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UPA

DOE MATERIAL TRANSFER STUDY

2015

EXECUTIVE SUMMARY

This report examines the impacts of the US Department of Energy's (DOE) excess material transfers on the domestic (US) uranium market. The report addresses these impacts in the context of DOE's latest Request for Information (ROI), published on December 8, 2014, which outlines seven specific questions regarding the effect its material transfers have had on the US uranium industry. The ROI asks the industry what the Department might do to reduce the negative impact of material transfers on the uranium market, what it might do to support the industry, and inquires about market developments the industry is currently anticipating.

The current state of the market is defined by oversupply, and this condition has led to periods of low liquidity and low volatility in the post-Fukushima period (post-March 2011). TradeTech measures these indicators through its Active Supply and Active Demand dataset, which tracks material supply and demand in the uranium and conversion markets. Low liquidity and prolonged downward price pressure, as a result of oversupply, even in the short term, has resulted in deferred production and industry contraction and consolidation.

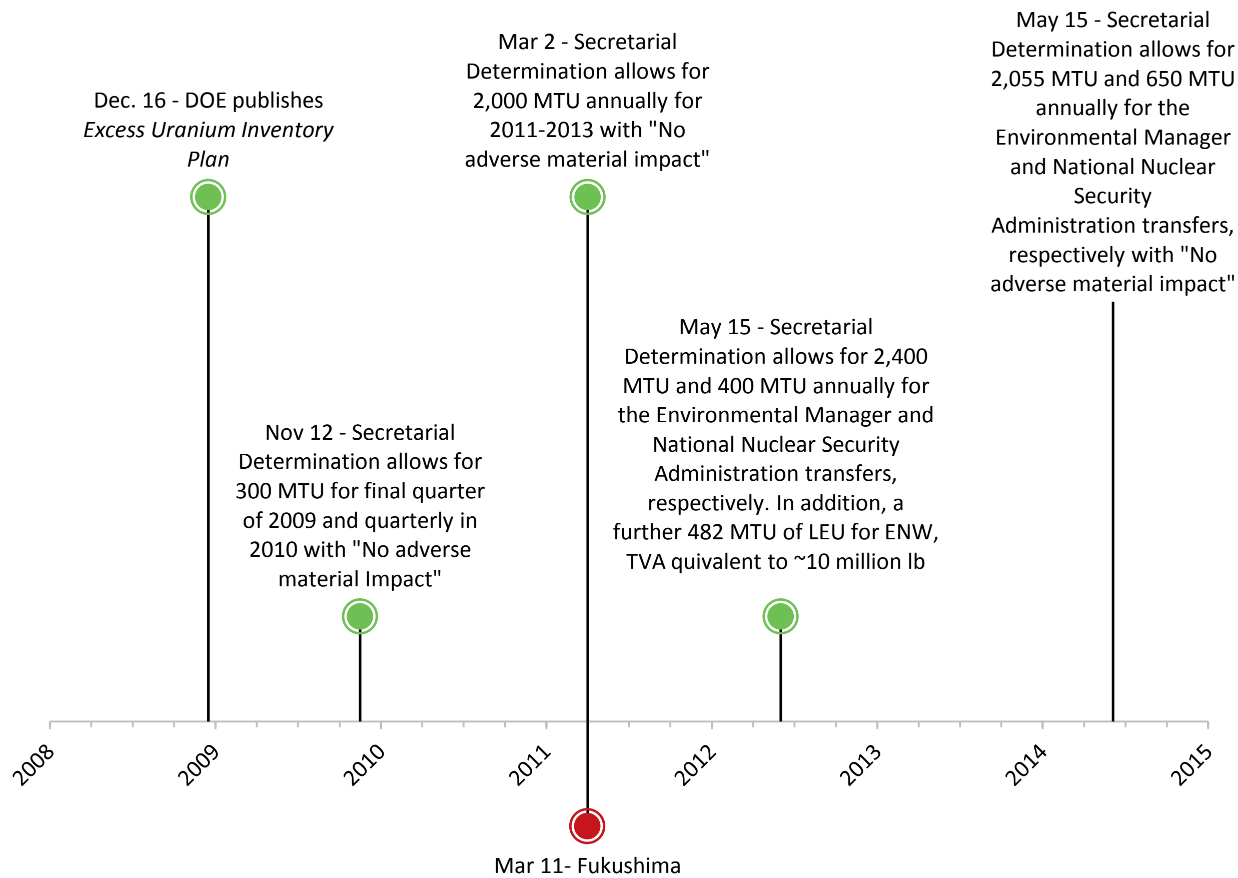
Price insensitive material can displace significant amounts of production. Declining uranium producer margins further reflect the circumstances that have defined the domestic uranium industry in the post-Fukushima period. During early- to mid- 2014, many uranium producers interpreted low volatility as a signal and reduced, deferred, or mothballed production. Price-insulated, price-insensitive, and politically strategic supply sources are not responsive to such signals.

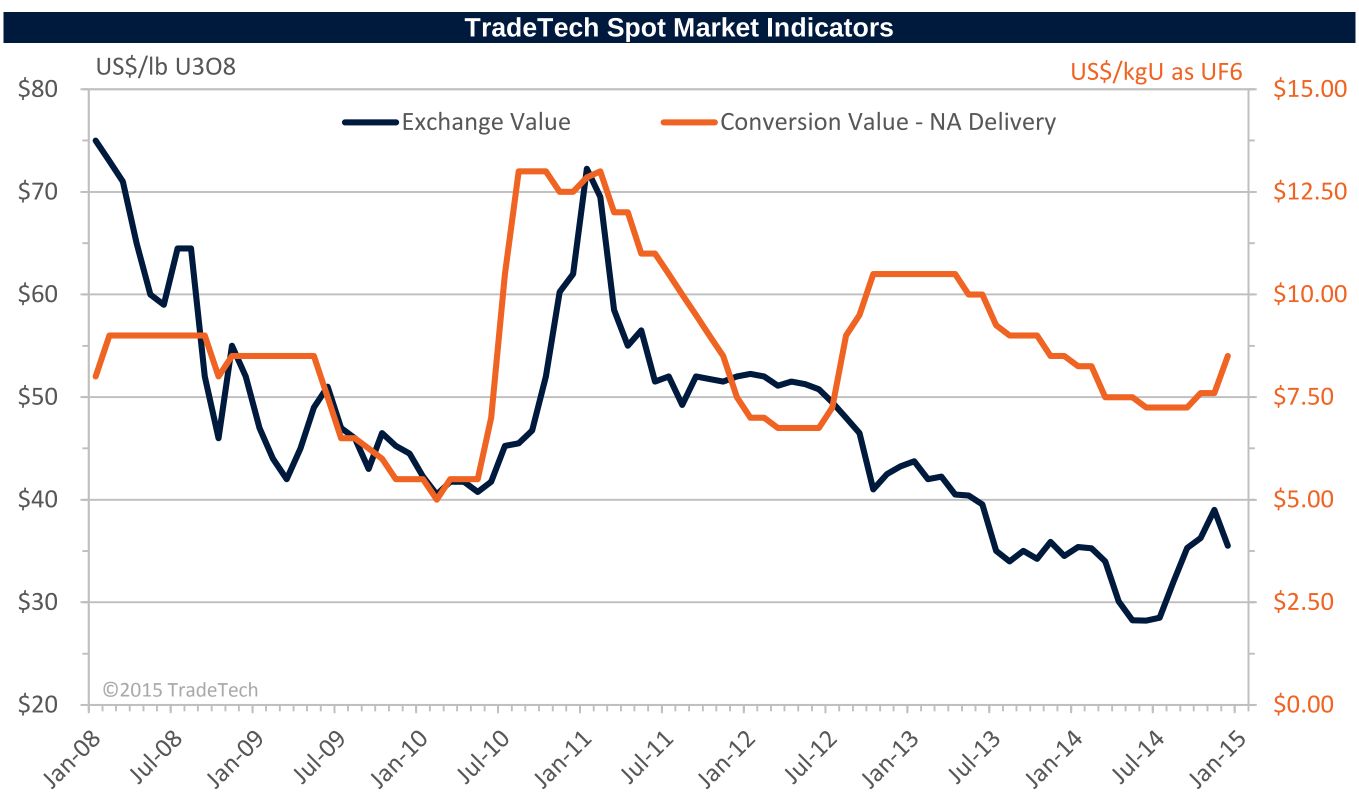
TradeTech's models indicate that DOE material transfers entering the spot uranium and conversion markets have had a measureable negative price impact on prices and uranium producer margins.

Forward-looking forecasts indicate continued transfers will have similar effects on spot uranium and conversion prices.

Material transfers at a reduced rate would likely relieve some downward pressure on spot uranium and conversion prices.

Forecasts indicate decreased uranium requirements in the long term for Japan, as well as stagnant US requirements and decreased requirements in select European nations. Emerging Chinese uranium demand is not necessarily driven by reactor requirements, but is seemingly strategic in nature and therefore presents a downside demand risk to the market should its current rate of procurement suddenly decrease.


Dec. 16 - DOE publishes
Excess Uranium Inventory Plan
Mar 2 - Secretarial Determination allows for 2,000 MTU annually for 2011-2013 with "No adverse material impact"
May 15 - Secretarial Determination allows for 2,055 MTU and 650 MTU annually for the Environmental Manager and National Nuclear Security Administration transfers, respectively with "No adverse material impact"
May 15 - Secretarial Determination allows for 2,400 MTU and 400 MTU annually for the Environmental Manager and National Nuclear Security Administration transfers, respectively. In addition, a further 482 MTU of LEU for ENW, TVA quivalent to ~10 million lb
Nov 12 - Secretarial Determination allows for 300 MTU for final quarter of 2009 and quarterly in 2010 with "No adverse material Impact"
2008
2009
2010
2011
2012
2013
2014
2015
Mar 11- Fukushima


TradeTech Spot Market Indicators
US$/lb U3O8
US$/kgU as UF6
Exchange Value
Conversion Value - NA Delivery
$80
$70
$60
$50
$40
$30
$20
$15.00
$12.50
$10.00
$7.50
$5.00
$2.50
$0.00
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RESPONSE TO DOE ROI

1. FACTORS

What factors should DOE consider in assessing whether transfers will have adverse material impacts?

In gauging potential adverse material impacts of DOE transfers, it is important to assess the state of the uranium market. This can be accomplished by measuring market liquidity, quantified through a price volatility evaluation, which reflects the (im)balance between Active Supply and Active Demand. This measure is critical in gauging the relative health of the market and its participants; low liquidity, as a result of oversupply, even in the short term, will result in deferred production and industry contraction and consolidation. The supply and demand equation is, of course, relative to the size of the market, which can be measured through an examination of historical and projected deliveries under spot and term contracts. Regional differences in contracting (and inventory) strategies reveal the relative advantage of secure domestic production; however, price insensitive material can displace significant amounts of production. Declining estimated uranium producer margins further reflect the circumstances that have defined the industry in the post-Fukushima period (post-March 2011).

Key Points:

- Market liquidity can be measured in part by evaluating volatility
- Low volatility is indicative of oversupply
- Persistent oversupply leads to industry contraction and consolidation
- The quotient between Active Supply and Active Demand presents a means to measure oversupply
- Price insensitive supply displaces primary production and contributes to declining margins

1.1 Market Characteristics

The nuclear fuel market is unusual, relative to other fuel markets, in that it is not traded in "over the counter" markets or on a commodity exchange. There are many reasons for this including:

- In commodity exchanges, the majority of the players are speculators, who do not usually seek delivery. In the nuclear fuel industry security of supply is crucial and the primary participants include end users and suppliers.
- In an over-the-counter market, brokers or dealers arrange the contract terms and bring together the holders (buyers) and writers (sellers) of material. In the uranium industry, the relationship between the suppliers (uranium producer) and the utility is very important, and intervention by an intermediary is not routinely welcome.
    - The uranium market as a whole does not utilize a common trading platform to facilitate its transactions. Further hindering active trading is the fact that the uranium market is highly regulated and governed by treaties, sometimes-opaque import/export tax structures, and statutes governed by the International Atomic Energy Agency.
    - In exchanges, such as coal, oil, and natural gas, there are a large enough number of suppliers of the commodity to ensure anonymity, which is desirable for brokerage and trading entities that are the principal market participants. The principals in the nuclear fuel industry, however, are the world's nuclear utilities, which must source fuel from a small number of uranium producers—a market structure that is not regularly open to formal exchanges.

As **Figure 1** shows, the majority of uranium bought and sold is done via long-term contracts accounting for approximately 90 percent of the market, with spot market activity accounting for approximately 10 percent of all uranium traded in a year. About 81 percent of the total purchased comes from what we refer to as primary sources or actual uranium miners or uranium producers, with 19 percent derived from "secondary" sources, such as government stockpiles or other inventories.

Figure 1
Uranium Market

2014		Primary Supply	Secondary Supply
		81%	19%
Spot Market	10%	5%	5%
Long Term Market	90%	76%	14%

1.2 Market Liquidity

Why Liquidity Matters

While today's uranium market is more liquid than in the past, it remains less liquid than other commodities or fuels. This reality is borne out by contracting data for the uranium market—recent total annual volume of (spot and long-term) uranium contracted worldwide has rarely exceeded 150 million pounds combined, and involves, on average, approximately 250 spot and 40 long-term transactions per year. Although the spot uranium market today is more liquid than the market of 10 years ago, when compared to the amount of trading that occurs daily on common stock and commodity exchanges, it is still readily apparent that the uranium industry is not yet active nor liquid enough to participate in organized financial markets.

A high degree of liquidity in a commodities market is generally looked upon favorably: the perception is that markets with high liquidity feature more frequent reports with better information, since trading volume can be measured with a higher degree of accuracy. Moreover, these data points can be laid against a backdrop of independent variables, which, at times, can produce a clearer picture of a specific market. The collection of more market data can lead to detailed forecasts, which is often the case in traditional commodities. Increased market liquidity can also result in new financial products, such as derivatives, since liquid primary markets support secondary markets. Liquid markets also allow for more market participants overall; this was witnessed in the uranium market in the early- to mid-2000s when a heightened awareness of uranium's value brought more frequent trading and, with it, the arrival of institutional investors and other financial entities.

High liquidity also reduces the barriers to transaction entry and exit within the market, as buyers and sellers execute trades according to their own timelines. Due to the availability of information in high liquidity situations, bids and asks are more closely related, and thus, statistics can be more accurate.

While analysts continually debate the ideal liquidity measurement in any given market, there is consensus that the target variable is one that promotes narrow bid-ask spreads without introducing unwarranted volatility. In securities markets, the focus generally lays in assessing the balance among volume, frequency, bid-ask spreads, quote sizes, and trade sizes.

Liquidity has been a challenge in the post-Fukushima period (since March 2011), and spot market activity was low throughout most of 2013, due to uncertainty surrounding certain nuclear programs, material oversupply, and inventory positions. The uranium market was stagnant throughout much of 2013, primarily subject to discretionary demand and limited seller interest.

Liquidity in the mid-term market has increased as a result of lower spot prices and a marginal arbitrage opportunity.

Barriers to Market Liquidity

Material Origin

Certain statutes govern from where, when, and to whom uranium may be sold. The source, destination, and intermediary agents are often of interest to governments; hence, various agreements have essentially scripted market positions and directed subsequent transactions. Agreements and legislation has also arisen from commercial antidumping cases.

Off-Market Transactions

Off-market transactions, that is, transactions conducted beyond the view of an open marketplace, compound the issue of liquidity by inherently reducing market transparency. Off-market transactions can also incidentally reduce the amount of available information about the state of the market, which can lead to potentially advantageous positions. While some identify private off-market transactions as a cost-saving tactic, one that would hopefully offset production costs (fuel, operating, and maintenance), they are a disadvantage to complete real-time market analytics.

Effects of Market Liquidity

Recent market behavior indicates that an inability to sell material in an open commodity market may lower prices as motivated sellers look to stimulate discretionary demand by lowering their prices. Savvy buyers who will delay purchases in hopes of low prices encourage this tactic. Similarly, liquidity in the long-term (multi-year) market is partially determined by the perceived supply:demand balance. Other procurement factors, such as supply diversification and inventory objectives, also affect long-term liquidity. The perception of limited liquidity also affects price expectations in the form of perceived market risk. Without complete context, market participants tend to assume the presence of a higher degree of risk.

1.3 Market Volatility

The illiquid uranium market is further characterized by periods of high price volatility. Volatility measures risk by revealing how widely dispersed a financial instrument's values are, and to what degree those values fluctuate over time. Accurately describing those fluctuations is key for investors who are concerned with not only the emotional impact of price swings, but also in the potential portfolio value of an asset at a specific point in time. Simply put, higher volatility equals a higher range of potential values.

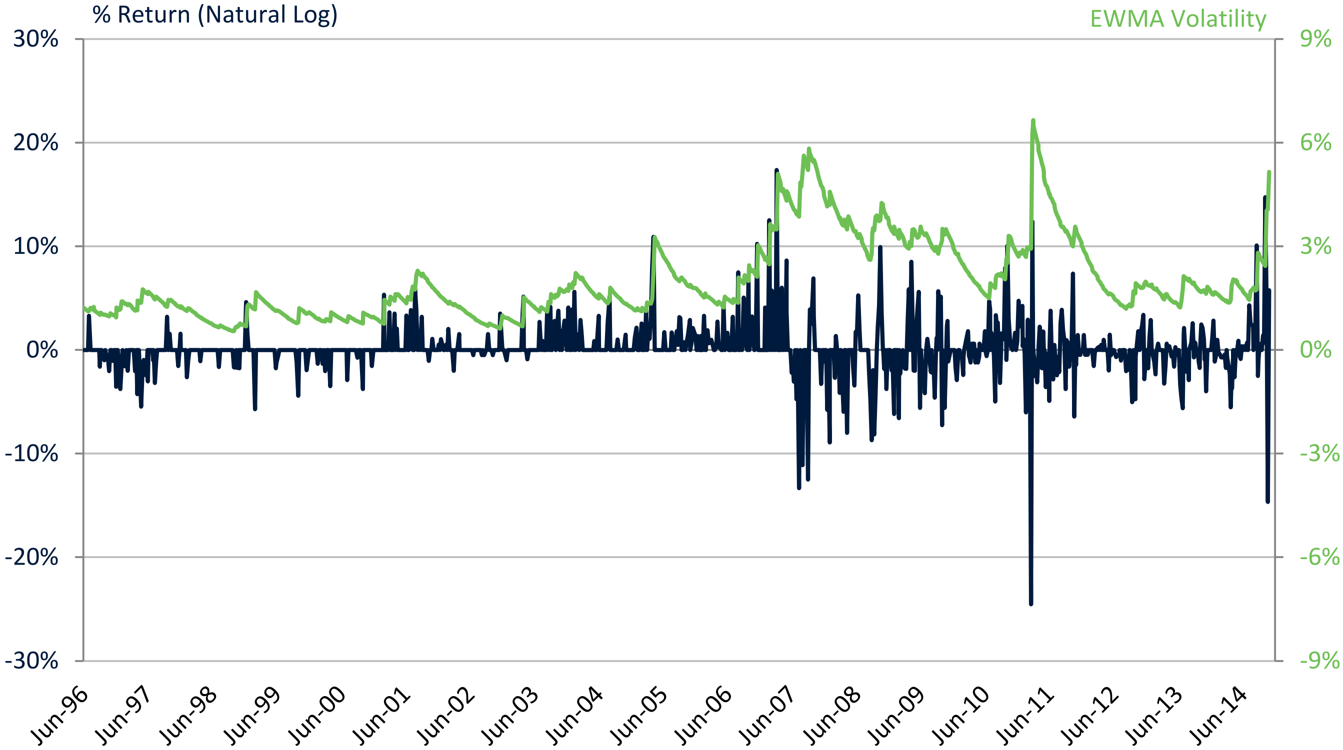
How Volatility Is Measured

Typically, simple volatility measurements gauge the degree of movement in historical prices (or returns) from the mean, relying on an annualized standard deviation to gauge the degree of volatility at any moment in time. This approach defines the past as prologue, relying on historical data to arrive at today's volatility measurement. For generic backwards-looking volatility estimates, an absence of normal distribution complicates the accuracy of the standard deviation by shifting a significant proportion of the higher probability values to the left or right of the statistical mean (in the case of the uranium spot price, to the left, or lower end). As volatility measurements are used to gauge risk, the unevenness in the distribution can result in volatility estimates that underestimate the cost of higher probability values. The uranium spot price history is saturated with values on the lower end of the price spectrum and forces that perpetuate that distribution will, in statistical terms, further cloud the actual risk. **Figure 2** illustrates a volatility measurement using standard deviation (STDEV):

Figure 2
Spot Price and Standard Deviation Volatility

Measurements of volatility that use returns as a basis have a number of statistical advantages, and is the preferred methodology among many financial institutions. **Figure 3** illustrates a volatility measurement using the natural log of returns and an exponential weighted moving average (EWMA), which places more emphasis on more recent values.

Figure 3
Spot Price and Exponential Weighted Moving Average Volatility

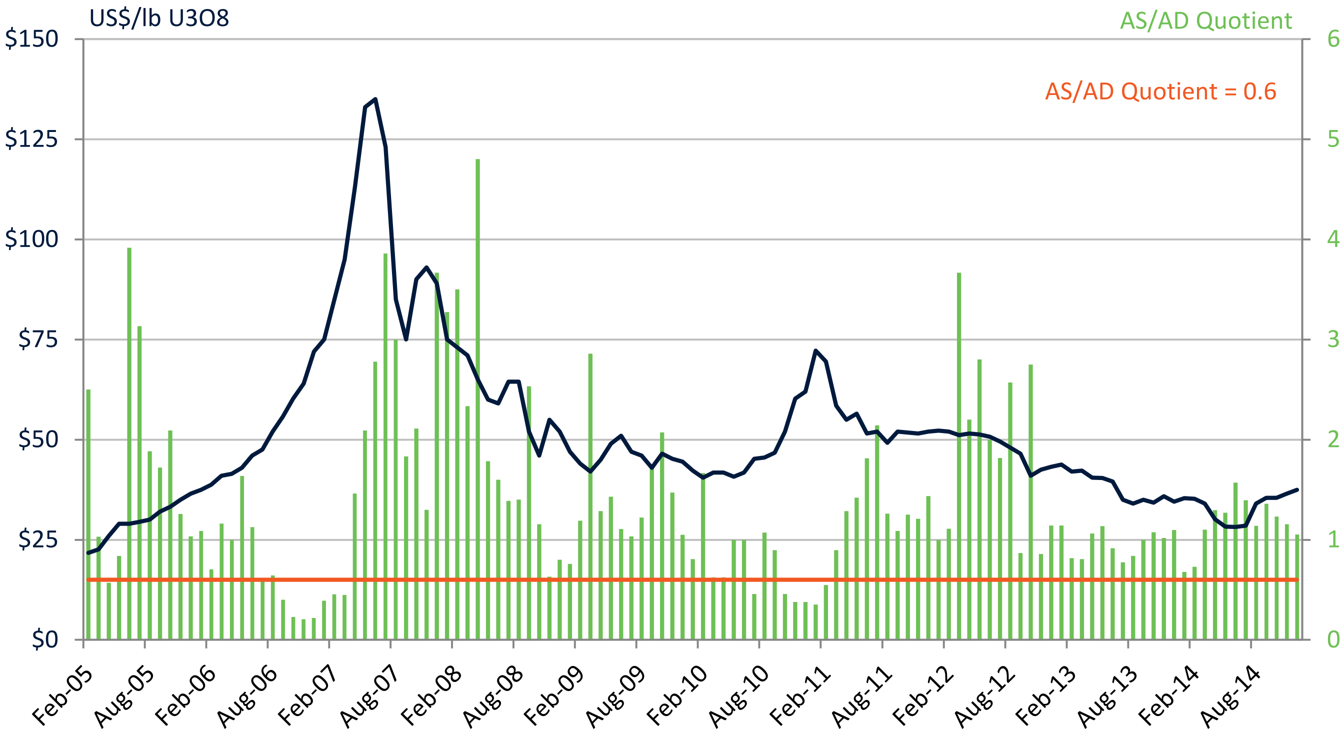


Both volatility estimates exhibit volatility clustering, indicating that the spot price is subject to micro trends. Imbalances in the supply:demand ratio inform conditional volatility: that is, as the supply:demand ratio shifts one way or another, volatility responds in kind. The spot market price increases more readily as the supply:demand ratio decreases. (Buyers are more willing to accept higher prices than sellers are willing to reduce prices in order to stimulate demand and, hence, market liquidity).

Supply and Demand Relationship

Changes in price are captured by volatility, but driven by degree of available supply. Underlying the volatility measure is the relationship between Active Supply and Active Demand (AS/AD). **Figure 4** shows the Active Supply quotient compared to the uranium spot price trend. Illustrated in the comparison between AS/AD and spot price history is the apparent tendency for prices to rise significantly when the AS/AD quotient falls below ~0.6; Conversely, prices have appeared to decline or flatten when the AS/AD quotient is above ~1.0, indicating, then, that prices rise notably when demand is roughly double supply but when the markets are in balance or oversupplied, the price flattens or declines.

Figure 4
Spot Price and AS/AD Quotient



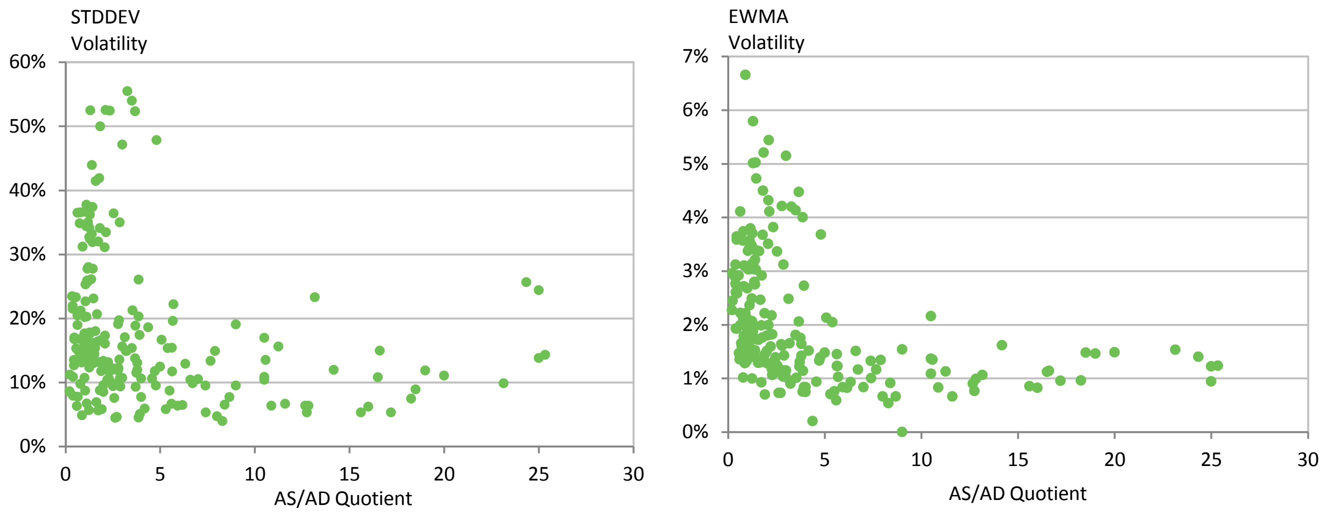
This relationship was also analyzed by Brunetti and Gilbert, who studied the volatilities and stock-consumption ratios of the six London Metals Exchange (LME) commodities—aluminum, copper, nickel, lead, tin, and zinc—and noted that this relationship is true for all six metals, which led to the conclusion that supply/demand fundamentals are the major determinants of non-ferrous metals price volatility.

Using the same analyses for the uranium industry, Brunetti and Gilbert's findings apply: when uranium is in short supply, even a small change in demand will have a large impact on the price of uranium. Further, as spot supplies become even more compressed, a price rise high enough to provide an incentive for increased production may occur. In contrast, when supplies are abundant, a small increase or decrease in demand will cause a lesser impact on prices. Thus, the spot uranium supply and demand quotient is the leading gauge for measuring not only the direction, but also the volatility of the uranium industry.

Relationship between Volatility and AS/AD

TradeTech analysis of market activity from 1996 to 2014 produces similar observations to the LME metals market. The uranium market exhibits a non-linear relationship between volatility and the supply:demand ratio; high volatility is associated with low supply:demand ratios, and lower volatility is observed in association with both high and low supply:demand ratios (put another way, volatility is clustered where the supply:demand ratio is low) (**Figure 5**). Thus, uranium exhibits market characteristics similar to other mineral commodities in that it is responding more to short-term supply/demand fundamentals: volatility can be expected when the supply:demand ratio is low and the market is liquid, while oversupply and illiquidity are reflected by low volatility.

Figure 5
Volatility and AS/AD Scatterplots



Short-term uranium price volatility is related to the availability of stocks (spot supply), the primary material determinant of volatility. When the availability of uranium in the spot market is abundant in relation to consumption (spot demand), prices tend to weaken. In contrast, when spot supplies are scarce with respect to spot demand, prices tend to firm. Volatility, however, mostly increases only in the latter case: when supplies are tight relative to demand, or when supply and demand are relatively in balance.

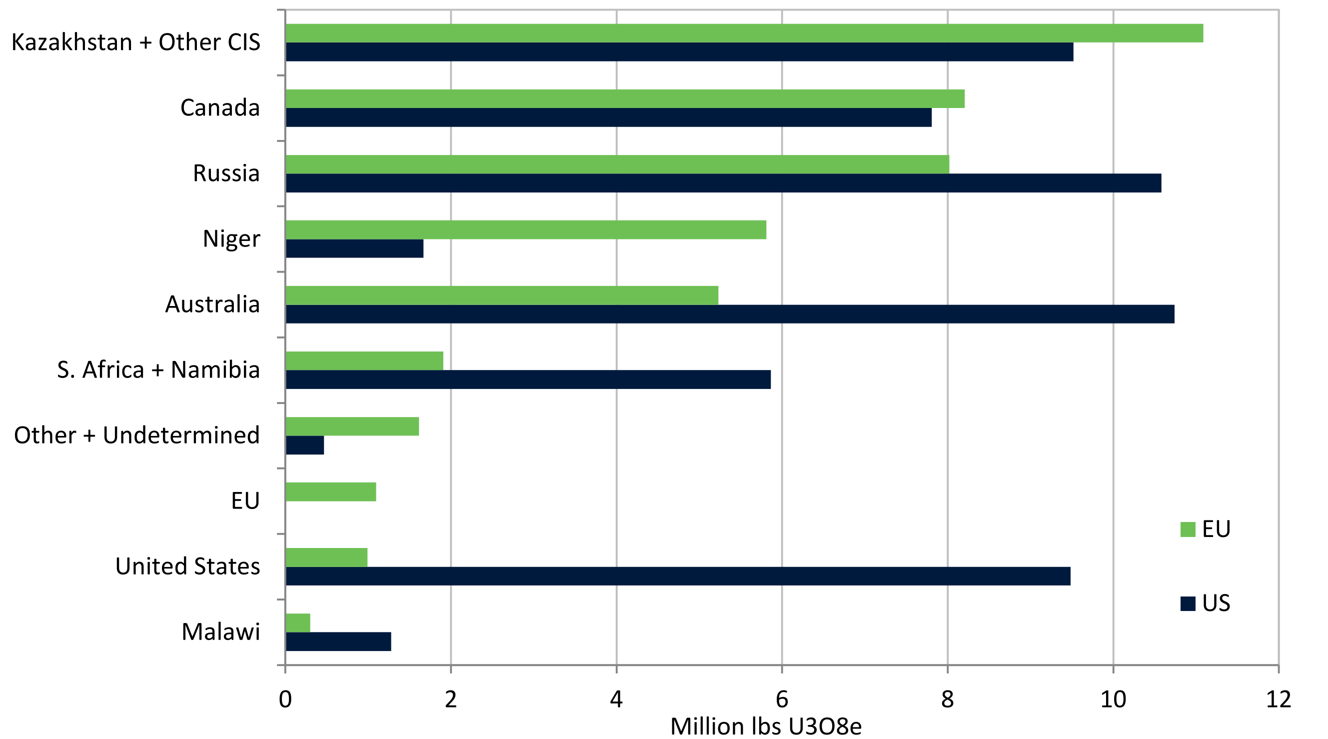
Thus, should near-future demand outpace supply, prices would firm and some volatility would accompany any (upward) price movement. In the case of unexpected supply entering the market, prices weaken, but without the volatility seen in the former case. Weakening prices, of course, erode value and result in contraction, which translates to economic impacts well beyond uranium sales.

1.4 Market Size

Multiannual contracts for which deliveries were concluded in 2013 by European Union (EU) utilities totaled 41.1 million pounds and carried a weighted average price of US$43.25 per pound U_3O_8e. Spot purchases accounted for just over 3 million pounds U_3O_8e at an average price of US$39.97 per pound.

According to the US Energy Information Administration (EIA), in 2013 owners and operators of US civilian nuclear power reactors took delivery of 57 million pounds U_3O_8e, representing 31 million pounds of uranium concentrate, 19 million pounds of natural UF_6, and 7 million pounds of enriched UF_6. The EIA weighted average price for deliveries in 2013 was US$51.99 per pound. In 2013, 20 percent of U_3O_8e was purchased under spot contracts at a weighted average price of $43.83 per pound. Deliveries by country of origin for EU and US utilities in 2013 are shown in **Figure 6**.

Figure 6
Deliveries by Country of Origin, 2013 (Sources: EIA and ESA)



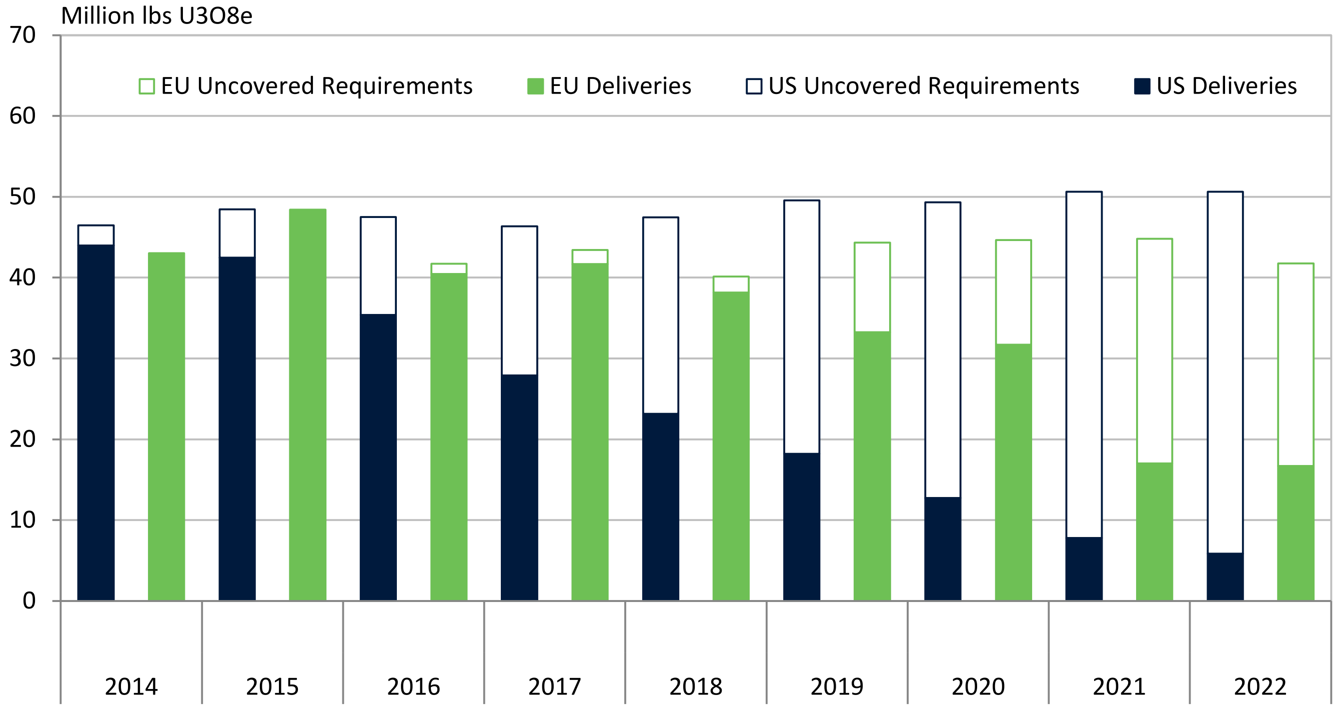
The majority of EU deliveries were sourced from Kazakhstan and Canada, which supplied 43.5 percent of the EU's total natural uranium deliveries; the USA provided 2.3 percent (0.99 million pounds U_3O_8e) to EU utilities. In the USA, domestic purchases accounted for 17 percent (9.48 million pounds U_3O_8e) of deliveries. If the US market took in the sum of DOE transfers in 2013, the material would have satisfied nearly 74 percent of domestic deliveries, or just over 12 percent of all deliveries.

In recent years, data regarding volumes purchased from US uranium producers has been withheld; in 2011, the amount of material purchased from US uranium producers by owners and operators of US civilian nuclear power reactors totaled 0.6 million pounds U_3O_8e.

Contractual Coverage

Uncovered demand varies widely from region to region. In 2013, EU aggregate contractual coverage equated to a coverage rate of over 100 percent in 2014, for natural uranium and enrichment services (**Figure 7**). That rate declines to 71 percent in 2020, and then to 40 percent in 2022. US contractual coverage rates decline more rapidly, with an estimated 95 percent coverage rate in 2014, declining to 26 percent in 2020, then to just 12 percent by 2022.

Figure 7
US and EU Contractual Coverage 2014-2022 (Source: EIA and ESA)



In recent years, the EU uranium market has been characterized by long-term contract coverage, largely attributable to utilities following Euratom Treaty guidelines. Conversely, the North American market has pursued less coverage in the nearer term, potentially enjoying more flexibility in pursuing spot purchases. The latest annual Euratom Supply Agency and EIA reports bear this out, with the USA purchasing eight million pounds U_3O_8e more in the spot market in 2013 than their EU counterparts.

Market Contraction and Consolidation

However, depressed prices in the spot market, combined with reduced overall demand (idled Japanese reactors, Germany's plans to reduce their fleet, premature US plant retirements) have resulted in supply-side contraction and consolidation. Recently, in the USA:

- Powertech has acquired Azarga Resources, its main shareholder;
- Energy Fuels has sold a number of assets, including its Piñon Ridge Mill and Marquez uranium project;
- Energy Fuels has announced its intention to merge with Uranerz Energy Corp.;
- Uranium Energy Corp has slowed production at its Palangana operation; and
- Uranium One has ceased well drilling at Willow Creek in Wyoming.

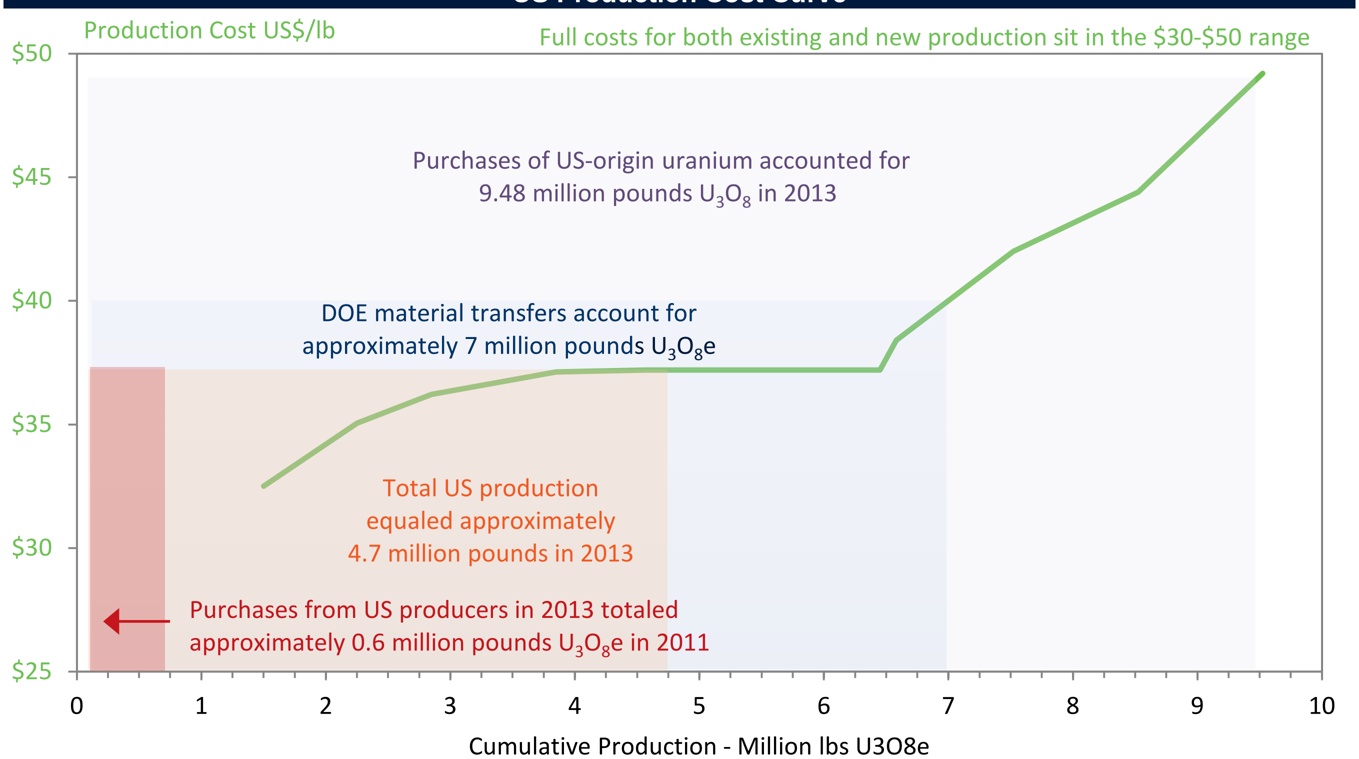
And globally:

- Paladin Energy has sold 25 percent of its Langer Heinrich mine to China National Nuclear Corp. for US$190 million;
- Alliance Resources has announced its intent to sell its 25 percent stake in the Four Mile project in Australia;
- AREVA has suspended plans to develop its Imouraren project in Niger until uranium prices improve;
- Paladin Energy has put its Kayelekera mine in Malawi on care and maintenance;
- Rio Tinto has reduced output at Rossing, its Namibian operation, to 50 percent;
- Cameco deferred permitting the company's Millennium project in Canada, and has revised downward its production plans through 2018.

1.5 Price Insensitive Supply, Production Cost Curve, and Purchased Volumes

Price insensitive supply has the potential to displace both current and planned production. **Figure 8** illustrates a production cost curve, shown by the green line, populated by US uranium producers, both in and near production. The various shaded regions of the chart show volumes of material purchased by US owners and operators of US civilian nuclear power plants, as reported in the EIA's *2013 Uranium Marketing Annual Report*. In 2011, purchases of US-produced uranium totaled 0.6 million pounds U_3O_8e; data was withheld for 2012 and 2013. Total US production in 2013 equaled approximately 4.7 million pounds U_3O_8e, while DOE transfers can account for up to 7 million pounds U_3O_8e. Total purchases of US-origin uranium accounted for 9.48 million pounds U_3O_8e in 2013.

Figure 8
US Production Cost Curve



Notably, price insensitive material will push the cost curve to the right, potentially by as much as 7 million pounds. During 2013, the amount of US-origin uranium purchased was 9.48 million pounds U_3O_8. As only approximately

0.6 million pounds U_3O_8e is assumed to be have been supplied by US producers in recent years[1], it appears the hyper-competitive DOE stock has represented the vast majority of deliveries.

If we assume all DOE material transfers are directed into the US market, and assuming purchases from US uranium producers approximated the average of the last five years where volumes were reported (~0.33 million pounds U_3O_8e), material transfers exceed purchases of US production by 21 times.

Recently, several domestic uranium producers throughout the cost curve have announced plans to delay expansions, defer or reduce planned production, or shut down indefinitely, highlighting the financial sensitivity of operating in the ~$35-per-pound full cost segment.

In 2013, six companies conducting US domestic uranium production operations produced 4.7 million pounds U_3O_8; annual production in each operation ranged from just under one hundred fifty thousand pounds to just over one and a half million pounds U_3O_8; production volumes have recently been lower than nameplate capacity in many instances due to market conditions. Volumes of price insensitive material that appear modest in comparison to global production easily equate, and indeed exceed, current US production.

Notably, the US enrichment market experienced contraction when cost-driven shifts in fundamentals resulted in reduced competition. Today, just one uranium enricher operates in the USA, and while those circumstances were borne of technological innovations, price insensitive supply in the form of underfed material from enrichers with excess capacity also threatens to eclipse the production of smaller US uranium companies.

1.6 Uranium Producer Profit Margins

For by-product uranium producers, it can safely be assumed costs have been incurred elsewhere in the production stream; although their material enters the cost curve at a lower point, their margins will more closely resemble primary uranium producers. For primary uranium producers, as shown in **Figure 9**, decreasing estimated margins are materializing largely due to a decline in realized prices. Notwithstanding concerted efforts on the part of many uranium producers to reduce or stabilize costs, realized prices have declined in many instances, narrowing margins and putting pressure on the viability of certain projects. While companies such as AREVA, Cameco, and BHP Billiton have witnessed increases in costs, their operations have remained largely cost competitive. Further along the curve, however, companies such as Rio Tinto and Paladin Energy have pursued mining cost control measures through various programs (mainly through production optimization strategies) that have successfully reduced their respective costs.

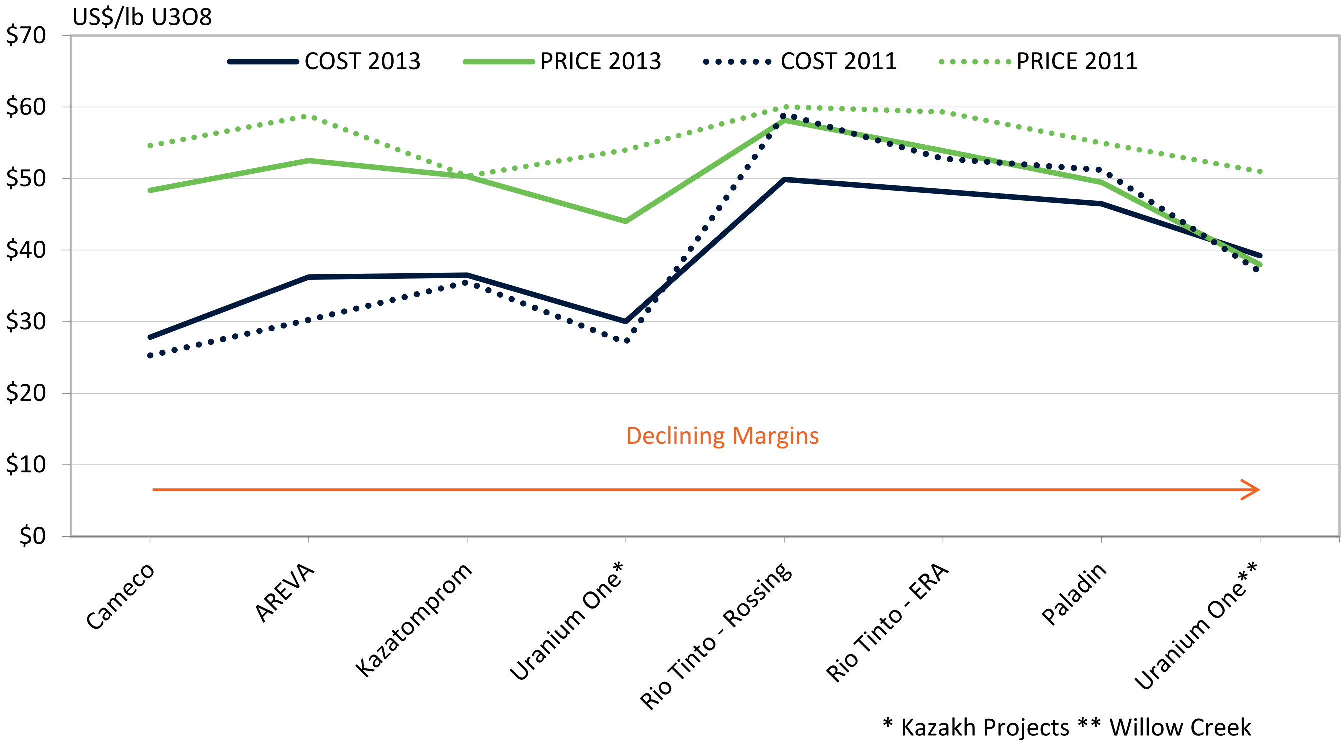
However, in spite of the success of those programs, declining realized prices have obstinately closed the gap, challenging the profitability of certain projects, such as Paladin Energy's Kayelekera mine, which the company announced it would mothball in 2014. Similarly, for Uranium One, whose Kazakh projects have remained competitive, declining prices caused the company to mothball its Honeymoon (Australia) project and suspend further development at Willow Creek (USA) in spite of relatively predictable costs. While hedging into long-term contracts protects revenue, the expiration of long-term contracts (signed when prevailing prices were much higher),

[1] Figures were withheld in 2005, 2009, 2012, and 2013 to avoid disclosure of individual company data

is reflected in declining realized prices. Declining realized prices, which lag current prices, ultimately result in declining margins.

Additionally, proportions of supplier portfolios left exposed to a spot market characterized by oversupply will add pressure to already-shrinking margins.

Figure 9
Estimated Producer Profit Margins



2. EFFECTS OF PRIOR TRANSFERS

With respect to transfers from DOE's excess uranium inventory in calendar years 2012, 2013, and 2014, what have been the effects of transfers in uranium markets and the consequences for the domestic uranium mining, conversion, and enrichment industries relative to other market factors?

Transfers of excess DOE uranium inventory into the uranium market have had a negative price impact on the spot uranium and conversion market prices. Price modeling that utilizes supply and demand balance in order to derive absolute and relative components indicates that prices have been pushed downward an average of 9.5 and 25.2 percent for the uranium and conversion spot markets, respectively.

Reduced demand has equated to structural oversupply due to other factors, such as the Fukushima accident; however, the volumes contributed by price insensitive material outweigh those contributed by reduced Japanese demand.

Key Points:

- Modeling indicates that transfers of excess DOE uranium supply have had a negative impact on the uranium spot price;
- Modeling indicates that transfers of excess DOE uranium supply have had a negative impact on the North American spot conversion price;
- Modeling indicates that the DOE material transfer negative price impact could have been a deciding factor in a uranium producer's viability over the period 2012-2014; and
- Transfers of DOE material outweigh oversupply due to Fukushima in the short term.

Reduced demand has equated to structural oversupply due to other factors such as the Fukushima accident, but transfers of price insensitive material continues to outweigh overhanging volumes, largely due to the continued commitment to honor existing contracts.

2.1 Effects of Transfers on the Uranium Market

Model Background

TradeTech's Dynamic Pricing Model (DPM) utilizes an econometric forecasting approach that quantifies the impact of supply and demand balances on uranium spot price. A perception-driven accelerator is used to capture market exuberance and regression testing is performed on historical data to gauge the model's accuracy. The DPM assesses the equilibrium between two dimensions termed Active Supply and Active Demand, both of which are determined by aggregating trading activity data. In order to create the absolute components critical to the econometric forecasting function of the Dynamic Pricing Model, TradeTech factors supply and demand coefficients with corresponding active supply and demand figures. Once absolute components are determined, differential components are similarly derived. Unique to the DPM, a quadratic coefficient is also employed to capture market exuberance, which captures market momentum. The model is then solved for fit and a price trend is plotted.

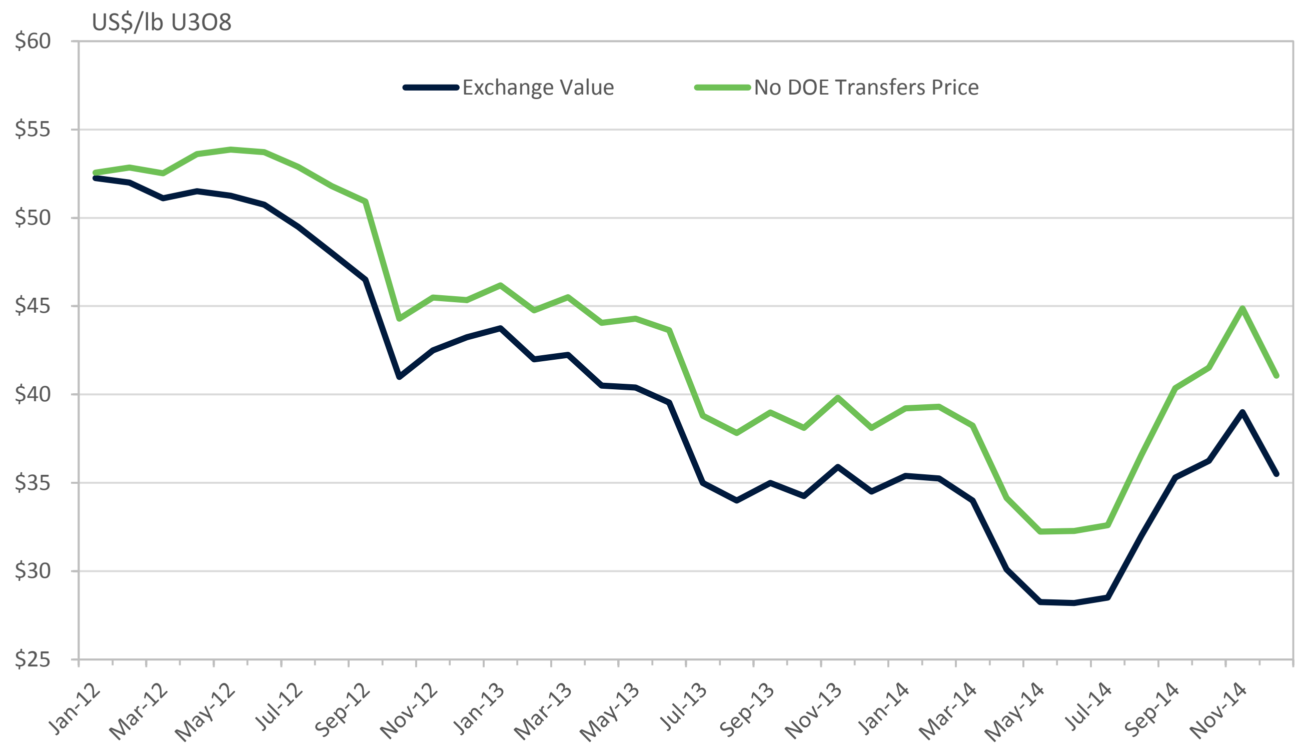
TradeTech's Base Case scenario assumes that 50 percent of the DOE transfer material enters the spot market and the remaining portion is introduced into the market through long-term contracts. This is consistent with statements from current DOE transfer material marketing agent(s).

TradeTech's "No DOE" scenario assumes that there will be a reduction to Active Supply equivalent to 50 percent of total DOE transfer volumes and that Active Demand will increase by the same amount - it is assumed parties and/or end users expecting to receive DOE material will need to (re)enter the market for replacement material as the DOE material will no longer be available.

2012-2014 Combined Price Impacts

Figure 10 shows a rationalized price impact estimation with the years 2012-2014 combined into a single series (wherein the last month of a given year represents the baseline for the first month of the next year, thereby preserving the linear qualities of the forecast model). The blue line represents TradeTech's published monthly Exchange Value, while the green line represents TradeTech's estimate of the price without DOE material entering the market. Using this data series, TradeTech estimates that over the 36-month period from January 2012 through December 2014, the uranium spot price was reduced by an average of \$3.55 per pound U_3O_8 due to this added supply in the market. The median is \$3.82 per pound U_3O_8 and the maximum was \$5.86 per pound U_3O_8.

Figure 10
Price Impact



However, the impact of DOE material is reflected in areas other than the price itself.

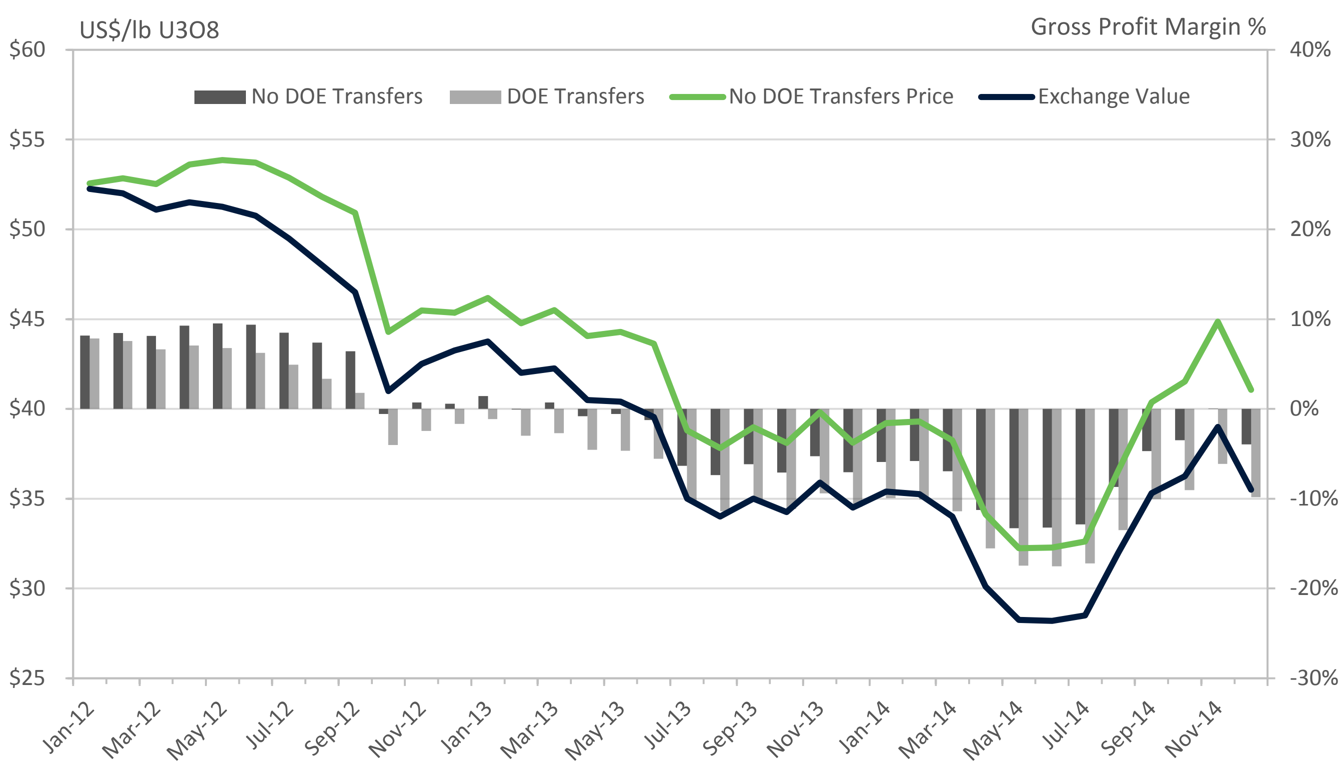
Individual company margins present an important measurement of a uranium producer's financial health. Key to this equation is the degree to which the prevailing spot price is impacted by the DOE's material.

With the long-term component of the realized price set at $50 for this example, and marginal production costs set to $47.41, the scenario excluding DOE material from the market results in more attractive margins.

Figure 11 illustrates a uranium producer's profit margin assuming 50 percent spot market exposure, a long-term realized prince component of $50, and marginal production cost of $47.41. The green line represents the No DOE Transfers scenario while the DOE Transfer scenario is represented by the blue line (Actual Exchange Value).

Figure 11 indicates that a uranium producer, under a scenario of no DOE transfers, would have been able to maintain a higher gross profit margin over the previous three years, although still realizing a loss. Based on actual prices that were negatively impacted by DOE transfers, the uranium producer would have fallen further into a situation of negative gross profit. The average gross profit margin for the No DOE material scenario was -1.5 percent over the three years, yet and under the DOE Transfers case it fell to -5.2 percent.

Figure 11
Price Impact vs Producer Margin @ $47.41 Marginal Production Cost

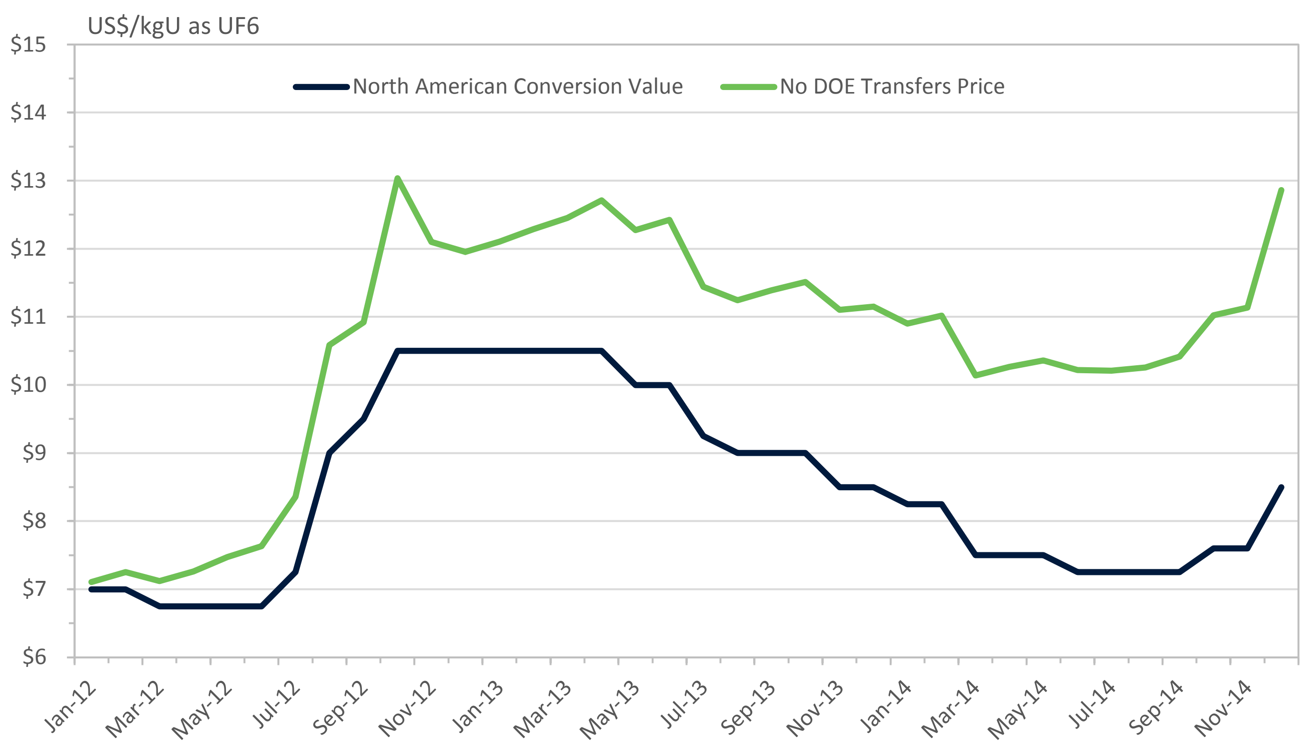


2.2 Effects of Transfers on the Conversion Market

2012-2014 Combined Price Impacts

Figure 12 shows a rationalized price impact estimation with the years 2012-2014 combined into a single series (wherein the last month of a given year represents the baseline for the first month of the next year, thereby preserving the linear qualities of the forecast model). The blue line represents TradeTech's published monthly North American Conversion Value, while the green line represents TradeTech's estimate of the price without DOE material entering the market. Using this data series, TradeTech estimates that over the 36-month period from January 2012 through December 2014, the conversion price was reduced by an average of $2.13 per kgU as UF_6 due to this added supply in the market. The median is $2.33 per kgU as UF_6 and the maximum was $4.36 per kgU as UF_6.

Figure 12
Cumulative Readjusted Price Impacts



2.3 Effect of Transfers Relative to Other Factors

Japan

Perhaps the largest single factor affecting the uranium market is the reduction of Japanese reactor requirements in the wake of the Fukushima accident in March 2011. Since the accident, Japanese utilities have placed all of their reactors into standby while the German and Swiss governments have elected to pursue energy policies that specifically exclude nuclear power from their future respective energy plans; as a result, the uranium market has battled a condition of objective oversupply. Cumulatively, Japanese reactor requirements were reduced by a total of nearly 55 million pounds U_3O_8 between 2011 and 2014 (declining from approximately 16.5 million pounds U_3O_8 in 2010 to zero in 2014), equating to an average decline of 13.7 million pounds U_3O_8 per year. TradeTech estimates that Japanese utilities have taken 70 percent of their deliveries, which will further reduce forward needs by 44.2 million pounds U_3O_8 until 60 percent of their reactors are back online by 2019.

Therefore, in the near term, existing Japanese demand will taper as existing contracts expire and Japanese utilities are able to use their inflated stocks. TradeTech estimates that Japanese utilities carrying four years' worth of stocks will not re-enter into contracted deliveries until the mid 2020s.

In comparison, DOE material transfers can potentially add approximately 7 million pounds U_3O_8 to the market in any given year. With Japanese utilities estimated to still be receiving approximately 70 percent of their deliveries in spite of significantly reduced requirements, DOE material transfers outweigh excess material due to Fukushima (estimated at 5 million pounds U_3O_8, or 16.5 million pounds less 70 percent continued deliveries) by nearly 2 million pounds U_3O_8.

The situation in Japan is also a naturally occurring effect on a market due to uncontrollable events. The dissemination of DOE excess material into a market is controllable and cannot be considered an equivalent occurrence.

3. EFFECTS OF CONTINUED TRANSFERS

What market effects and industry consequences could DOE expect from continued transfers at annual rates comparable to the transfers described in the 2014 Secretarial Determination?

The effects and industry consequences that DOE could expect from continued transfers, at annual rates comparable to the transfers described in the 2014 Secretarial Determination, are naturally signaled first by their impact on price. Sustained downward price pressure would likely result in further industry contraction and consolidation, fewer supply options for utilities, and fewer domestic suppliers in key areas of the nuclear fuel cycle.

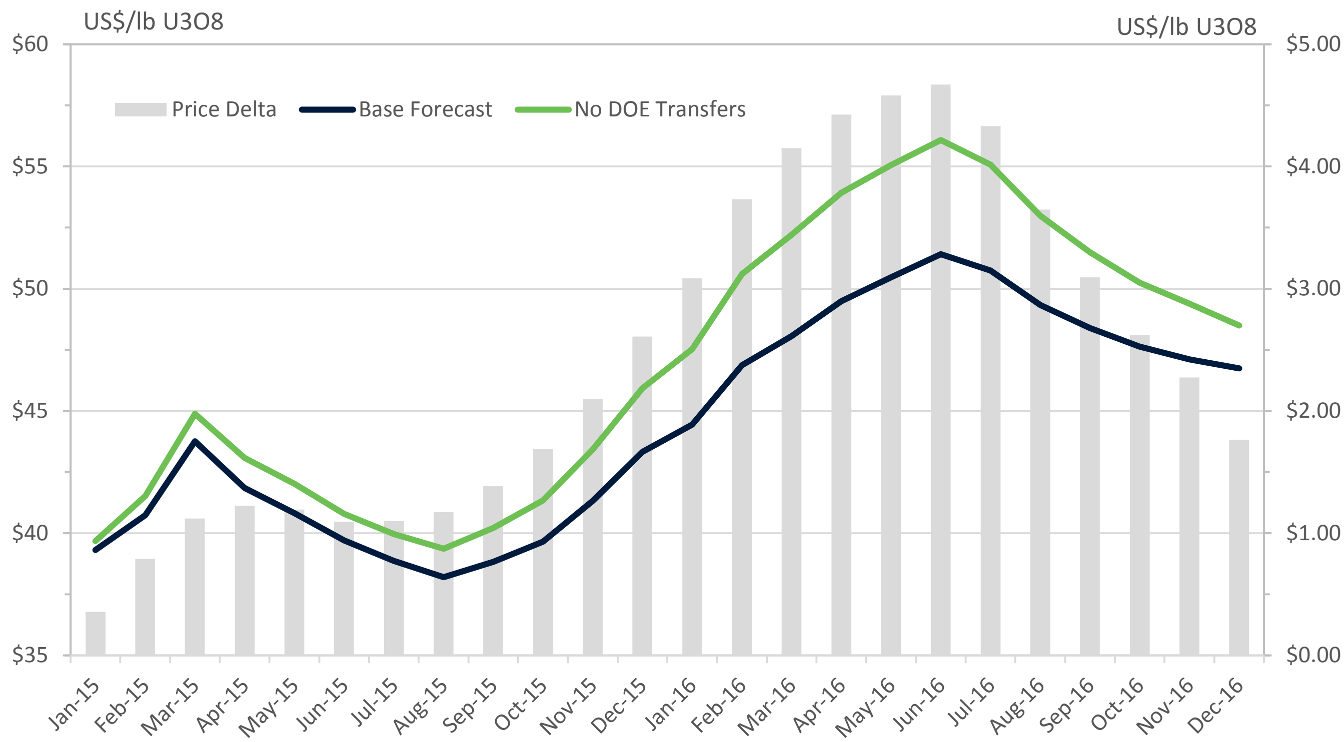
Key Points:

- Modeling indicates that transfers of excess DOE uranium supply will continue to a have a negative impact on the uranium spot price by as much as $4.67 per pound U_3O_8 (8.3 percent) over the next 24 months.
- Modeling indicates that transfers of excess DOE uranium supply will continue to a have a negative impact on the North American conversion spot price by as much as $1.45 per kgU as UF_6 (13.6 percent) over the next 24 months.
- DOE transfer material could influence the fate of a uranium producer, both existing and in development, through its impact on prevailing prices.

3.1 Uranium Price Impact

The impact on the uranium spot price of continued DOE transfers at annual rates comparable to the transfers described in the 2014 Secretarial Determination are shown in **Figure 13**. The blue line represents TradeTech's forecasted Exchange Value, while the green line represents a forecast of the Exchange Value without DOE material entering the market. TradeTech estimates that over the 24-month period from January 2015 through December 2016, the uranium spot price will be reduced by an average of $2.43 per pound U_3O_8 due to this added supply in the market. The median is $2.19 per pound U_3O_8 maximum is $4.67 per pound U_3O_8.

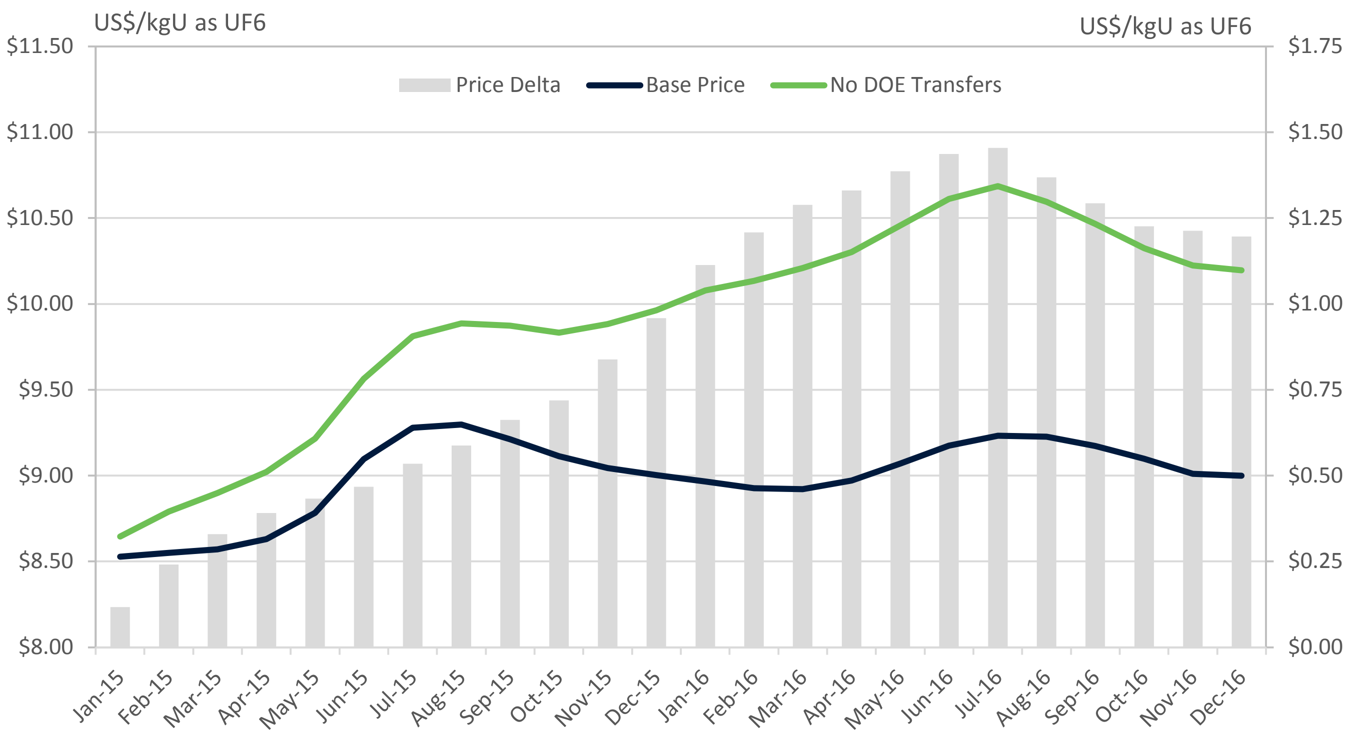
Figure 13
Forecasted Uranium Price Impact of Continued DOE Transfers



3.2 Conversion Price Impact

The impact on the North American Conversion Value of continued DOE transfers at annual rates comparable to the transfers described in the 2014 Secretarial Determination are shown in **Figure 14**. The blue line represents TradeTech's forecasted North American Conversion Value, while the light green line represents a forecast of the North American Conversion Value without DOE material entering the market. TradeTech estimates that over the 24-month period from January 2015 through December 2016, the uranium spot price would be reduced by an average of $0.91 per kgU as UF_6 due to this added supply in the market. The median is $1.04 per kgU as UF_6 and maximum is $1.45 per kgU as UF_6.

Figure 14
Forecasted Conversion Price Impact of Continued DOE Transfers



3.3 Potential Consequences

The potential consequences of prolonged downward price pressure are myriad, but recent market conditions have provided a glimpse into what effects would likely be seen in the near future.

With prolonged downward price pressure comes further industry consolidation and project deferral. Realized prices, based on contracts signed in a market with higher prevailing prices, would further erode. While the marginal impact on suppliers would increase, options would naturally decrease, leading to a potential reduction in the number of market participants and contracting parties.

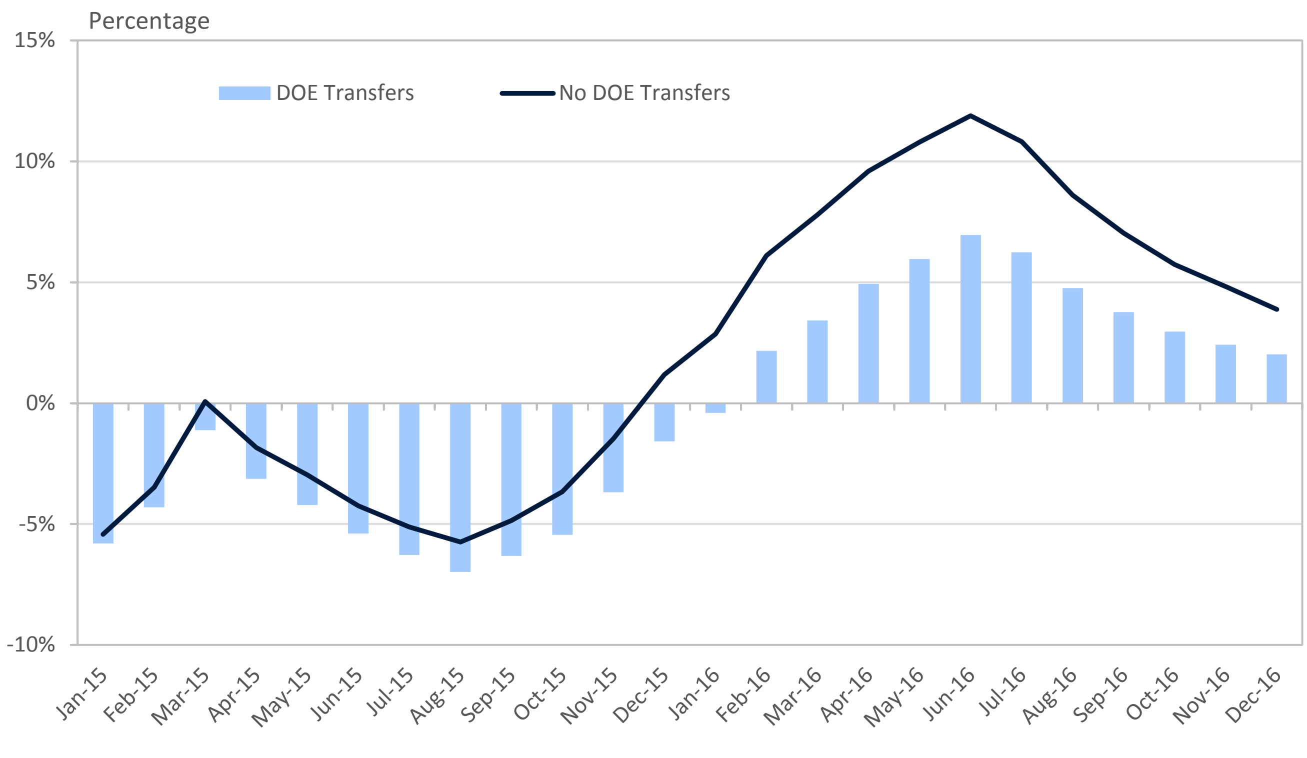
A reduction in the number of participants in the uranium industry has a direct impact on employment, as well. In recent years, primarily due to persistently low prices (in turn, as a result of reduced demand and oversupply), businesses that are directly and indirectly involved in the nuclear fuel supply chain have consolidated or, worse yet, ceased production. This has meant lost jobs, often in rural areas where uranium mines are typically located. While reduced employment is unfortunate in any case, lost jobs in rural towns have disproportionate impact on these smaller economies.

Further, a reduction in available market participants means increased security of supply risk for nuclear power utilities. The potential loss of a US uranium converter would be especially damaging in this respect.

Figure 15 illustrates the impact on margins a uranium producer would realize at different production costs under both the continued transfer of DOE material scenario and that of No DOE material[2]. The illustration indicates that a producer might be able to survive or reach production given its required return in the event that DOE transfer material was removed from the market.

In the case of a production cost of $47.41 per-pound U_3O_8, if the producer required a 10 percent margin in order to bring its operation into commercial production, whether or not the DOE material were included in the market could be the deciding factor.

Figure 15
Producer Margin @ $47.41 Marginal Production Cost



[2] The example assumes the producer has a 50 percent exposure to spot market prices and the long-term component of its realized price is $50 per pound U_3O_8.

4. EFFECTS OF SLOWED TRANSFERS

Would transfers at a lower annual rate significantly change these effects, and if so, how?

DOE material transfers conducted at annual rates less than those seen in 2012-2014 have the potential to positively impact the uranium spot price. This is especially evident in the first half of 2016, when demand is expected to outpace supply.

Key Points:

- Modeling indicates that transfers of excess DOE uranium supply at reduced rates would continue to have a negative impact on the uranium spot price, although the effect would be reduced through rate reductions.
- Modeling indicates that transfers of excess DOE uranium supply at reduced rates would continue to have a negative impact on the North American conversion spot price, although the effect would be reduced through rate reductions.
- Negative price impacts remain regardless of rate of transfers and producers' viability could remain at the mercy of DOE's price-insensitive transfer material.

Model Background

TradeTech's supply and demand forecast takes into consideration anticipated economic, political, and commercial trends in the nuclear fuel market. Select factors are explored further in Section 7.2 (Anticipated Changes), and include:

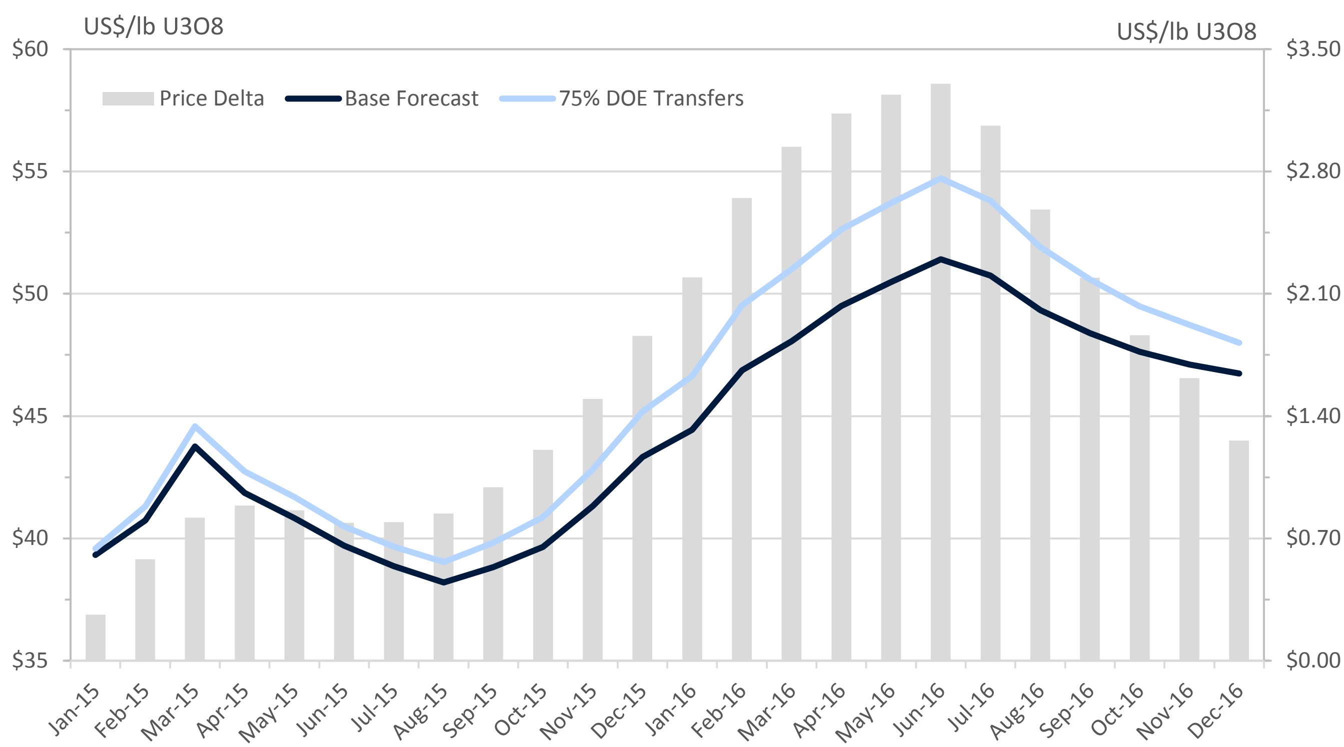
- Japanese reactor requirements and interim stock building;
- early retirements, new builds, and plant life extension US growth in the nuclear power sector, as well as domestic competition from natural gas;
- reduced nuclear-powered electricity generating capacity in select European countries; and
- growth in China, and the availability of new demand to the Western market.

4.1 Projected Uranium Price Impact at Lower DOE Transfer Rates

75 Percent of Current Transfer Rate

The impact on the uranium spot price of continued DOE transfers at 75 percent of rates comparable to the transfers described in the 2014 Secretarial Determination are shown in **Figure 16**. The blue line represents TradeTech's forecasted Exchange Value, while the light blue line represents a forecast of the Exchange Value with DOE material reduced by 25 percent. TradeTech estimates that over the 24-month period from January 2015 through December 2016, the uranium spot price would raise an average of $1.73 per pound U_3O_8 due to this reduction. The median rise is $1.56 per pound U_3O_8 and the maximum increase is $3.30 per pound U_3O_8.

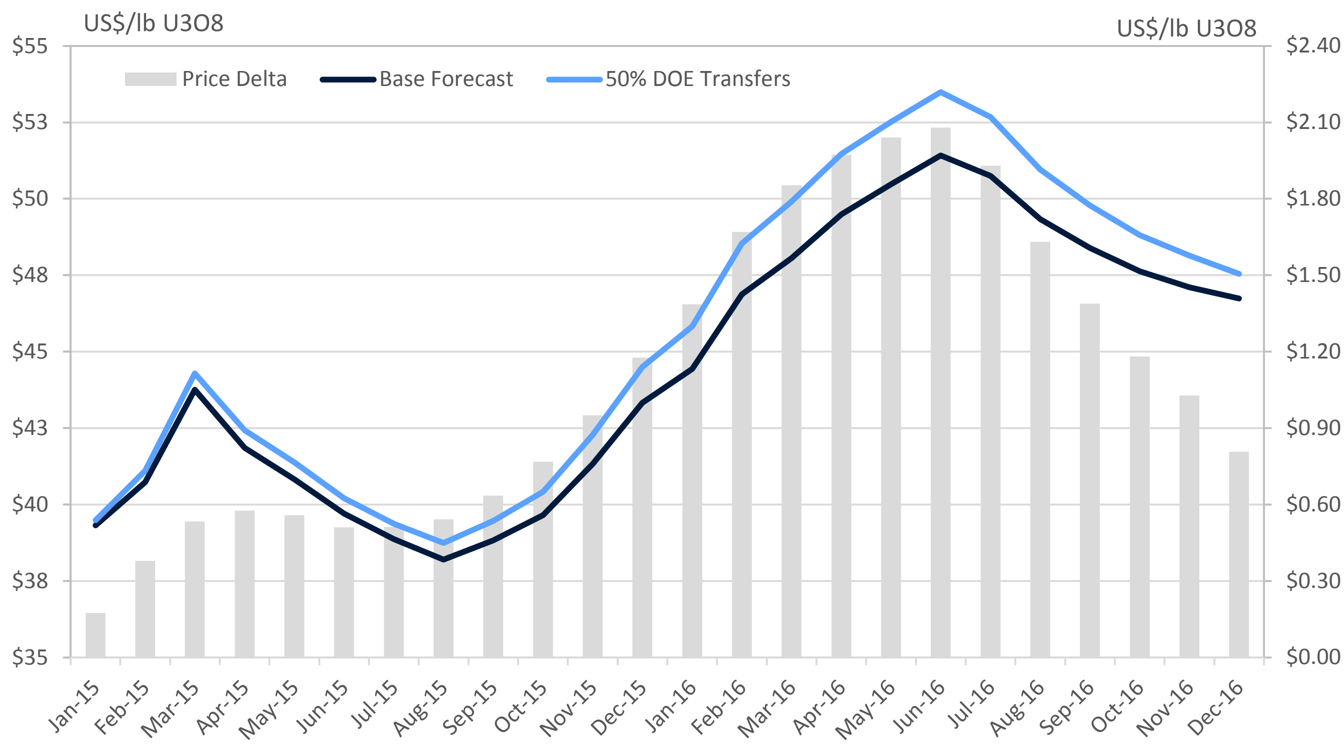
Figure 16
Transfers at 75 Percent of Established 2014 Volumes



50 Percent of Current DOE Transfer Rate

The impact on the uranium spot price of continued DOE transfers at 50 percent of rates comparable to the transfers described in the 2014 Secretarial Determination are shown in **Figure 17**. The blue line represents TradeTech's forecasted Exchange Value, while the light blue line represents a forecast of the Exchange Value with DOE material reduced by 50 percent. TradeTech estimates that over the 24-month period from January 2015 through December 2016, the uranium spot price would raise an average of $1.10 per pound U_3O_8 due to this reduction. The median rise is $0.99 per pound U_3O_8 and the maximum increase is $2.08 per pound U_3O_8.

Figure 17
Transfers at 50 Percent of Established 2014 Volumes



25 Percent of Current DOE Transfer Rate

The impact on the uranium spot price of continued DOE transfers at 25 percent of rates comparable to the transfers described in the 2014 Secretarial Determination are shown in **Figure 18**. The blue line represents TradeTech's forecasted Exchange Value, while the light blue line represents a forecast of the Exchange Value with DOE material reduced by 75 percent. TradeTech estimates that over the 24-month period from January 2015 through December 2016, the uranium spot price would raise an average of $0.53 per pound U_3O_8 due to this reduction. The median rise is $0.48 per pound U_3O_8 and maximum increase is $0.98 per pound U_3O_8.

Figure 18
Transfers at 25 Percent of Established 2014 Volumes

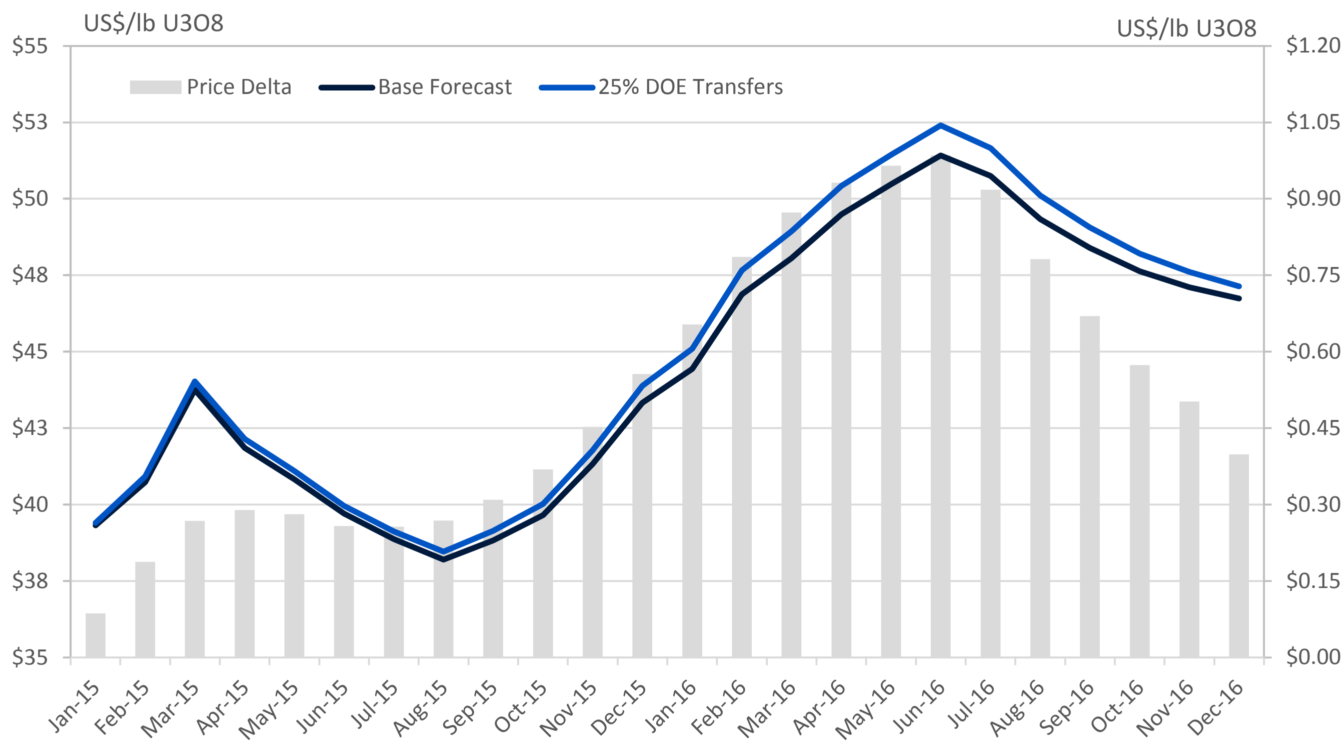
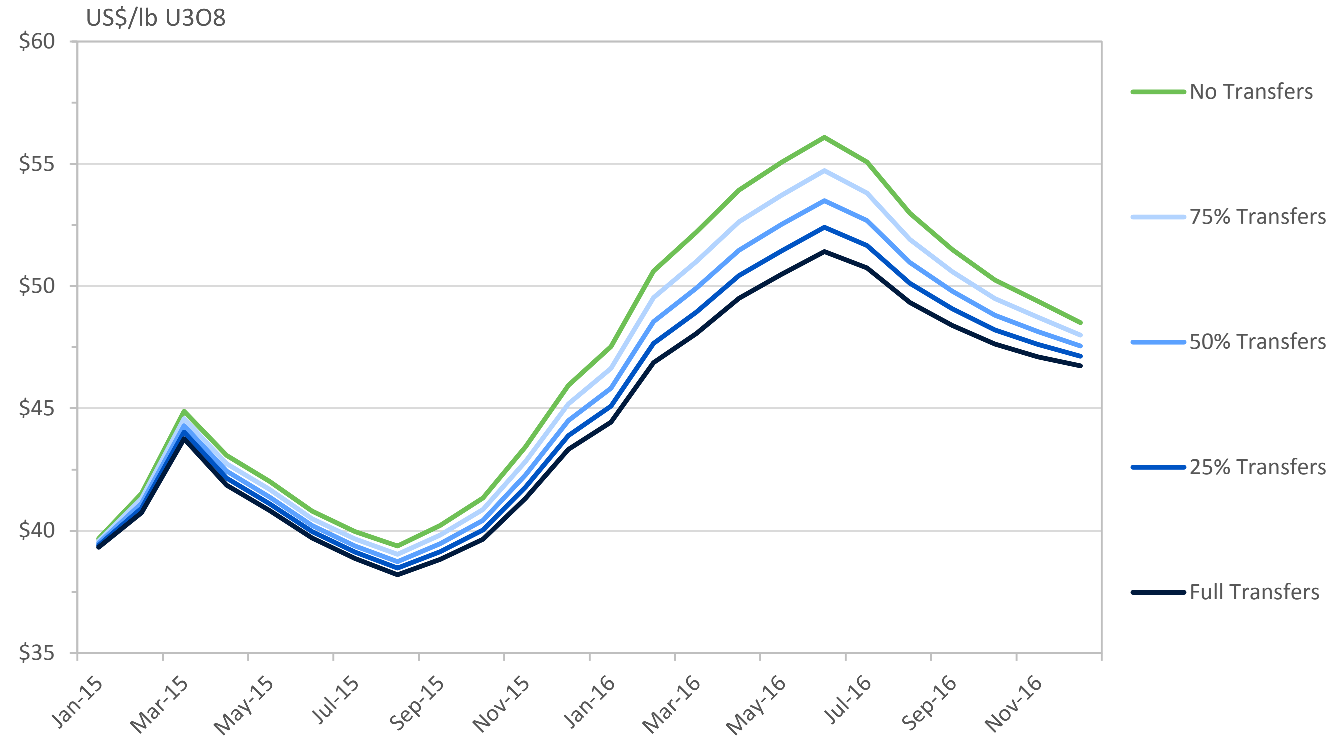


Figure 19 summarizes the evaluated reductions.

Figure 19
Transfers at Incremental Reductions to Established 2014 Volumes



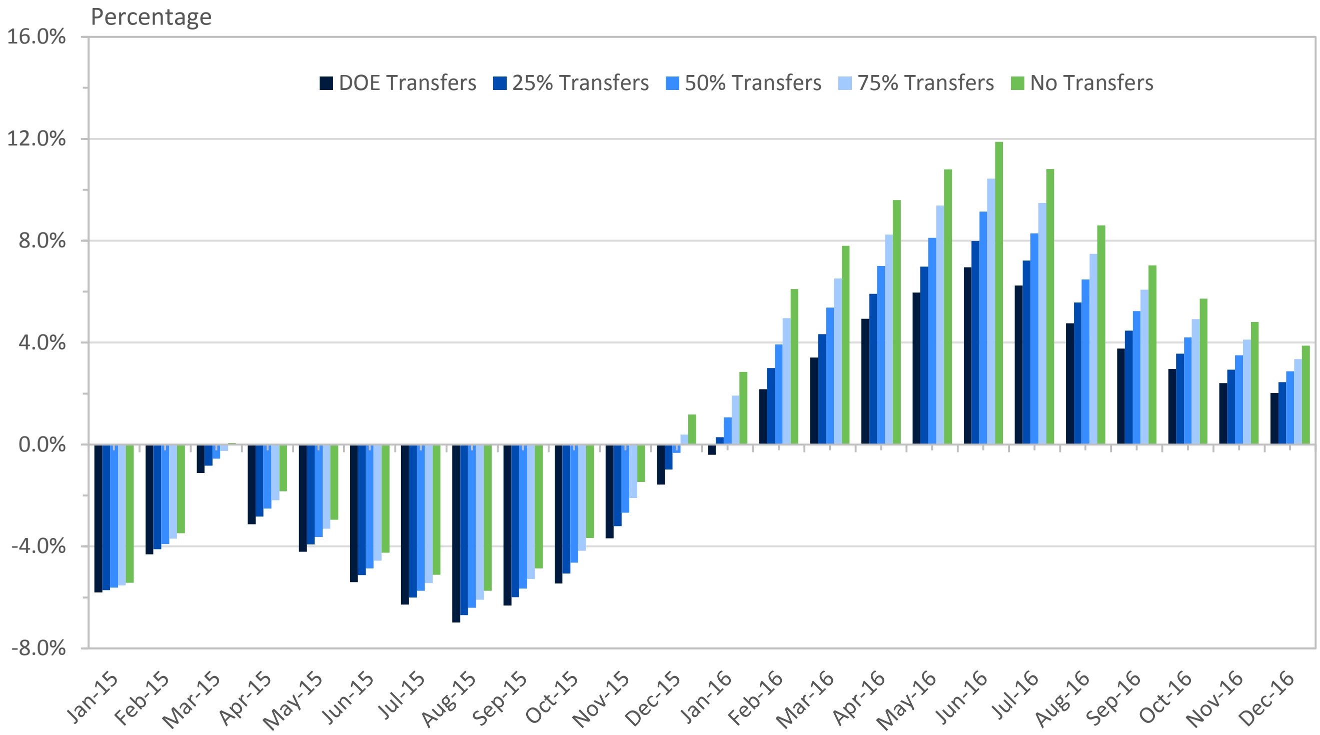
Similar to previously presented examples, the viability of a uranium producer considering its margins has been evaluated based on several specified rates of reduction to DOE material transfers (presented above) from the rates described in the 2014 Secretarial Determination.

Figure 20 illustrates the impact on margins a uranium producer would realize at different transfer rates[3], using a production cost of $47.41 per pound U_3O_8. The illustration indicates that a producer may be able to survive or reach production given its required return in the event that DOE transfer material was removed from the market.

The average margin percentage for the DOE Transfers scenario utilizing a marginal production cost of $47.41 is -0.4 percent. The average margin value increases with each 25 percent incremental adjustment. The average margin percentage for the 25 percent, 50 percent, 75 percent and No Transfers scenario is 0.2, 0.8, 1.4, and 2.2 percent, respectively. While this may seem slight, a margin percentage reduction on this scale could be the difference between a uranium producer maintaining commercial operation or ceasing to exist.

[3] The example assumes the producer has a 50 percent exposure to spot market prices, a $47.41/lb U_3O_8 production cost and a realized price of $50 per pound U_3O_8 for the long-term component.

Figure 20
Margin Percentages at Varying Transfer Rates

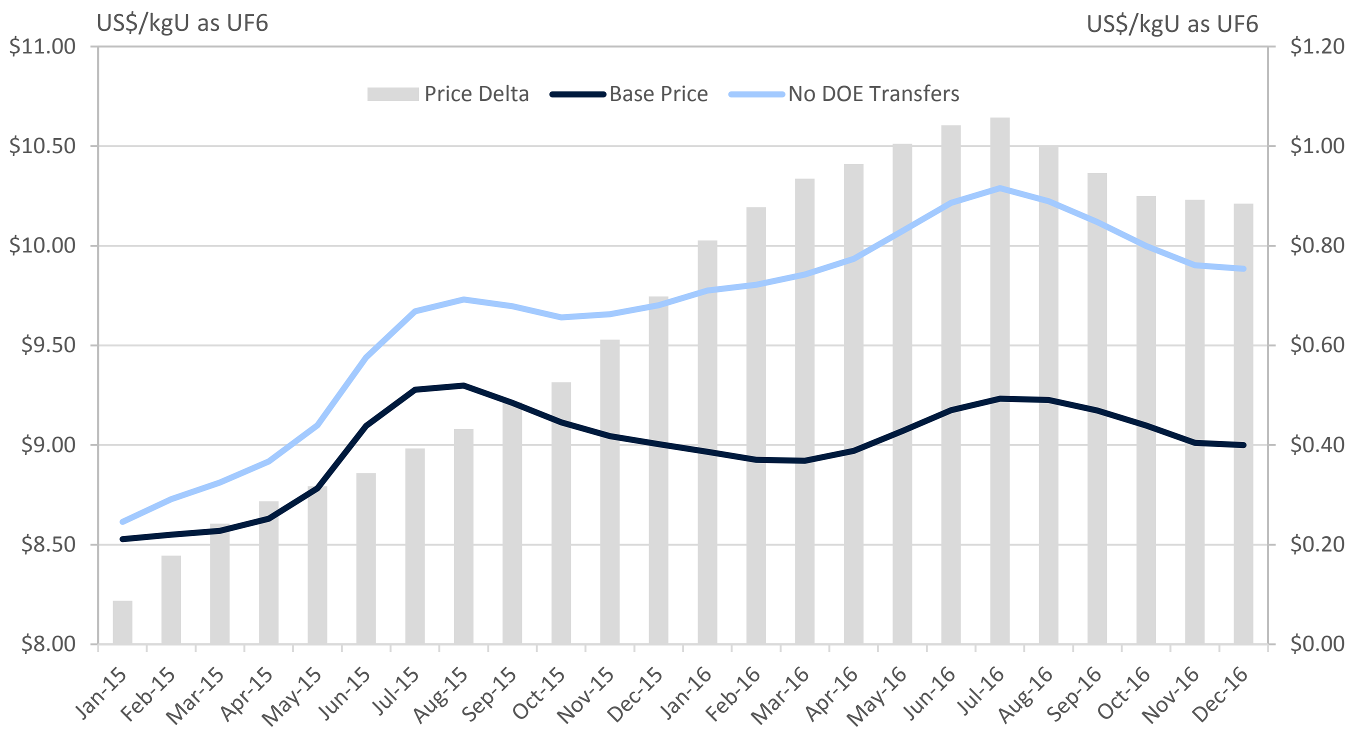


4.2 Projected Conversion Price Impact at Lower DOE Transfer Rates

75 Percent of Current DOE Transfer Rate

The impact on the conversion price of continued DOE transfers at 75 percent of rates comparable to the transfers described in the 2014 Secretarial Determination are shown in **Figure 21**. The blue line represents TradeTech's forecasted North American Conversion Value, while the light blue line represents a forecast of the North American Conversion Value with DOE material reduced by 25 percent. TradeTech estimates that over the 24-month period from January 2015 through December 2016, the conversion price would raise an average of \$0.66 per kgU as UF_6 due to this reduction. The median rise is \$0.75 per kgU as UF_6 and maximum increase is \$1.06 per kgU as UF_6.

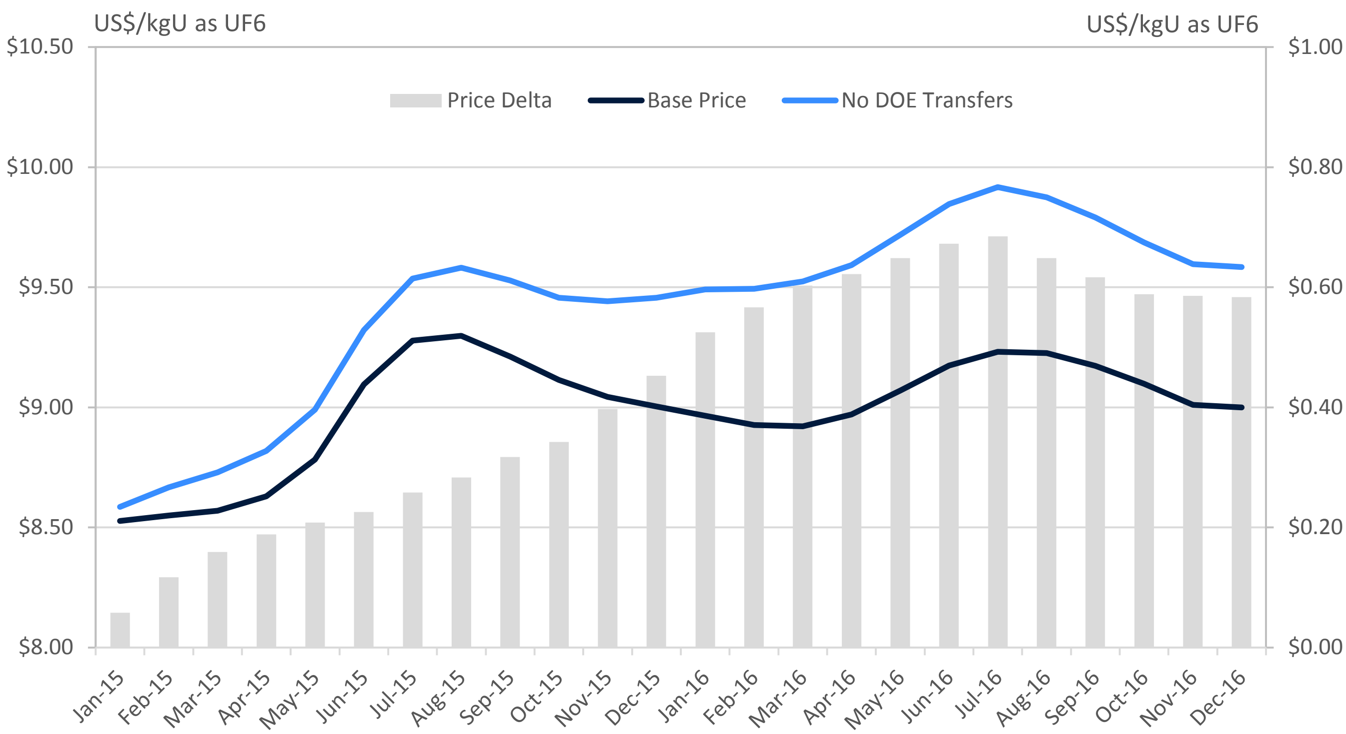
Figure 21
Transfers at 75 Percent of Established 2014 Volumes



50 Percent of Current DOE Transfer Rate

The impact on the conversion price of continued DOE transfers at 50 percent of rates comparable to the transfers described in the 2014 Secretarial Determination are shown in **Figure 22**. The blue line represents TradeTech's forecasted North American Conversion Value, while the light blue line represents a forecast of the North American Conversion Value with DOE material reduced by 50 percent. TradeTech estimates that over the 24-month period from January 2015 through December 2016, the conversion price would raise an average of $0.43 per kgU as UF_6 due to this reduction. The median rise is $0.49 per kgU as UF_6 and maximum increase is $0.68 per kgU as UF_6.

Figure 22
Transfers at 50 Percent of Established 2014 Volumes



25 Percent of Current DOE Transfer Rate

The impact on the conversion price of continued DOE transfers at 50 percent of rates comparable to the transfers described in the 2014 Secretarial Determination are shown in **Figure 23**. The blue line represents TradeTech's forecasted North American Conversion Value, while the light blue line represents a forecast of the North American Conversion Value with DOE material reduced by 75 percent. TradeTech estimates that over the 24-month period from January 2015 through December 2016, the conversion price would raise an average of $0.21 per kgU as UF_6 due to this reduction. The median rise is $0.24 per kgU as UF_6 and maximum increase is $0.33 per kgU as UF_6.

Figure 23
Transfers at 25 Percent of Established 2014 Volumes

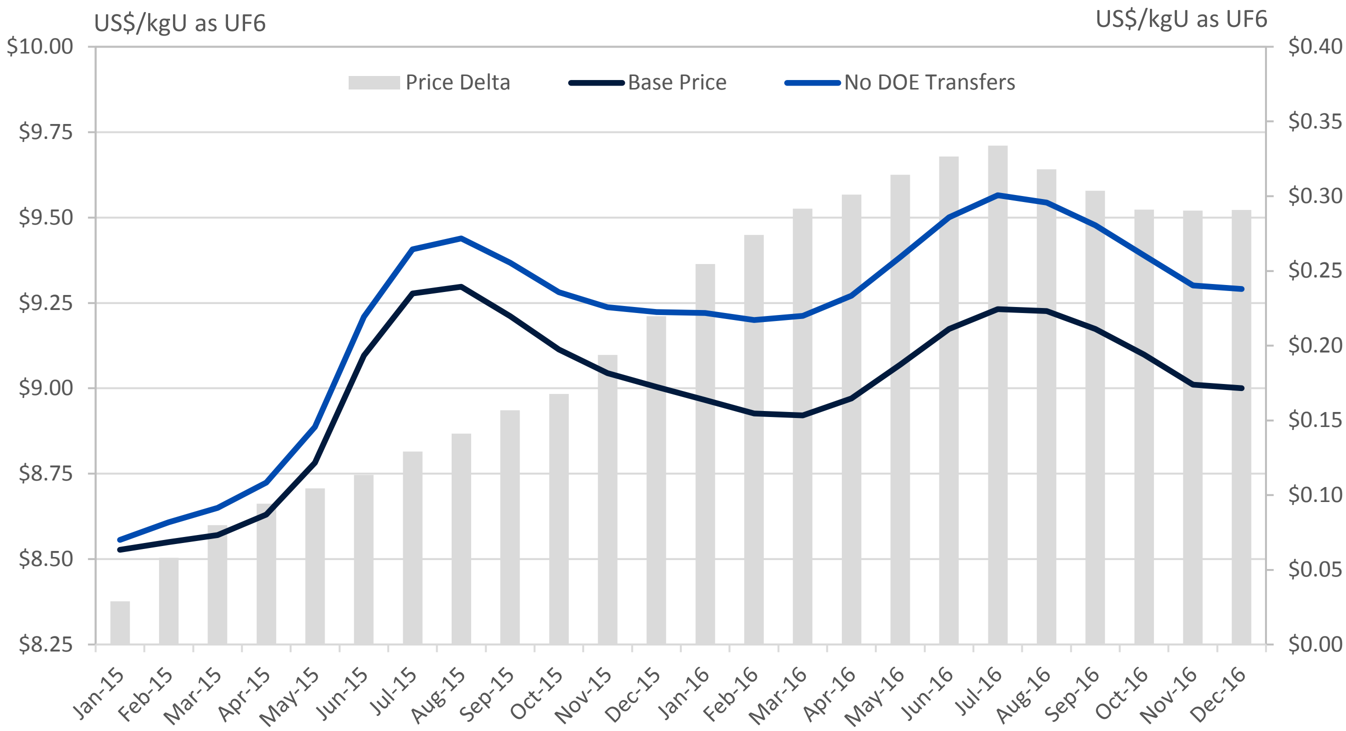
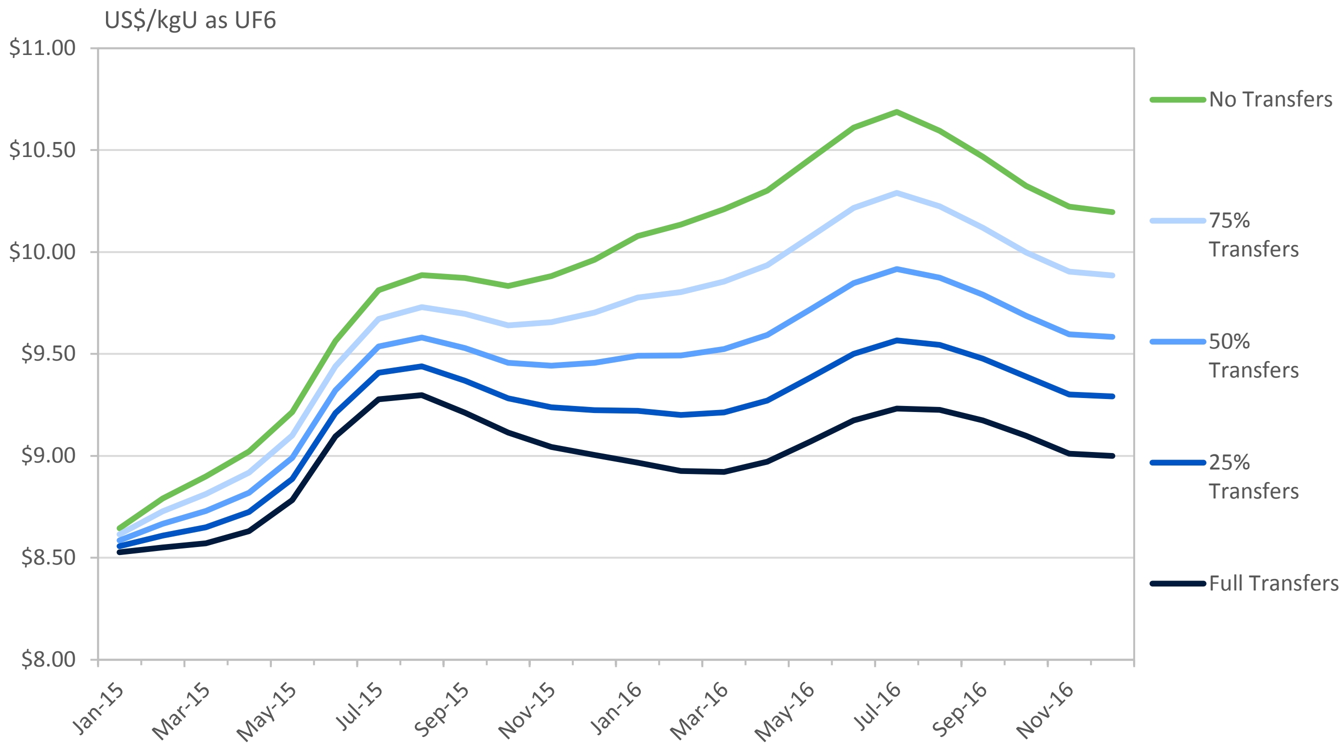


Figure 24 summarizes the evaluated reductions.

Figure 24
Transfers at Incremental Reductions to Established 2014 Volumes



The scenarios outlined above highlight the notion that hyper-competitive supply does not belong in a functioning marketplace (especially one as small and specialist as uranium, which is prone to illiquidity and external market forces). The entrance of price-insensitive supply into the market has the potential to place further downward pressure on prices already dampened by oversupply. TradeTech has identified the AS/AD quotient as a key measure, in addition to estimating potential price impacts, to further refine when transfers at a reduced rate may be warranted.

Material transfers at a slower rate have the potential to mitigate potential effects on the market insomuch as they can preserve the integrity of prevailing price (itself an effect of the AS/AD balance). Avoiding undue downward price pressure naturally preserves margins and future realized prices, which protect the ability of uranium producers to plan for the long term.

7. ANTICIPATED CHANGES

Are there any anticipated changes in these markets that may significantly change how DOE transfers affect the domestic uranium industries?

Anticipated changes in the uranium market largely concern reduced demand and the subsequent rational choice to reduce or defer production. Overall demand increases, but plans for plant life extensions or new builds have long since been accounted for in production plans or are out of the reach of most uranium producers (China and their desire for self-sufficiency in the fuel cycle, for example). Reduced demand in the uranium market has the potential to change how DOE transfers affect the domestic uranium industries; when the supply and demand ratio is tilted toward the former, downward price pressure is the common result. Current supply and demand forecasts indicate persistent structural oversupply, while new demand has largely already been addressed by forward-looking production plans, or is out of reach of domestic suppliers.

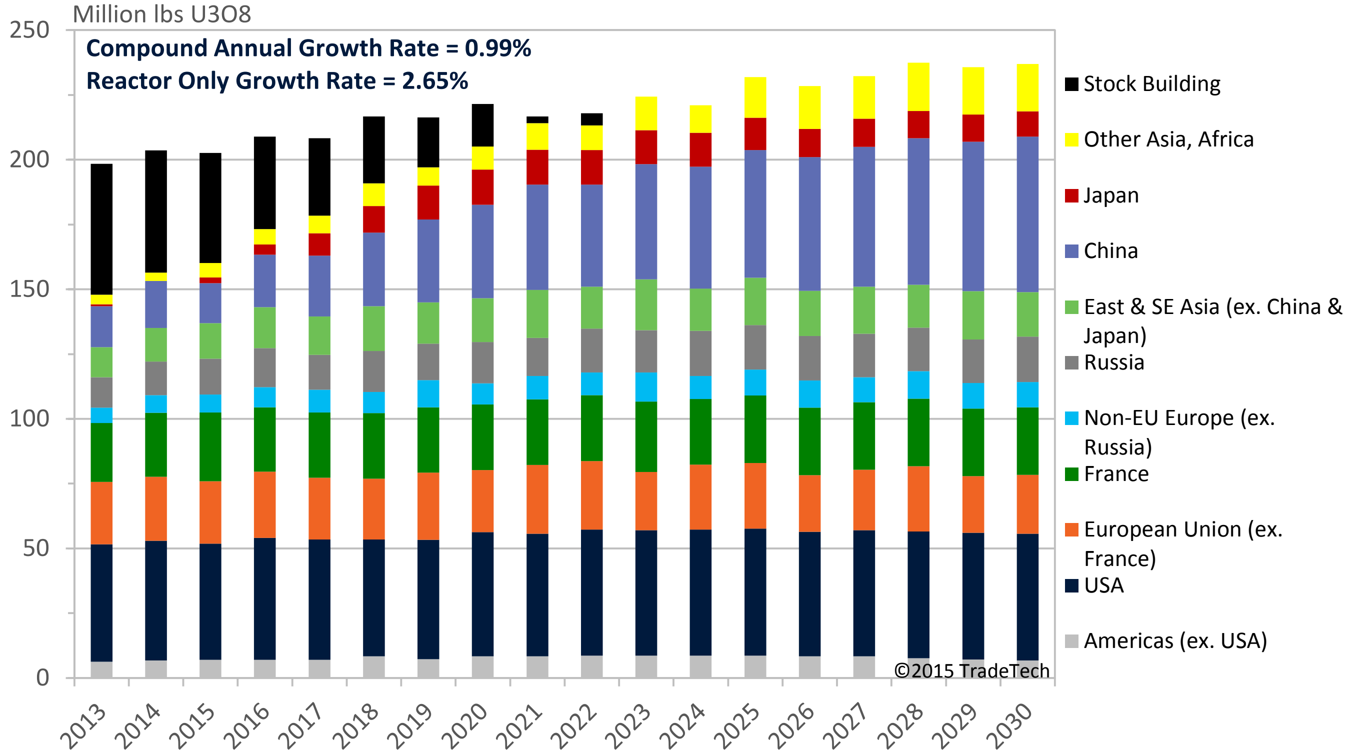
Key Points:

- Projected demand to 2030 increases at less than one percent annual compound growth, including stock building;
- Japanese uranium demand is steady in the short term, but interim stock building will prolong new contracting.
- Growth in US uranium demand is relatively flat, due to only marginal increases in nuclear power capacity to 2030.
- Nuclear power growth in China is notable, but future supply has already largely been addressed.

7.1 Projected Global Demand

Demand in the global nuclear fuel market is projected to increase at a relatively modest pace. As shown in **Figure 25**, including stock building, overall demand is expected to grow at a compound annual growth rate of 0.99 percent from 202.5 million pounds U_3O_8 in 2015 to 236.9 million pounds U_3O_8 in 2030, while reactor-only growth is expected to increase at 2.65 percent from 160.2 million pounds U_3O_8 in 2015 to 236.9 million pounds U_3O_8 in 2030.

Figure 25
Global Uranium Requirements



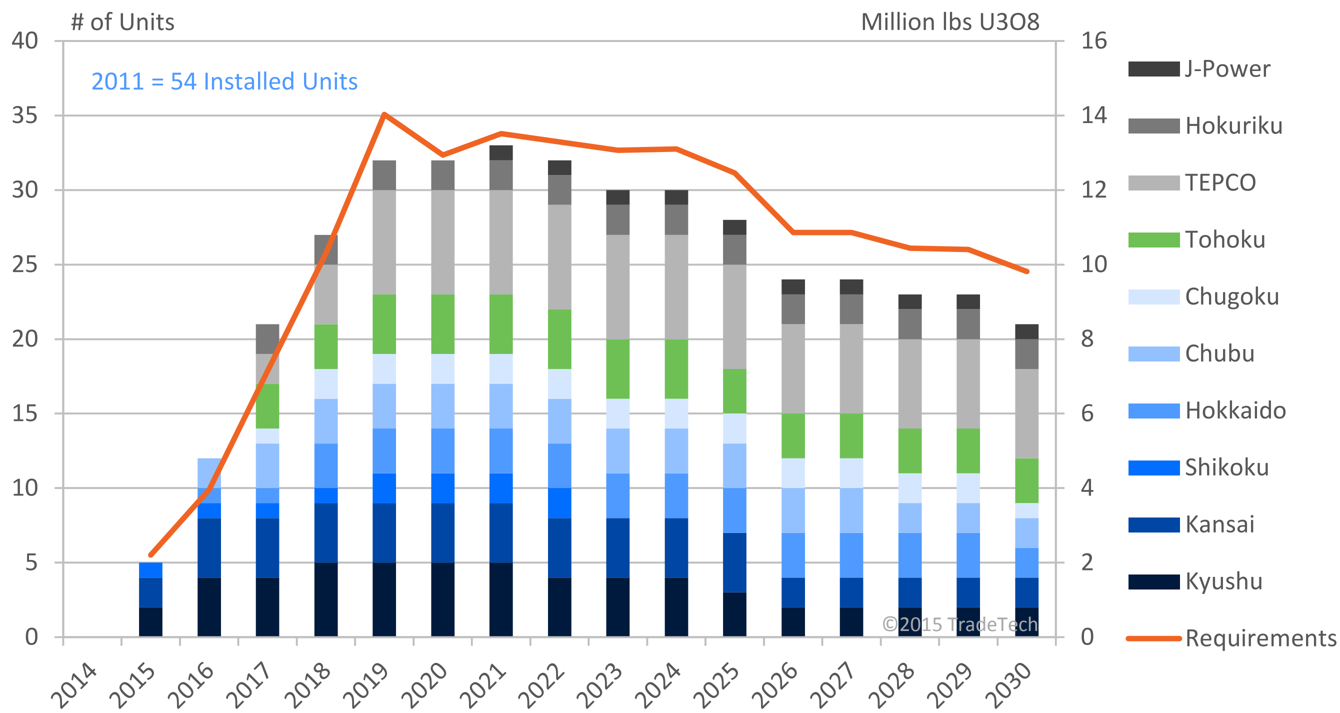
The low compound growth generated by TradeTech's requirements forecast is due mostly to the stock-inflated, near-term demand position. Reactor growth alone over the period falls into two clear phases. The current growth phase runs until 2024, where reactor growth equates to 3.52 percent compound growth per year; this is followed by a largely static period of nuclear growth from 2025, where 0.36 percent compound growth per year is seen. From a modeling perspective, the transition from the growth phase to the static phase also removes additional buying for associated stock build.

7.2 Anticipated Changes

Japan

TradeTech assumes around 65 percent of Japan's generating capacity will resume by 2020 (**Figure 26**).

Figure 26
Japanese Reactor Restart Schedule and Projected Uranium Requirements



Japanese Deliveries

In the meantime, about 70 percent of deliveries are still being made. TradeTech believes that Japanese demand remains reasonable over the near term, but as existing contracts expire, demand in the uranium market, which TradeTech terms "Call On Mine Production," will taper as existing contracts expire and Japanese utilities are able to use their inflated stocks.

Japanese Stock Positions

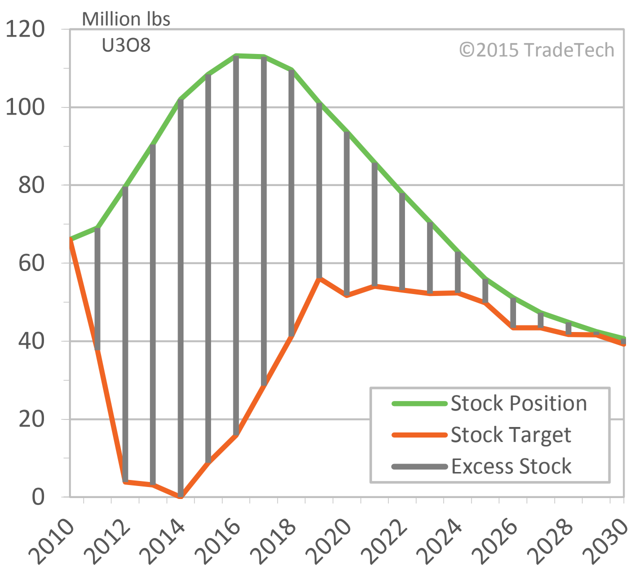
Figure 27 highlights how continuing Japanese deliveries are expected to swell stock positions. The estimated delivery schedule supports stock reduction through 2026-2027, when delivery increases could be justified as the stock target begins to fall in line with requirements.

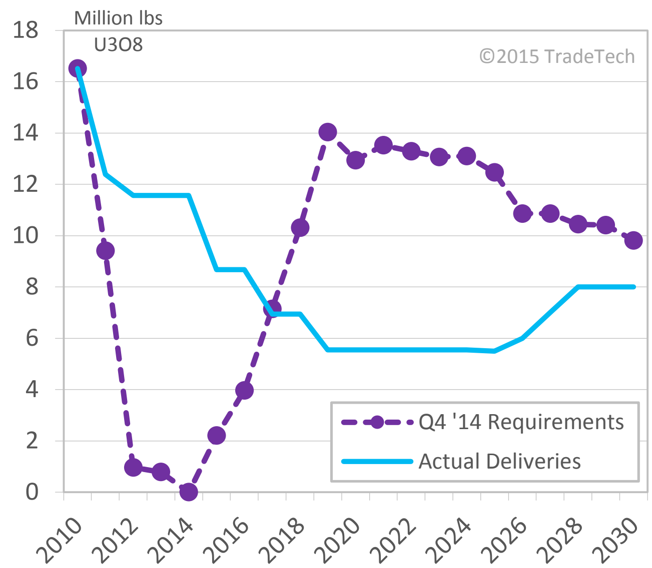
The vertical grey lines indicate that, on this basis, excess stock will be worked off by 2030. The orange line reflects the target stock level defined as four times annual needs. This is low in the 2012-2014 period while reactors are offline and no stock targets for those years would be expected. Similarly, the excess stock level is artificially high in the same period. As reactors restart, a long-run stock level target of about 50 million pounds U_3O_8 is defined by 2025, falling further to nearly 39 million pounds U_3O_8 by 2030.

The green line in **Figure 27** on the left reflects the total stock position. This is inflated from around the 66 million-pound-level to the 113 million-pound-level on the assumption that deliveries have continued at about 70 percent over the 2011-2014 period, and will continue to do so until current contracts expire. As reactors restart and procurement is deferred, the total stock level drifts back down to the target 56 million-pound-level in 2025, but as many reactors reach their 40-year life expectancy by 2025, the stock target begins to slide to meet the reducing demand of fewer reactors to 2030.

The blue line in **Figure 27** on the right displays the deferred delivery schedule that would generate the stock reduction defined in the figure on the left. On this basis, actual deliveries would total about 24 million pounds U_3O_8 lower than defined reactor requirements over the 2013-2025 period.

Figure 27
Estimated Japanese Delivery Needs





Future Japanese Demand

TradeTech's analysis indicates that once current contracts expire (estimated in 2018), it is unlikely that Japanese utilities will reenter into contracted deliveries until the mid 2020s.

USA

Stagnant reactor growth and premature plant closures due to economic forces and technical difficulties equate to a near-term decline in uranium demand from 46.9 million pounds in 2011 to 44.8 in 2015.

In 2013, Dominion Resources shut down its 556 MWe Kewaunee Power Station in Wisconsin, citing economic conditions as the basis for the decision. Pointing to low power prices, high cost structure, and flaws in the design of the wholesale electricity market as grounds for the closure, Entergy shut down its Vermont Yankee plant at year-end 2014. Entergy has indicated similar challenges exist at its FitzPatrick and Pilgrim plants in New York and Massachusetts, respectively. Southern California Edison spent $600 million to replace steam generators at its San Onofre plant, but problems with the installation forced the company to shut the plant down in January 2012. It never reopened and in June 2013, the company announced it would permanently decommission the plant. In 2009, similar circumstances began to unfold as Progress Energy set out to replace steam generators in its Crystal River plant in

Florida. Installation procedures damaged the containment dome, however, and the plant never reopened, closing permanently in February 2013. Lastly, Exelon intends to shut down its Oyster Creek plant in New Jersey in 2019, 10 years ahead of its license expiration. Exelon has stated it intends to assess the viability of further operations at five of its units in 2015.

Barriers to US Growth in US Nuclear Power

Primarily unregulated electricity markets that favor cheaper forms of generation threaten nuclear energy's overall capacity. In the USA, merchant markets are currently gravitating toward natural gas to achieve both cleaner-than-coal carbon emissions and efficient pricing. Despite the historic volatility within the natural gas sector, the implementation of newer technologies, such as gas production via the fracking process, has alleviated many supply concerns. Natural gas prices have remained highly competitive, and have largely remained below the $5 mark over the past four years, according the Henry Hub Spot Price (**Figure 28**).

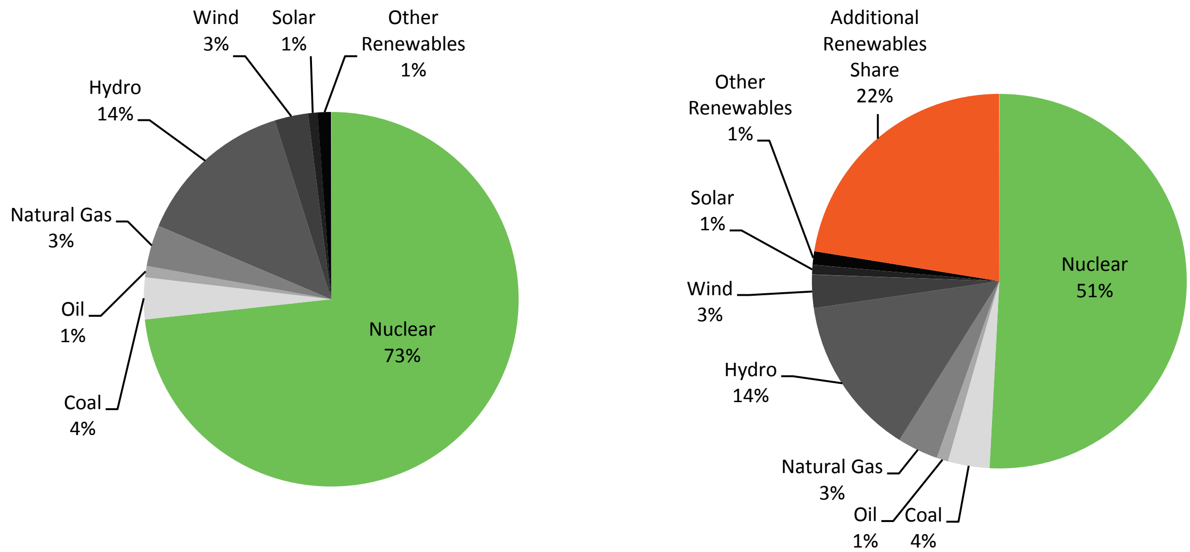
Figure 28
Henry Hub Natural Gas Prices 2005-2015

According to EIA forecasts, the Henry Hub Spot Price is expected to have an annual growth rate of just under 2.5 percent, with prices remaining below $7.50 per thousand cubic feet through 2035. The EIA's *Annual Energy Outlook 2014* forecasts 70 percent of all new electricity generating capacity between 2020 and 2040 to be fueled by natural gas.

France

In June 2014, French Energy and Environment Minister Ségolène Royal presented a bill, which if approved by parliament, would boost renewable sources in the national energy mix and limit nuclear power production at current levels. The new bill would cut nuclear power's share of France's electricity mix to 50 percent by 2025, from more than 70 percent today, while the share of renewables would climb to about 40 percent, from around 11 percent today, by 2030 (**Figure 29**).

Figure 29
2013 and Forecasted France Generation Share by Type



Under the proposed law, the nuclear cap would be 63.2 GWe, which would force EDF to shut down certain plants if it wants to operate the new Flamanville Unit 3 plant, which is under construction and planned for connection to the grid in 2017. It would also likely ensure that the Fessenheim nuclear plant in eastern France be closed by 2016, which was pledged by the Hollande government earlier.

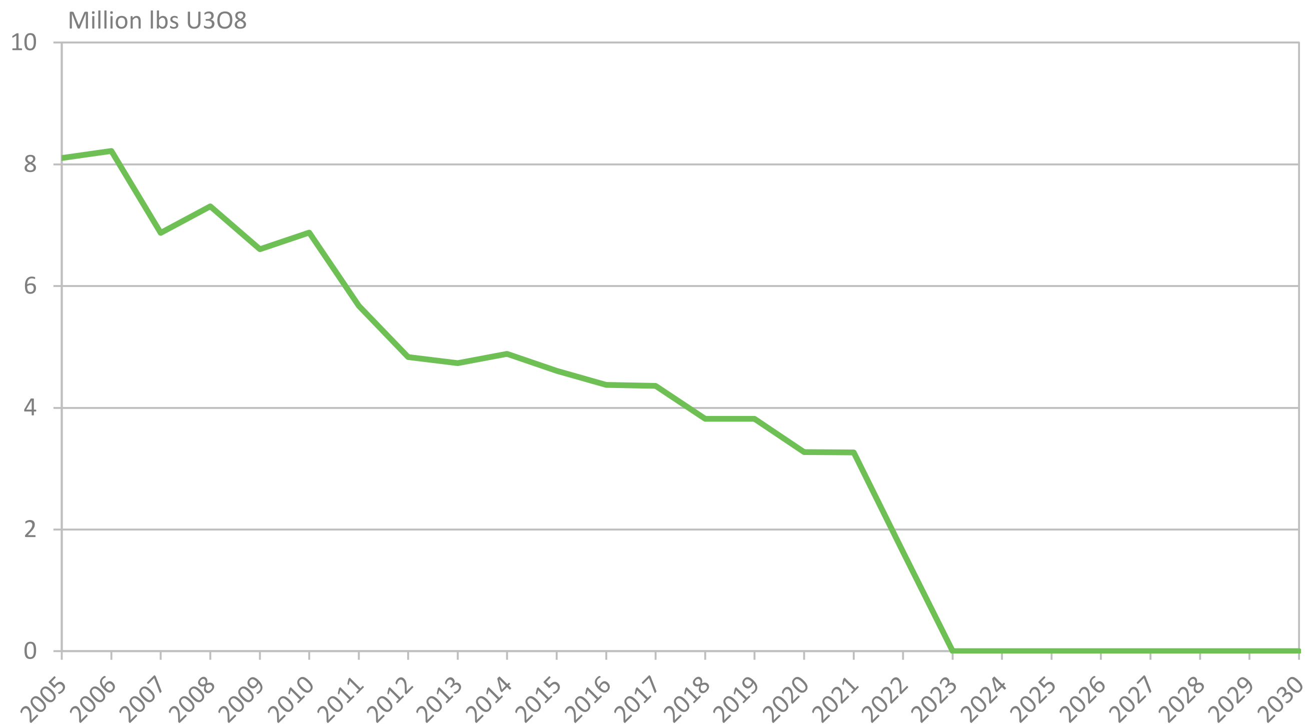
Additionally, France is ready to sell shares in energy companies as part of a privatization plan if the government maintains the power to steer strategy, according to Environment Minister Ségolène Royal. Proceeds from the sales should be used to finance France's transition to more renewable energies, Royal said on November 16.

Although nuclear power's share of the generation mix could be reduced without reducing actual capacity (by simply increasing capacity in other areas, for example), should the government pursue a 31.5 percent reduction in French nuclear capacity, it would result in a reduction in uranium demand from 24.7 million pounds U_3O_8 to 16.9 million pounds U_3O_8, using 2014 values.

Germany

Prior to the accident at Japan's Fukushima nuclear facility, nuclear power accounted for approximately 15 percent of installed capacity and 25 percent of Germany's electricity generation. Seventeen reactors, owned and operated by four utilities accounted for over 20 GWe of available capacity; four additional VVER-type reactors located in the eastern region were shut down upon the country's reunification and are being decommissioned. **Figure 30** shows the forecasted decline in Germany's uranium and enrichment services demand as a result of the planned nuclear phaseout. In 2005, demand totaled approximately 8.1 million pounds U_3O_8; in 2014, demand totaled approximately 4.9 million pounds U_3O_8. By the end of 2022, if the phaseout is completed according to published plans, those figures will reach zero.

Figure 30
Total Reduction in German Uranium Needs



Belgium

Belgium's seven nuclear reactors generate approximately 51 percent of its electricity. A 2003 government act limited the operating lives of the country's nuclear plants to 40 years and prohibited construction of new reactors, effectively meaning a nuclear phaseout beginning with the Doel Nuclear Station in 2014. The Act's intent to remove nuclear power form the energy mix was initially dependent on the availability of alternate secure supply, and the Belgian government has since approved an energy plan that provides for taxpayer subsidies to gas- and offshore wind-powered generation.

Of the remaining Belgian units, Doel Unit 3 and Tihange Unit 2 are expected to close when each reaches the end of their 40-year operating lives in 2022 and 2023, with Doel Unit 4 and Tihange Unit 3, as well as Tihange Unit 1 (for which an extended 10-year operating license was approved in 2014) closing in 2025. **Figure 31** shows the forecasted decline in Belgium's uranium demand as a result of the planned nuclear phaseout. In 2011, demand totaled approximately 2.5 million pounds U_3O_8. By the end of 2026, if the phase out of nuclear power is completed according to published plans, uranium requirements will reach zero.

Figure 31
Total Reduction in Belgian Uranium Needs

China

The Chinese government has called for nuclear to supply 4.5 percent of the country's electricity by 2020. China is currently operating 23 reactors with 25 under construction, for a total of 48 reactors in the fleet, either operating or under construction. Presently, China has 25 reactors under construction, about 40 percent of global nuclear power construction today, and is forecast to reach approximately 93 GWe of installed capacity by 2025.

Chinese Uranium Demand

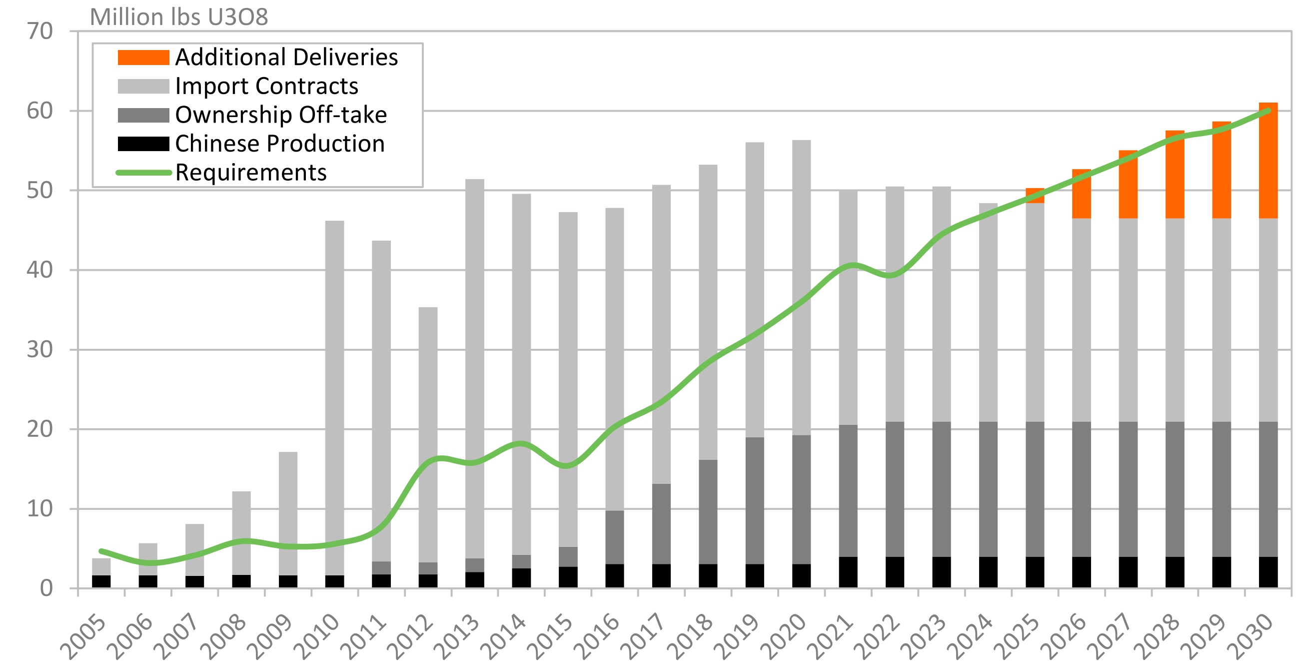
China's demand for uranium was estimated at approximately 3 million pounds U_3O_8 in 2007, and reached 15.8 million pounds U_3O_8 in 2013. Plans to increase nuclear generation capacity to an estimated 160 GWe over the next 25 years will cause China's uranium requirements to increase three-fold by 2025, to over 49 million pounds U_3O_8, making it the world's second-largest consumer of uranium following the USA, according to TradeTech forecasts.

China's uranium requirements, as illustrated by the green line in **Figure 32** are forecast to reach 16 million pounds by 2015, 39 million pounds by 2020, and 49 million pounds by 2025. The addition of stock material to its requirements presents a total delivery plan that equals 39, 44, and 53 million pounds in those same years, utilizing a 5-years-plus forward stock building assumption (based on 2030 endpoint), based on China's recent activity in the market and their plant build schedule.

China's uranium requirements curve is plotted against its total delivery plan, represented in its component form, in **Figure 32**. Uranium deliveries that constitute the total delivery plan are composed of import contracts, ownership off-take agreements, and primary production. Primary production grows steadily over the entire 2005-2030 period, while ownership off-take supply is ramped up to a consistent volume over the 2015-2012 period, to around 12 million pounds U_3O_8. Import contracts, as they stand today, taper off significantly in the 2020-2030 period, indicating impending long-term contract demand.

Operating under a strategy that dictates a five-plus-years stock basis, additional deliveries, illustrated by the orange bars, indicate Chinese demand beyond current contracted volumes that are needed new to maintain that position, which could be satisfied through either new import contracts, further off-take agreements, or some combination of the two. The need for additional material outside of the currently assumed sources grows from 10 million pounds in 2020 to 40 million pounds in 2030.

Figure 32
Chinese Uranium Supply vs. Requirements



Recent Chinese uranium stock building has been significant, as shown in **Figure 33**. The uranium market has integrated Chinese stock building into its demand forecasts. TradeTech anticipates continued Chinese stock building at the rates shown below, but reaffirms expectations regularly due to the relative opaqueness under which the Chinese nuclear program is advancing. In December 2014, China approved plans to resume building unspecified plants on its eastern coast.

Figure 33
Chinese Uranium Stock Trajectory