The U.S. Nuclear Fuel Cycle: Looking Forward to 2025

EILEEN M. SUPKO
PRINCIPAL
ENERGY RESOURCES INTERNATIONAL, INC.

2017 FUEL CYCLE INFORMATION EXCHANGE
JUNE 13, 2017

Overview

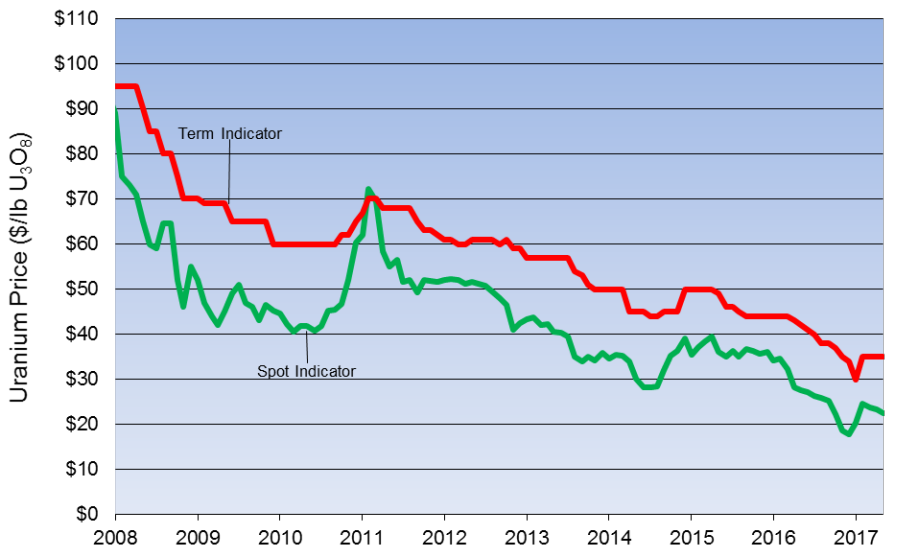
- U.S. Nuclear Fuel Cycle in 2017
- Uranium production 2025
- Fuel cycle facilities 2025: natural uranium conversion, uranium enrichment and fuel fabrication
- Spent fuel management 2025

Today's Dire Market Conditions

- U.S. nuclear power plant operators are at an economic disadvantage to cheap natural gas and subsidized renewable power.
- Over the past 4 years, 6 reactors have closed prematurely.
- By 2025, at least another 7 reactors are expecting to close before the end of operating licenses.
- While some States are addressing these issues, in certain markets additional plants may close if the operators continue to lose money.
- Due to excess world inventories and excess capacity, the U.S. nuclear fuel cycle companies face conditions that pose a threat to U.S. nuclear fuel supply.

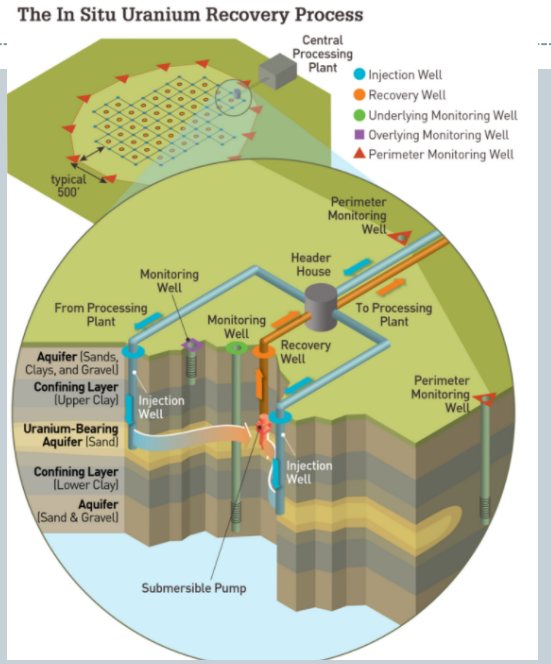
2017: U.S. Uranium Industry

- In 2016, U.S. uranium production was 2.9 million pounds U_3O_8 from 7 facilities in Nebraska, Texas, Utah and Wyoming.
- In 2014, production was 4.9 million pounds U_3O_8 from 8 facilities.
- Wellfield development is on hold at several insitu recovery (ISR) facilities, which will result in further declines in uranium production in 2017.
- No conventional mines are operating – all are on standby.
- The only conventional mill is processing "alternate feed materials." The mill may be placed on standby at the end of 2017.
- A number of applicants have requested NRC to hold further review of pending applications.



Source: TradeTech, www.uranium.info

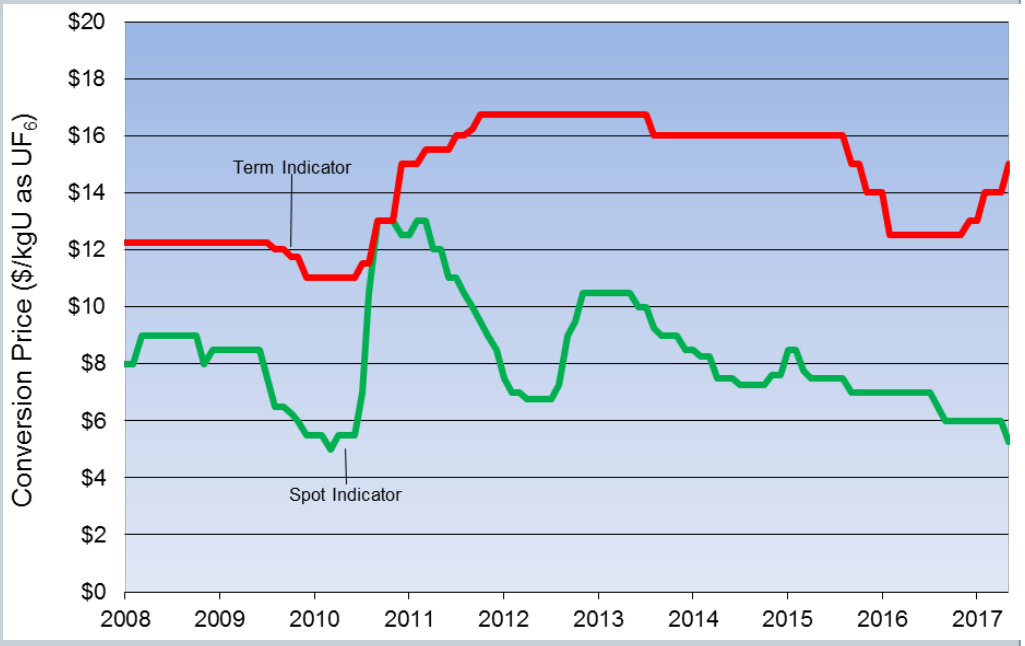
Uranium Industry Regulatory Issues



- NRC licensing process has increased from what was a 2-4 year process to a 5-7 year process. The industry does not see a technical justification for this extended review period.
- NRC part 170 fees charged to licensees have more than doubled.
- In EPA's 40 CFR Part 192 rulemaking, EPA is overstepping NRC jurisdiction to add baseline, operational, and post operational monitoring that will raise costs significantly.
- CERCLA 108(b) financial assurance rulemaking for hard rock mines, including uranium, will add financial burdens that are not in line with the low facility risk.
- Increased regulatory burdens from NRC, EPA, etc., exacerbate the already weak market conditions and could result in additional ISR facility closures.

2017: U.S. Uranium Conversion

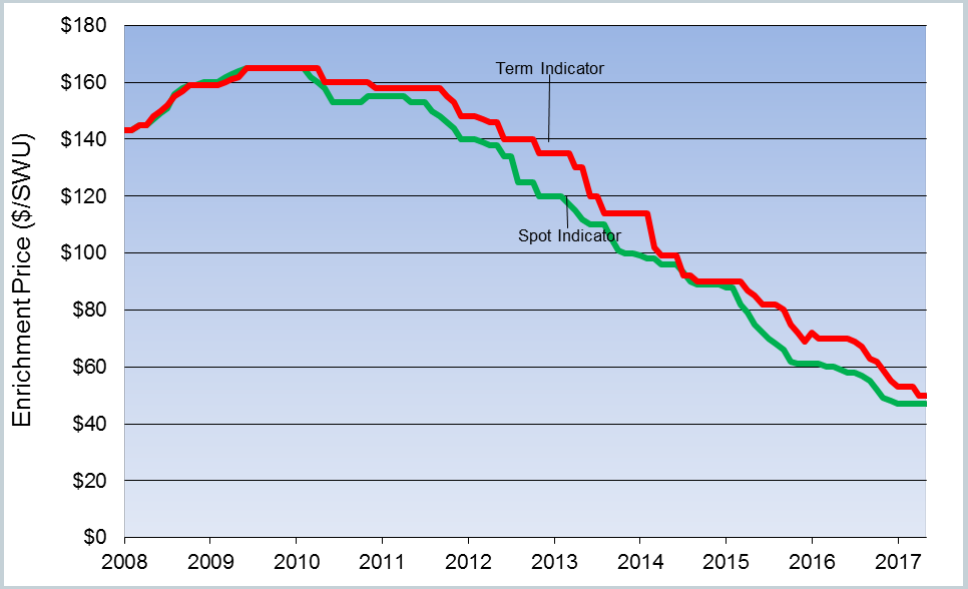
- Conversion spot market prices are at a record low.
- In January 2017, Honeywell announced plans to lay off employee and contractor staff at Metropolis Works, as part of its effort to reduce costs.
- Honeywell has also made changes to permanently reduce the capacity of the Metropolis Works facility to 7 million kgU as UF_6 per year – less than 50% of its nameplate capacity.



Source: TradeTech, www.uranium.info

2017: U.S. Uranium Enrichment

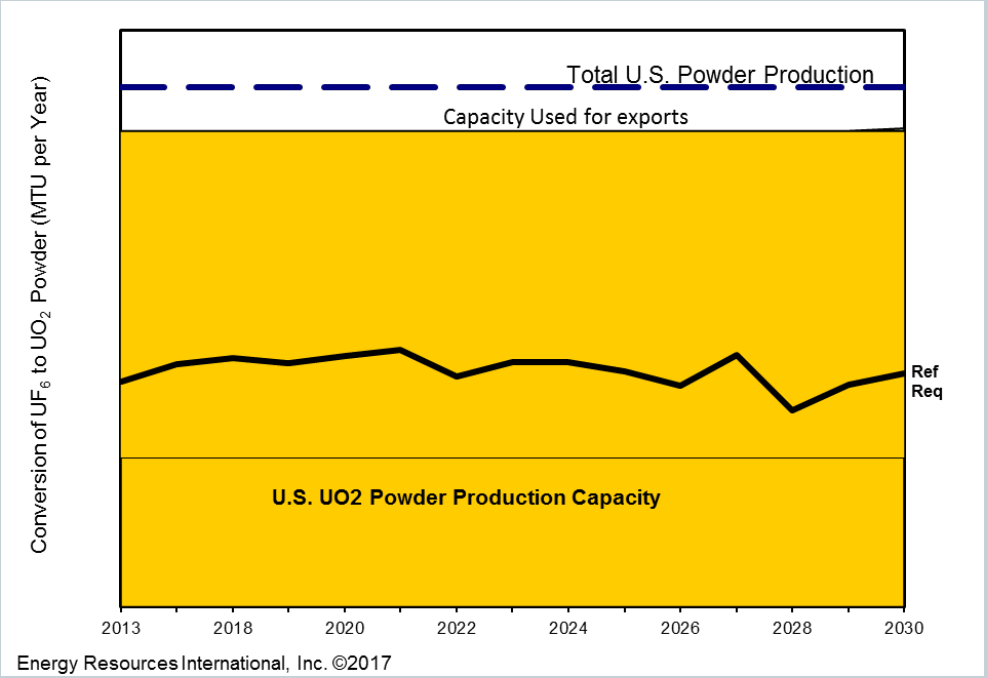
- Enrichment services spot market and term market prices are also at record lows.
- In 2016, URENCO took an impairment of URENCO USA assets of €760 million due to continued downward pressure on long-term price forecasts for uncontracted SWU.
- Continued oversupply in enrichment capacity worldwide will continue pressure on SWU price, as well as uranium and conversion.
- AREVA requested that NRC terminate the license for Eagle Rock Enrichment Facility in Idaho.



Source: TradeTech, www.uranium.info

2017: U.S. Fuel Fabrication

- Fabrication capacity is also in oversupply both in the U.S. and world-wide.
- UO_2 powder production capacity in the U.S. is more than twice that of annual fabrication requirements.
- The slow restart of Japanese reactors and closure of reactors in Europe result in lower exports of U.S.-produced UO_2 powder.
- U.S. reactor closures have also resulted in little growth in demand, even with four new plants coming on line.



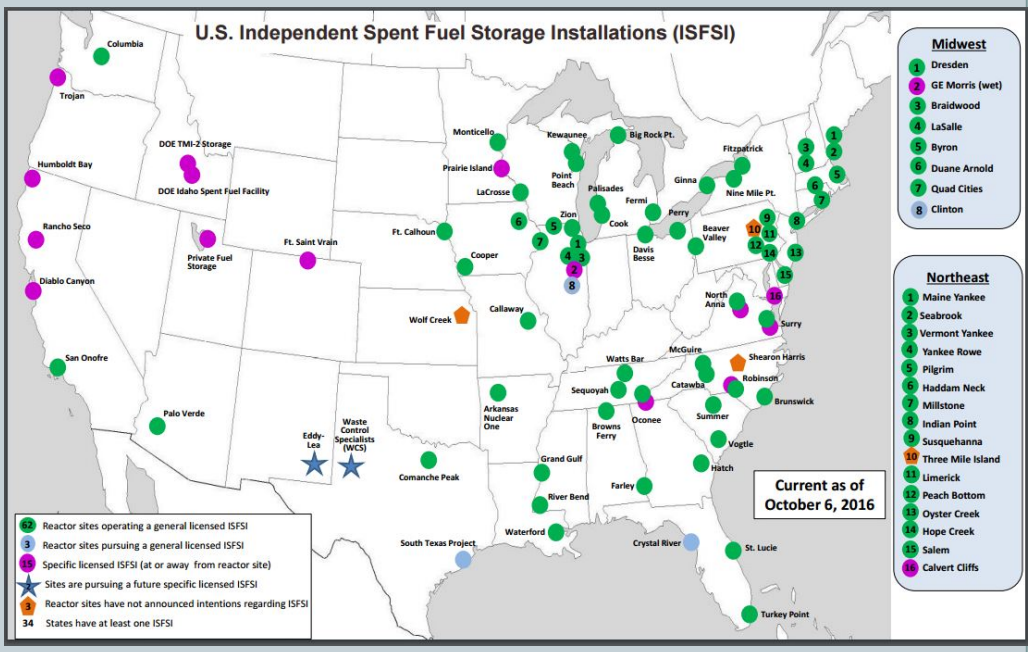
Fuel Cycle Facility Regulatory Issues

- Cyber-Security Rulemaking for Fuel Cycle Facilities
  - Cyber security is an important issue that should be addressed.
  - Industry's view is NRC should take a consistent approach across all licensees; that is, only facilities subject to a Design Basis Threat that results in a threat of radiological sabotage should be subject to this rule.
- Cost of NRC review
  - Licensees faced with increased costs for NRC regulatory reviews
  - No ability for licensees to audit costs charged by NRC reviewers – no transparency
  - Longer review times, high cost of review can lead to additional financial stress for fuel cycle facilities that are already under financial pressure
- Proposed Rulemaking and Guidance, "Amendments to Material Control and Accounting Regulations"
- Changes to 10 CFR Part 61 and impact on DUF_6 disposal
  - Current LLW disposal practices are safe. NRC's regulatory basis for this rulemaking does not challenge this premise.
  - New requirements for disposal of depleted UF_6 will place additional financial pressure on sole U.S. enricher.

2017 U.S. Spent Fuel Management

- 69 ISFSIs storing SNF under general license
- 15 ISFSIs with site-specific licenses
- 3 sites pursuing general license
- ~ 2,400 dry storage systems loaded (12/2016), storing ~ 29,000 MTU of SNF
- >78,000 MTU discharged
- No active disposal program

- Two private efforts to license Consolidated Interim Storage Facilities in Texas (WCS) and New Mexico (Holtec/ELEA).
- WCS requested that NRC suspend review of its license application, pending a potential merger with Energy Solutions.



Source: U.S. Nuclear Regulatory Commission

U.S. Uranium Industry 2025

- U.S. uranium production by 2020.
  - Without an increase in market price, U.S. production is expected to drop further in 2017 and 2018.
  - U.S. production has the ability to increase in future, depending on market conditions:
    - Existing ISRs and conventional mill
    - Expansion of existing ISRs
    - Restart of idle ISRs and conventional mills
    - Development of prospective ISRs and conventional mines
  - U.S. production expected to be < 15% of U.S. annual requirements.

- U.S. nuclear operators will continue to import an estimated 85-95% of uranium through 2025.

U.S. Conversion Industry 2025

- U.S. has one converter: Metropolis Works, Metropolis, Illinois – operated by Honeywell
- Nameplate and licensed capacity of 15 million kgU as UF_6
- Honeywell has requested that NRC renew its facility license for an additional 40 years.
- Capacity reduction to 7 million kgU per year is expected remain through 2025
- U.S. requirements for conversion services ~ 17 million kgU through 2025.
- U.S. nuclear operators will continue to import significant quantities of natural UF_6 or UF_6 feed contained in enriched uranium product from Canada, Europe, Russia and China.
- U.S. will export natural UF_6 feed to enrichers in Europe, Russia and China.
- Stability in transport package certification is a necessity for reliable fuel supply in the U.S. and with our international partners.

U.S. Enrichment Industry 2025

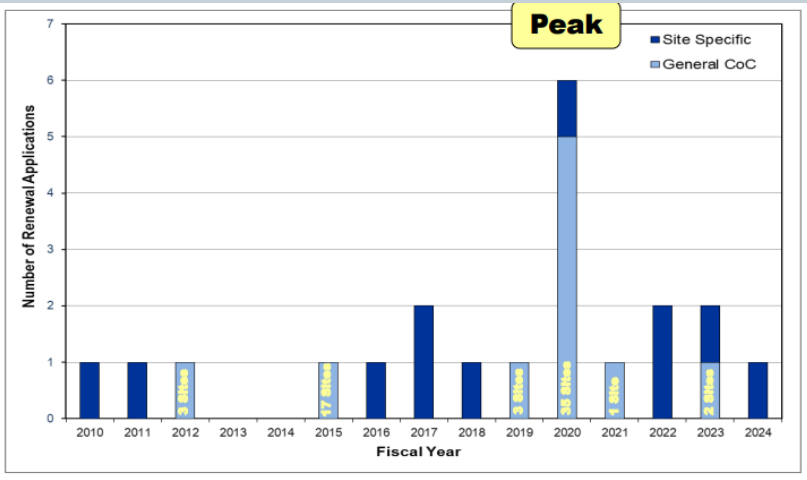
- U.S. requirements for enrichment services are ~ 15 to 16 million SWU annually, and are expected to remain at this level through 2025.
- Urenco USA, Hobbs, New Mexico – gas centrifuge enrichment facility operated by Louisiana Energy Services, LLC.
  - Current capacity is 4.8 million separative work units (SWU) annually.
  - Licensed capacity is 10 million SWU.
  - Capacity of 4.9 million SWU by year-end 2018.
- U.S. will continue to import significant quantities of enriched uranium from Europe, Russia and China.
- Export of U.S. enriched uranium to other countries will continue.
- Maintenance of existing approvals for transport packages and approval of new packages for the shipment of enriched uranium.
- Disposal of depleted UF_6 will remain as the largest future liability for Urenco USA.
- Will there be a need for enrichment levels above 5 % U235?

U.S. Fabrication Industry 2025

- U.S. requirements for fabrication services are ~2,000 kgU annually, and are expected to remain at this level through 2025.
- With return of additional Japanese reactors, by 2025, exports of UO2 powder to Japan should increase.
- Exports of UO2 powder to Europe will continue but at decreasing levels due to declines in installed capacity in Europe and slower than planned replacement capacity.
- U.S. exports of nuclear fuel assemblies will continue to Mexico, Taiwan, and China. Although Chinese fuel assembly exports are expected to decline as China begins to fabricate both initial cores and reload fuel for AP1000 plants.
- Joint venture between GNF-A and JSC TVEL to introduce the TVS-K fuel to the U.S. is moving forward with planned LTAs in 2019 in a U.S. PWR. Reload quantities of fuel could be introduced by 2025.
- Fuel needs for advanced reactors (enrichments >5% U235), innovative fuel designs (Lightbridge), etc. are on the horizon.
- Accident Tolerant Fuel implementation will require new methods, possible changes to regulations, and additional licensing actions.

Spent Fuel Management 2025

- By 2025:
  - 98,000 MTU of SNF arisings
  - ~50,000 MTU in dry storage in ~4,000 casks
  - Dry storage at almost every plant site expected ~75 ISFSIs (including INEL)
  - Additional 4 sites with recently shutdown reactors plan to transfer SNF from pool storage to dry storage by ~ 2025
- Amendments to existing Part 72 and Part 71 CoCs and review of applications for new storage technologies are expected to continue at same rate seen in recent years.
- License renewal
  - Site specific licensees
  - General licenses – peaking in 2020.



Spent Fuel Management 2025

- Centralized Storage?
  - Two companies have submitted license applications for CISFs.
  - DOE supports a pilot facility for storage of SNF from shutdown plants
  - Can the Nuclear Waste Policy Act be amended to allow the Nuclear Waste Fund to be used to pay for interim storage?
  - Transport of SNF?
- Geologic Disposal?
  - Yucca Mountain project restart?
  - Continued actions on DOE's consent-based siting process?
- Transportation of spent fuel?