The Nuclear Fuel Market-Post Fukushima

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TradeTech Energy
Uranium has to be further processed to become nuclear fuel.

“Natural” UF$_6$ (uranium hexafluoride)

U$_3$O$_8$ or Yellow Cake

The enrichment stage has variable economic efficiency, creating a substitution factor of electricity for uranium.
This fuel cost still represents only a small part of total electricity cost and are rolled into the generating cost over the course of several years.
Topics

- Uranium Market
- Enrichment Market
- Overall Market Conclusions
Uranium Prices in 2010+

US$/Pound U3O8

Spot Price*
Long-Term Price**

2004-2009 By Month
2010+ By Week

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Spot Prices climbed significantly in the second half of 2010, but began gradually declining in January and dropped significantly after the Fukushima incident.

Average Spot Price for 2010 is $46.71

* TradeTech’s NUEXCO Exchange Value through 2009; TradeTech’s weekly Spot Price Indicator for 2010-2011 YTD
** TradeTech’s Long-Term Price Indicator for U3O8
Uranium Market

- Recent Developments Impacting Price
- Uranium Demand Outlook
- Uranium Supply Outlook
- Price Outlook
Recent Developments…

- 2010 had the largest spot volume in history of market; third year in a row of high volume
- Uranium prices were low in 2009 and mid-2010, but recovered later in 2010 through the beginning of the year 2011
- Excess US Government uranium stocks still overhang the market, with announcements of continued sales
Recent Developments (post-Fukushima)

- Incident at Fukushima Daiichi plant following earthquake/tsunami on March 11th

- Germany announces immediate shut down of 7 older nuclear units and reevaluation of future plans to extend the lives of operating nuclear plants

- China announces reassessment of safety standards for all future licensing of plants
How Does The Uranium Market Work?

- Has been described as a very immature “horse-trading” market, and is definitely a *boutique* market.

- Market reporters like TradeTech publish price *indicators*.

- No open exchange like LME.
Secondary supply is very large (40%)
A few producers control primary supply
## Current Uranium Supply Sources and Markets

<table>
<thead>
<tr>
<th>Year (2010)</th>
<th>Primary Supply = 69%</th>
<th>Secondary Supply = 31%</th>
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<tbody>
<tr>
<td>Spot Market = 13%</td>
<td>6%</td>
<td>7%</td>
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<td>Longer-Term Market = 87%</td>
<td>63%</td>
<td>24%</td>
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Physical traders have been market players since the mid-1980s. Rising uranium prices attracted a new class of spot market participant: Financials (physical investor/speculator).

Investors now have a major presence and influence in the spot uranium market!
Investor/speculators were net sellers in 2008, for the first time.

➤ Investors still have a major presence, but the financial crisis has lessened their buying interest/ability.
Uranium Market

- Developments in 2009 Impacting Price
- Uranium Demand Outlook
- Uranium Supply Outlook
- Price Range Forecast
Nuclear Power Worldwide

Nuclear Power Units*

- 139 Operating
- ~150 Planned
- ~320 Proposed

Nuclear energy is a growth industry

Large existing base + growth from nuclear renaissance

*WNA April 2011 data
Nuclear Capacity Growth
World Nuclear Association Reference Case

- Largest regional growth area: Asia

China’s growth exceeds that of the next highest 4 combined!

Following Fukushima accident Germany likely to cancel nuclear, UK?

*GW e To Be Added From 2008-2020

Largest regional growth area: Asia
Uranium Market

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Current and Projected Uranium by Country

Kazakhstan
Australia
Canada
Russia
Namibia
Niger
USA
South Africa
Uzbekistan
China
Mongolia
India
Romania
Ukraine
Malawi
Brazil
Spain
Argentina
Pakistan
Czech Rep
France

Million Pounds U3O8

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Thousand tU
2010+ Uranium Supply Developments

- Kazakhstan continues growth as new #1 producer
- Paladin Energy initiates production in Malawi
- BHP Billiton accident at Olympic Dam
- ERA announces extension of shut-down at Ranger operations in northern Australia
- McClean Lake Mill shut down in June 2010, due to lack of ore to process
- Cameco continues remediation at Cigar Lake
- Pace of exploration slows significantly
Russia will get reduced but continued access.
Maximum sales planned: 10% of US market (~6 million lbs U₃O₈)
Demand vs. Existing Supply Sources

- Production from new sources needed, especially starting in 2014
- The world needs new uranium mines!
- Supply from currently producing “primary” U₃O₈ mines.
- Supply from “secondary” sources.

- 40-80 million pounds U₃O₈ new production needed (Reference Demand Case)
Demand vs. Planned Supply Sources
Production Based on Producer Plans

- **World Supply**
  - WNA 2009 Requirements
  - Upper Case
  - Reference Case
  - Lower Case

- **Speculative mines**
- **New mines (no permits yet)**
- **Expansion at existing high-cost mines**
- **Expansion at existing low-cost mines**

- Potential supply glut, if all plans materialize.

- **The uranium industry has big plans!**

- **70 thousand tU new production planned**

- **Demand vs. Planned Supply Sources**

- **2005 2010 2015 2020 2025**

- **Million Pounds U₃O₈**

- **Thousand tU**

- **2009 Requirements**

- **Currently Operating**

- **Expansion at Existing Low-Cost Facilities**

- **Expansion at Existing High-Cost Facilities**

- **New Projects**

- **Secondary Sources**
Uranium supply will be driven by price evolution and financing availability!

Assuming several more years of credit crunch and depressed prices …
New uranium sources will be increasingly costly to produce.
The Major Current Suppliers

- Kazatomprom: Kazakh government company
- Cameco: Canadian company traded as CCO.TO
- AREVA: French conglomerate 4% publicly traded on NYSE Euronext
- Rio Tinto (Energy Resources of Australian-ASX: ERA)
- ARMZ: Russian government company
- Uranium One: Traded as UUU.TO on TSX
- Navoi: Uzbek government company
- BHP Billiton: Major mining company
- Paladin: Traded as PDN on ASX
Uranium Market

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Contrary to popular belief, the uranium spot market price DOES reflect fundamental supply and demand.

* TradeTech’s NUXCO Exchange Value
Uranium prices could recover faster, with any combination of rekindled buyer interest in the investor segment, utilities buying for inventory, or producer purchases due to production problems: prices could then rebound to above $80 by early 2011.
Conclusions

- 2009 -- the halt of the fall in spot prices, but downward pressure continued on the long-term price.
- Uranium still not traded on an open exchange, in spite of efforts in the past few years.
- Next 2 years -- prices to stay in the $40-60 range (spot) and maybe $55-70 (long-term), unless a major supply event occurs.
- Growth in world nuclear power usage projected (especially Asia), with two major non-production supplies ending.
- Expansion of uranium enrichment capacity will tend to dampen demand growth for uranium, as enrichment substitutes for uranium on the margin.
Enrichment Market
The supply industry is in a technology transition

The USA is the enrichment battleground

Russia is the “500-pound gorilla”

Trade restrictions continue to distort the market

Centrifuge technology will dictate uranium consumption

There may be “life after death” for old diffusion
The Major Suppliers

- Rosatom: The Russian nuclear conglomerate; output marketed by Techsnabexport
- AREVA: The French nuclear conglomerate; 4% publicly traded on NYSE Euronext
- Urenco: German/Netherlands/UK joint venture
- USEC Inc: U.S. company publicly traded as NYSE:USU
- CNNC: Chinese nuclear company; some output marketed by CNEIC
Future Enrichment Capacity*

* Current plus planned.

- Rosatom
- Urenco
- AREVA
- USEC
- CNNC
- JNFL
- GLE

Million SWU per year

Expansion or replacement at existing sites

New Projects

Expansion or replacement at existing sites

Centrifuge in Operation

Planned Centrifuge

Diffusion

Laser

* Current plus planned.
USA: The Battle Ground

Million SWU per year

- Enrichment Import Restrictions & The Weakening Dollar Foster Building In The USA

- Laser
- Diffusion
- Planned Centrifuge
- Centrifuge in Operation

Rosatom
Urenco
AREVA
USEC
CNNC
JNFL
GLE

* Current plus planned.
Enrichment Implications

- All the major suppliers will be on the centrifuge technology by the middle of the next decade, but the old gas diffusion plants might still have some useful life.

- Once centrifuge manufacture becomes routine and the cost matures, there is “no stopping” the continual installation of centrifuge capacity; the installation rate is merely a function of the size of the centrifuge manufacturing capacity.

- Production costs (and thus possibly prices) could then stabilize or drop, given the centrifuge technology’s low operating costs.

- But, maybe enrichment and uranium pricing will become locked in a competitive environment, if the relationship between the two becomes more transparent to the markets. Enrichment may serve as a long-term cap on uranium prices.

- Trade restrictions against Russia will continue to result in a sub-optimal, economically-inefficient nuclear fuel market for the foreseeable future.
Overall Markets: Potential Surprises

- Cigar Lake uranium deposit may be delayed well into the decade.
- Olympic Dam expansion may not occur within a 10-year time.
- GE’s SILEX enrichment system may rush to the forefront.
- The USA may decide to process enrichment tails material, for sale into the market.
- The USA may decide to release much more military stockpile into the market.
- A lingering Fukushima crisis could slow the expansion of nuclear power in many regions.
- Russia could become integrated into the world fuel markets without restrictions.