Jeff Combs: Comments on the global nuclear fuel market

The publisher of a nuclear fuel newsletter provides answers to questions about uranium and nuclear power, such as, "How high will fuel prices go?"

Jeff Combs is president of the Ux Consulting Company (UxC) and publisher of *Ux Weekly.* UxC was founded in March 1994 as an affiliate of the Uranium Exchange Company to provide greater focus on the company's consulting and information services capabilities. *Ux Weekly* provides spot prices for the uranium, conversion, and enrichment front end. The publication also tracks current activity in these markets, provides perspective articles on market trends and developments, and covers news affecting the front end of the fuel cycle.

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Combs, who has more than 30 years of experience in providing economic analysis and forecasting for the front end of the nuclear fuel cycle, is responsible for all of UxC's consulting and information services. Before joining the company in 1994, he was a senior economist at Science Applications International Corporation, where he developed the U-PRICE model of the uranium market, and was managing editor of the *Nuclear Fuel Market Quarterly.* From 1980 to 1989, Combs was a vice president for Nuclear Resources International, where he served as an expert consultant in a number of litigation and arbitration cases involving uranium pricing issues. He also was the principal economist associated with nuclear fuel market matters for the federal government while working for the predecessor agency of the Department of Energy.

Combs was questioned about the uranium market by Rick Michal, *NN* Senior Editor. The UxC Web site is at <www.uxc.com>.

What do you see as the main drivers for the price increases in uranium over the past few years?

The primary driver was the massive liquidation of commercial and government/military inventories that took place during the 1980s and 1990s. Because of this liquidation, the price was depressed, and production and exploration fell significantly. And, despite the fact that we publish probably the most referenced spot uranium price in the world, there was an over-reliance on spot prices, which really did not reflect the future scarcity of uranium. In this regard, we noted in 2003 that U.S. utilities had a large portion of their 2006 reactor requirements open, indicating that there was not much contracting occurring at the price at that time ($10.90 per pound), setting the stage for a price run-up. Several events, including a flood at McArthur River, the largest uranium mine in the world, precipitated the increase and helped reveal how fragile the production situation was. When contracting finally began in earnest, considerable pressure was placed on production, and price was forced higher. Since there were not many projects in the pipeline and no real excess capacity, price had to be bid higher to stimulate more production. Utilities and others sought to increase their inventory holdings, and this placed more pressure on price. Of course, the price today is about $37 a pound. The expansion of nuclear power in China and a renaissance in Russia's nuclear program also had an impact by placing more pressure on available supplies.

How high will the prices go?

We have seen estimates of $100 a pound, and even as high as $500, neither of which, I think, is realistic. I have gone on record as saying that it is quite possible that the price could reach $50, and that it is quite likely that the price will break $40 and test its historic high (in terms of nominal dollars) of $43 later this year.

What are the consequences of these price rises?

One of the main consequences has been a dramatic increase in long-term contracting volume. Our records indicate that last year, utilities worldwide contracted for more than a quarter of a billion pounds of uranium under long-term contracts, far and away a record amount. A major reason for

this increase is that the term of a number of these contracts reached 10 years and beyond, while in earlier periods contract lengths were typically three to five years. Part of the reason for these longer contract terms was utility concern about arranging for supplies in the future. But another, and perhaps more important, reason was the ability of uranium producers to dictate these terms because of the tight supply situation that currently exists. Other consequences have been a renewed interest in uranium mining and exploration, and also considerable interest in uranium stocks on the part of investors.

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What do you see as the weakest link in the nuclear fuel supply chain? And, is enough being done to strengthen this weakness?

Although some in the industry focus on conversion supply as the weakest link, I think it is uranium. While it's true that another mishap or strike at a conversion plant could have a significant impact on supply and price, new conversion capacity, as well as enrichment capacity, can be built, but new uranium deposits cannot be "built." These must be found and put into production on a regular basis not only to meet increasing demand, but also to offset the loss of production from mines that are going offline. I think that the rise in uranium prices is certainly doing a lot to stimulate new production and exploration. I think, however, that governments could do more to make land accessible to uranium mining and speed up the regulatory process by which new mines are permitted.

As an aside, when I entered the industry in 1975 as an economist for the Energy Research and Development Administration [the predecessor of the Department of Energy], one of my first jobs was to accompany my bosses to the Treasury Department, which was considering instituting a $1-billion loan guarantee program to stimulate the expansion of uranium mining in the United States. Since the price of uranium was in the process of doubling that year, I questioned the need for such a loan guarantee, believing that the market would provide a sufficient stimulus. From 1975 to 1980, U.S. uranium production almost doubled to 43 million pounds in response to the price rise. The point here is that the market works, but it also shows that the federal government was willing to do much more in the mid-1970s than it is today in the way of promoting uranium production in the United States.

Secondary supplies have made up 40–50 percent of uranium supply for many years now. How long do you see secondary uranium supplies being able to keep up this rate?

This percentage has now dropped below 40 percent and will continue to decline in future years. The reason for the decline is twofold—the absolute amount of secondary supplies has been declining, and reactor requirements have been growing. For secondary supplies to maintain their percentage, they would have to grow as well, which is difficult since they are essentially inventories. The only way that they could keep up this rate is for weapons material to be blended down at an increasing rate, which is highly unlikely. There will always be some component of secondary supplies, however, be it from recycled uranium, MOX [mixed-oxide] fuel, or enrichment of tails material.

Some green groups are saying that there is not enough uranium to make a significant difference to the world's energy problems in the medium term. What is your view of this?

First of all, I'm not sure what they mean by "medium term," but this surely must encompass the operating life of existing reactors, and we are clearly not going to run out of uranium to fuel currently operating reactors. The quantity of uranium in the earth's crust is not the problem; there is plenty of uranium. The rapid increase of price over the past three years has been a result of a surfeit of uranium as opposed to a scarcity. Because so much supply was coming from inventories, including former nuclear weapons, uranium prices were pushed to extremely low levels, and consequently uranium companies cut back on production and exploration. The problem then is one of production catching up with demand. In other words, it's a flow problem, not a stock problem. Prices are now high enough to stimulate production for many years to come. The issue with respect to how high the price goes is how quickly production expands.

These green groups are also saying that the grade of ore will reduce to such an extent that nuclear power becomes significantly carbon dioxide emitting. Do you think that this is correct?

If this is the best argument they can make, they're in a lot of trouble. There is no evidence that ore grades are decreasing to any great degree, and in fact the grades being discovered now are generally much higher than they were in the 1970s and earlier. As I said earlier, uranium prices have been rising because uranium was too plentiful and pushed the price to extremely low levels, which stymied production and exploration, not because it has been necessary to exploit lower-grade ores. Even if ore grades decrease, this argument doesn't hold up, because the energy content of uranium is so high—I think it's something on the order of 100 000 times higher than coal or oil. And when this uranium is consumed in a reactor, it does not produce greenhouse gases or other atmospheric pollutants, unlike fossil-based energy sources.

I also think that this view ignores the role that technology can play. The expansion of enrichment capacity and improvement in enrichment technologies can greatly extend the life of uranium resources and thus compensate for any reduction in ore grade, since enrichment and uranium are substitutable to a large degree in the production of enriched uranium. The fuel also can be configured so it is burned more efficiently, thus requiring less uranium. Both of these developments are happening now.

In addition, there is a considerable amount of fuel remaining in uranium after it is processed and burned in a reactor. Tails material can be enriched, and this currently supplies a notable share of uranium supply. Uranium and plutonium recovered from used fuel can be recycled. Beyond this, reactors can run on thorium in addition to uranium. President Bush has gone so far as to refer to nuclear power as a renewable. I wouldn't go quite that far, but I do think that nuclear is an "extendable" in that the nature of nuclear technology is such that it is able to produce so much power with relatively little fuel. In this regard, uranium supplies can take us very far into the future, far enough so that there will be time to develop other, more advanced technologies that further economize on the use of fuel.

What impact do you see arising from the entry of China and India into the global fuel market?

It will add demand and put pressure on available supplies and price. We have clearly seen this when it comes to other commodities, including oil, and uranium will be no different, especially if China and India pursue aggressive nuclear power expansion plans. But there is a positive side of this as well, as this additional demand gives producers more confidence about making investments in new mines and expanding production from existing mines and avoiding another boom/bust cycle that has characterized the uranium market in the past.

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What is your view on the likelihood that Kazakhstan can reach its stated goal of producing 15 000 tU per year by 2010?

I don't think it's very likely. This is not to say that the Kazakhs aren't serious about expanding production and that there isn't a lot of interest on the part of companies and countries outside of Kazakhstan, but it is an awfully ambitious goal, considering that Kazakhstan does not currently have a well-developed infrastructure to facilitate such an expansion. Investments are being made in the infrastructure and Kazakhstan will certainly be a major uranium supplier in the future—it has recently climbed to third place in the world, I believe—but it has a long way to go to catch up with Canada and Australia, which have more well-developed infrastructures and market presence, although not all of Australia is politically hospitable to uranium mining. Finally, to get the high production rates projected in Kazakhstan, which relies on the *in situ* method of production, high recovery rates would have to be achieved, which is far from guaranteed with respect to that type of mining.

Have any new significant reserves been discovered lately?

There have been a number of uranium discoveries announced, particularly around the Athabasca Basin region in Saskatchewan, Canada, which is home to world-class deposits at McArthur River, Cigar Lake, and Midwest Lake. The ore bodies associated with these discoveries have not yet been delineated to the point where they can be characterized as major reserves, but work is under way to perform the drilling necessary to do that. Because of high uranium prices, exploration is taking place in a number of countries worldwide that should eventually result in substantial additions to the reserve base.

What do you see as the key barriers to expanding production of uranium in the near future—for example, capital, regulation, personnel?

While all of these are obstacles to overcome, I think regulation and government policies are the key barriers. If price remains high, and especially if we are embarking on a nuclear renaissance, attracting capital should not present much of a problem. Given enough time, the personnel issue should also be addressed, as the funds will be available for training, and high wages will attract the necessary labor. Restrictive government policies and regulations, however, have the potential to impede the expansion of production by delaying the time in which new production and properties can be permitted and limiting what lands are open for exploitation. Since production expansion and exploration have been moribund for so long, the uranium industry is already fighting an uphill battle to make up for lost time. It doesn't need any roadblocks in the form of overly restrictive policies and regulations.

Some industry representatives have warned that uranium prices and supplies might not remain stable if there is a substantial worldwide increase in new reactor construction. Could more reactors destabilize the market?

I have heard the same concerns, but I don't think this is a major worry. Prices have shot up in recent years not in anticipation of massive new reactor builds, but because the industry is recovering from decades of massive inventory liquidations. Absent restrictive government policies, the market will work and will stimulate the production levels necessary to meet future growth.

Around 1980, world uranium production—including that of the former Soviet Union and its satellite states—topped 170 million pounds U_3O_8, or about 60 million pounds above the current level, increasing from about 90 million pounds in 1975. And all of this occurred before Key Lake, the first of the "mega-mines" that currently dominate the production profile, came on line. Olympic Dam, an Australian mine that produces uranium as a co-product of copper and has the world's largest uranium reserve, is currently considering different rates of expansion and could potentially expand to 65 million pounds per year, a rate that would supply more uranium than is currently being consumed annually in the United States.

Now, this is not going to happen overnight, but new reactor builds are not going to happen overnight either. I think that once we get past the current crunch of transitioning from a market that is dominated by inventory liquidation to one that is dominated by production, the production industry will be able to handle a robust growth in new reactor construction.

How high would prices have to go before they adversely influence the economics of nuclear power?

The prices would have to go extremely high, because fuel is a relatively small part of the overall costs of nuclear power, especially when compared with plants powered by fossil fuels. To answer this question with a specific number, I would need to know what coal, oil, and natural gas prices would be in the future. In this regard, while nuclear fuel costs have increased considerably over the past several years, so have fossil fuel prices, and these have a much bigger impact on electricity prices than the rise in nuclear fuel prices does.

Will use of MOX fuel expand to the point where it can take the pressure off uranium mine output?

MOX fuel currently takes some pressure off uranium mine output by reducing the demand for uranium. Its use could certainly grow in the future, but its growth will depend on the future economics of uranium supply. Because of the overall availability of uranium, MOX fuel likely will not be needed to any large extent in the foreseeable future, even if nuclear power experiences a renaissance. It does serve as a sort of a supply backstop, however, although more reprocessing capacity would have to be built before MOX use could be expanded to any degree.

The recent disturbances in the European gas market, resulting from the behavior of Russian suppliers, have caused renewed anxieties among many countries on security of supply issues. If the world becomes more dependent on uranium, could there be a similar problem, i.e., could customer nations be held for ransom by powerful supplier nations?

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First, the two largest suppliers of uranium are Canada and Australia, and no uranium is exported from the Middle East or Venezuela, which are potential trouble spots when it comes to the export of oil. Russia is a major exporter of enrichment and uranium, but I think that there are several important differences between Russia's exporting nuclear fuel and exporting natural gas. For one thing, Russia is a large exporter of nuclear reactors, which have a value much greater than the uranium it exports. If Russia were not seen as a reliable supplier of fuel, it would undercut its sale of reactors. Second, Russia's main source of uranium exports is blended-down weapons material, which is part of an extremely important nonproliferation initiative. It's in Russia's interest to see that this deal continues, for economic and strategic

reasons. Third, Russia itself does not produce a lot of uranium, so it will likely be dependent on imports in the future (or at least will not be a large net exporter), so it would not be a major uranium supplier. In fact, it appears that Russia wants to dramatically ramp up its nuclear power output to free up more natural gas for export, in which case it would be an even greater consumer of uranium.

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In terms of the environmental impact of uranium mining, what is done with the tailings? What are the other environmental consequences of a large expansion of extraction?

Tailings are segregated, often in tailings ponds, and along with waste rock are returned to the open pit or underground mine when these mines are reclaimed. *In situ* mining produces very little environmental damage. Solution is injected into the ground through a series of pipes, and so there is no mining—digging—in the conventional sense. Occasionally there have been accidents, but the fact that tailings ponds are monitored and open pit and underground mines are reclaimed shows that overall, considerable attention is being paid to protecting the environment.

As for the environmental consequences of a large expansion of extraction, it depends on the type of deposit. For underground mines like McArthur River, where the ore grade is extremely high, the footprint of the mine is quite small. As mentioned, *in situ* mining does not pose much of an environmental threat, and a fair amount of future output, including all the planned Kazakh expansion, will come via this route. In the case of Olympic Dam, uranium is produced as a by-product or co-product of copper—depending on the relative value of each—so the argument can be made that whatever environmental damage is associated with this mine would occur whether or not uranium is recovered. Since much of the future expansion over the next 15 years is expected to come from high-grade deposits in Saskatchewan, *in situ* production in Kazakhstan, and the expansion of Olympic Dam, one could argue that the environmental consequences of future uranium extraction should be kept to a minimum.

What changes do you see coming for the nuclear fuel market?

The structure of the nuclear fuel market is changing. In the past, Western nuclear utilities made up the bulk of demand for uranium. Recently, this has started to change. China is greatly expanding its nuclear power capacity, and India is seeking entry into the mainstream market while expanding its capacity. Russia is also looking to greatly expand its nuclear power program, as I mentioned earlier. These countries, which are not very resource-rich when it comes to uranium, will require a considerable amount of uranium to fuel these expansions and thus will be competing with Western utilities for available supplies.

In addition, hedge funds and investors, sensing the growth potential for nuclear power and uranium prices, have entered the spot market as buyers. On top of this, governments are creating what I call a "nonproliferation demand" for uranium as they seek to create fuel banks and other sorts of guaranteed supply arrangements for countries that agree to forgo building enrichment and reprocessing capabilities. Thus, in addition to traditional Western utility demand, we now have what might be termed a growing "Eastern" demand, hedge fund/investor demand, and nonproliferation demand for uranium.

Some of these changes may not be readily apparent, but they are significant. Take nonproliferation for example. The HEU [high-enriched uranium] deal with Russia was first and foremost a nonproliferation initiative, and it brought a considerable amount of uranium and enrichment into the market. The industry is now focused on the potential for HEU-derived supplies from Russia to stop flowing in 2013, when the current deal ends, but I don't know if it is considering the impact of the potential entry of India into the market or the demands created by a fuel bank. Once the HEU deal ends, and if India is allowed to participate in the market, that could be a swing of about 35 million pounds or more on an annual basis, a significant transition. Because of the apparent plentiful supply during the period of massive inventory liquidation, it's been a long time since utilities needed to think strategically about nuclear fuel supplies. Such strategic thinking is critical today because of the changing structure of the market coupled with life extensions and potential new reactor builds, which extend a utility's planning horizon far into the future. NN