. Based on average 1999-2008 consumption levels (uranium in fuel assemblies loaded into nuclear reactors), uranium reserves available at up to $100 per pound of U_3O_8 represented approximately 23 years worth of demand, while uranium reserves at up to $50 per pound of U_3O_8 represented about 10 years worth of demand. But since as indicated above, domestic U.S. uranium production supplies only about 10 percent of U.S. requirements for nuclear fuel, the effective years' supply of domestic uranium reserves is actually much higher, under current market conditions.

Nonetheless, the national appetite to access and develop these considerable proven reserves thereby reducing dependence on foreign supplies is uncertain. In the view of these authors, significant obstacles to the development of energy related natural resources continue to be encountered due to the lack of a comprehensive and coherent energy policy in the U.S., lack of understanding on many basic scientific principals of energy related resource development and use and the "politicizing" of these critical issues. This limits our ability to enhance our energy independence and the directly associated implications for national security. As is our current situation with oil, we are therefore highly reliant on foreign sources and some of these regimes (now and in the future) may not be friendly to the U.S. (e.g., see Table 2). Given the expansion of economies like China and India who plan on building large numbers of new nuclear plants in the next two decades, we will be competing for worldwide uranium supplies. Projects like Pinion Ridge will contribute to this critically needed fuel supply.

REFERENCES

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(2) USNRC 1977 Regulatory Guide 3.5 *Standard Format and Content of License Applications for Uranium Mills* (Currently under revision as Draft Guide 3024)

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