NEI INTERNATIONAL URANIUM FUEL SEMINAR 2004

Legacies Shaping the Future: Uranium Production, Inventories & Prices – 1947 - 2004

Thomas L. Neff
Senior Researcher
Massachusetts Institute of Technology

NEI

LES Exhibit 61

LEGACIES SHAPING THE FUTURE:

URANIUM PRODUCTION, INVENTORIES & PRICES

1947 - 2004

Thomas L. Neff

Center for International Studies

Massachusetts Institute of Technology

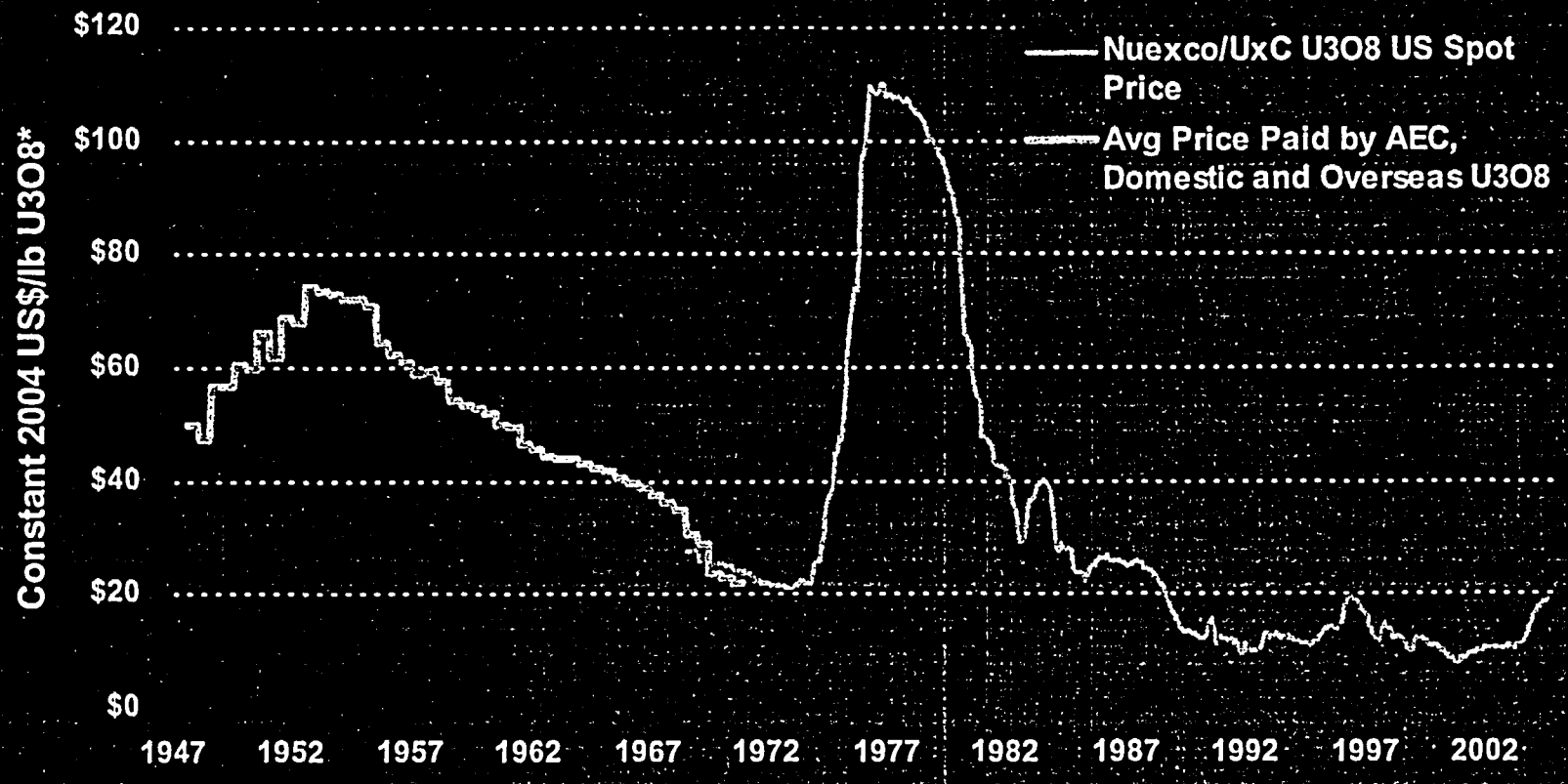
tlneff@mit.edu

WESTERN URANIUM HISTORY

- The Weapons Procurement Era (1940 – 1969)
- The Commercial Inventory Accumulation Era (1970 – 1984)
- The Inventory Liquidation Era (1985 – 2003)

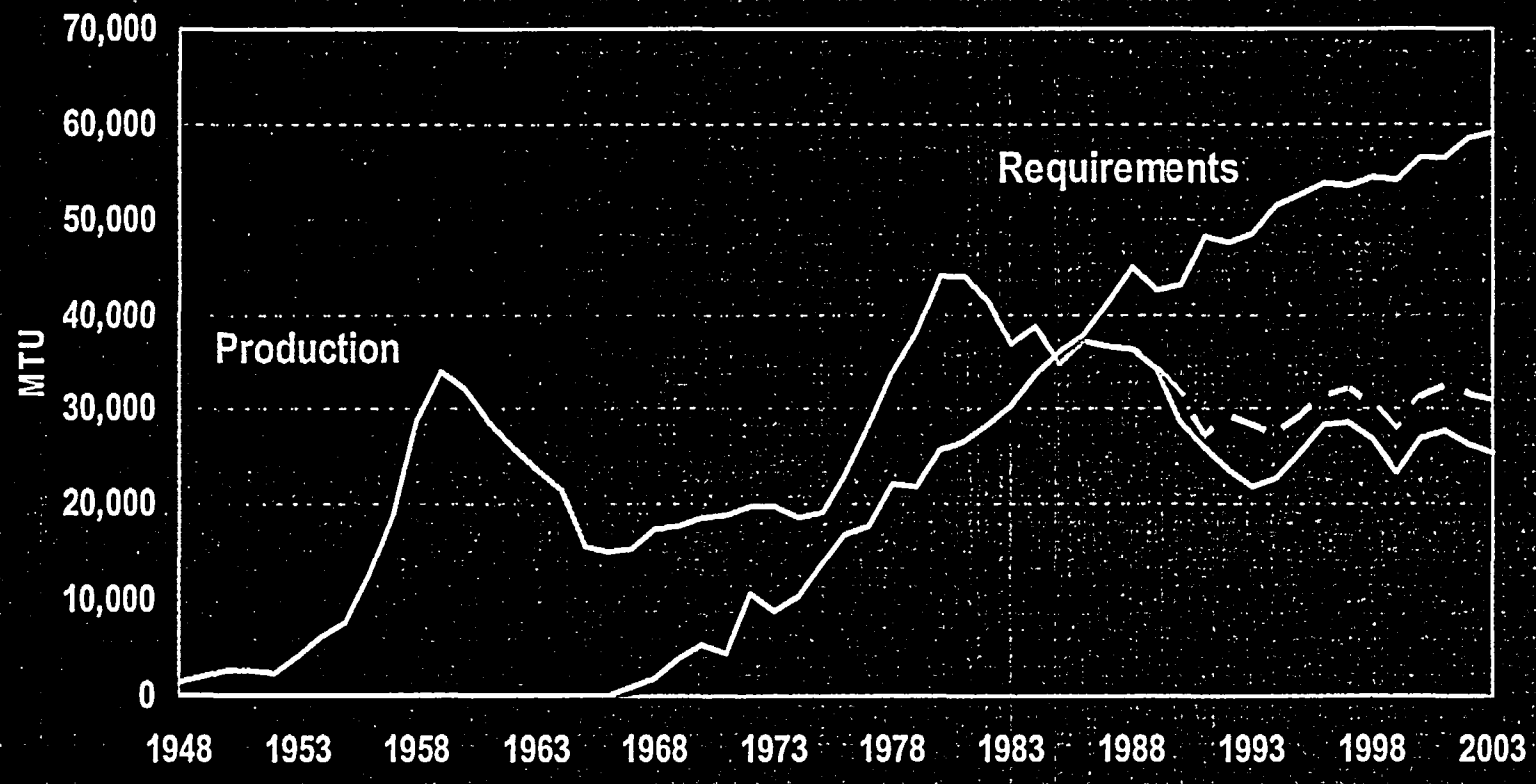
URANIUM PRICE 1947 – 2004

(Constant 2004 U.S. $)



*Adjusted by U.S. GDP IPD, 2nd Q, 2004

WESTERN URANIUM PRODUCTION & REQUIREMENTS: 1948 – 2003

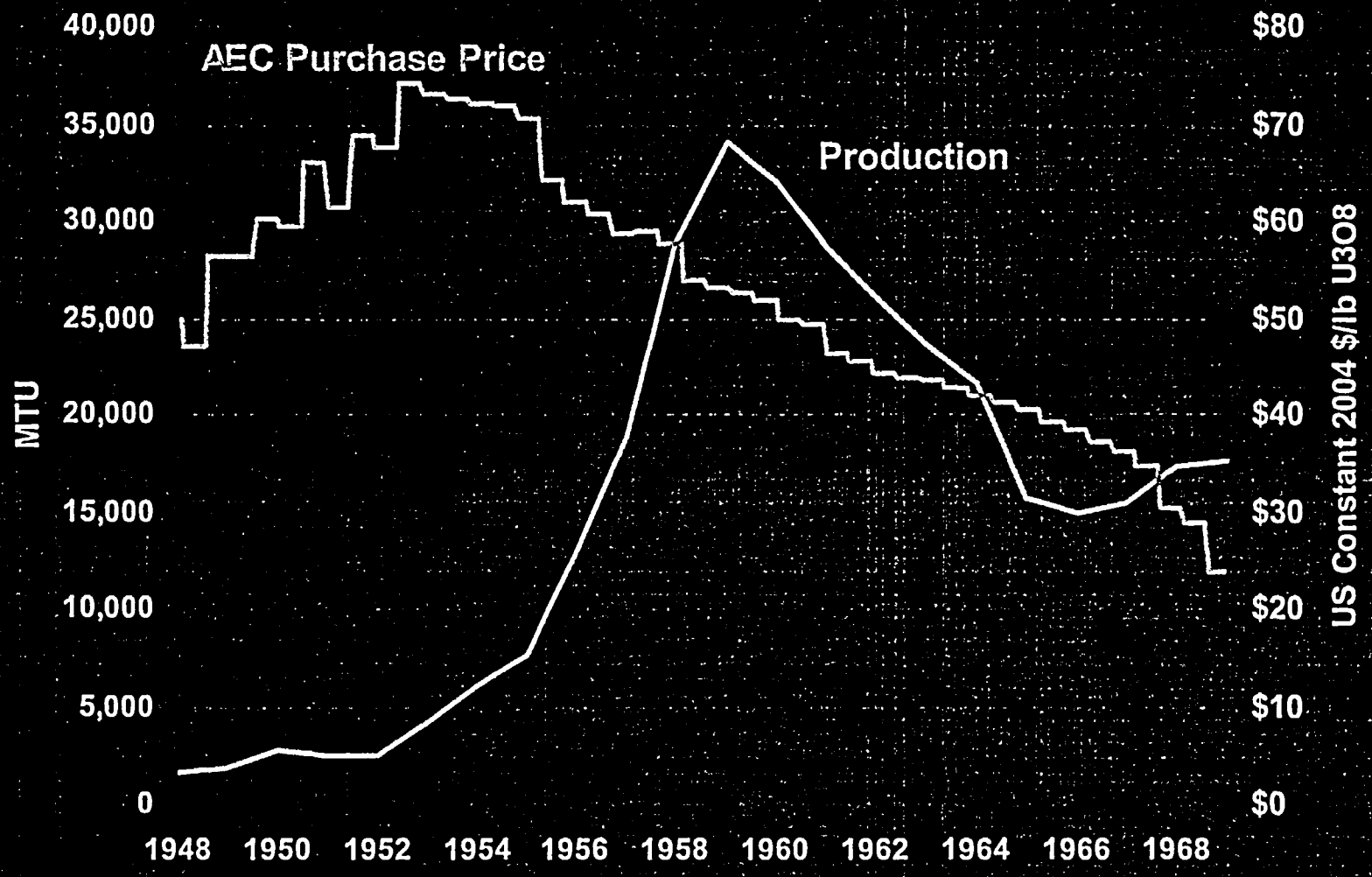


W.World Production includes Former E Germany (1985), Kazakhstan (1992), Uzbekistan (1992) and Czech Rep (1993)

WEAPONS PROCUREMENT ERA
(1940 – 1969)

- U.S. Atomic Energy Commission (CDA) – Posted Price for Uranium
  - Average Domestic U.S. Purchase Price: $42.59/lb ($111.28/kgU)
  - Average Foreign Purchase Price: $56.62/lb ($147.94/kgU)
- Production Lags Price by Ten Years
- U.S. Closes Borders to Imports
- Producing Countries Implement Stretch-Out & Stockpile Programs

PRODUCTION RESPONSE TO PRICE
1948 - 1969



PRODUCTION & DISPOSITION OF URANIUM
1947 - 1969

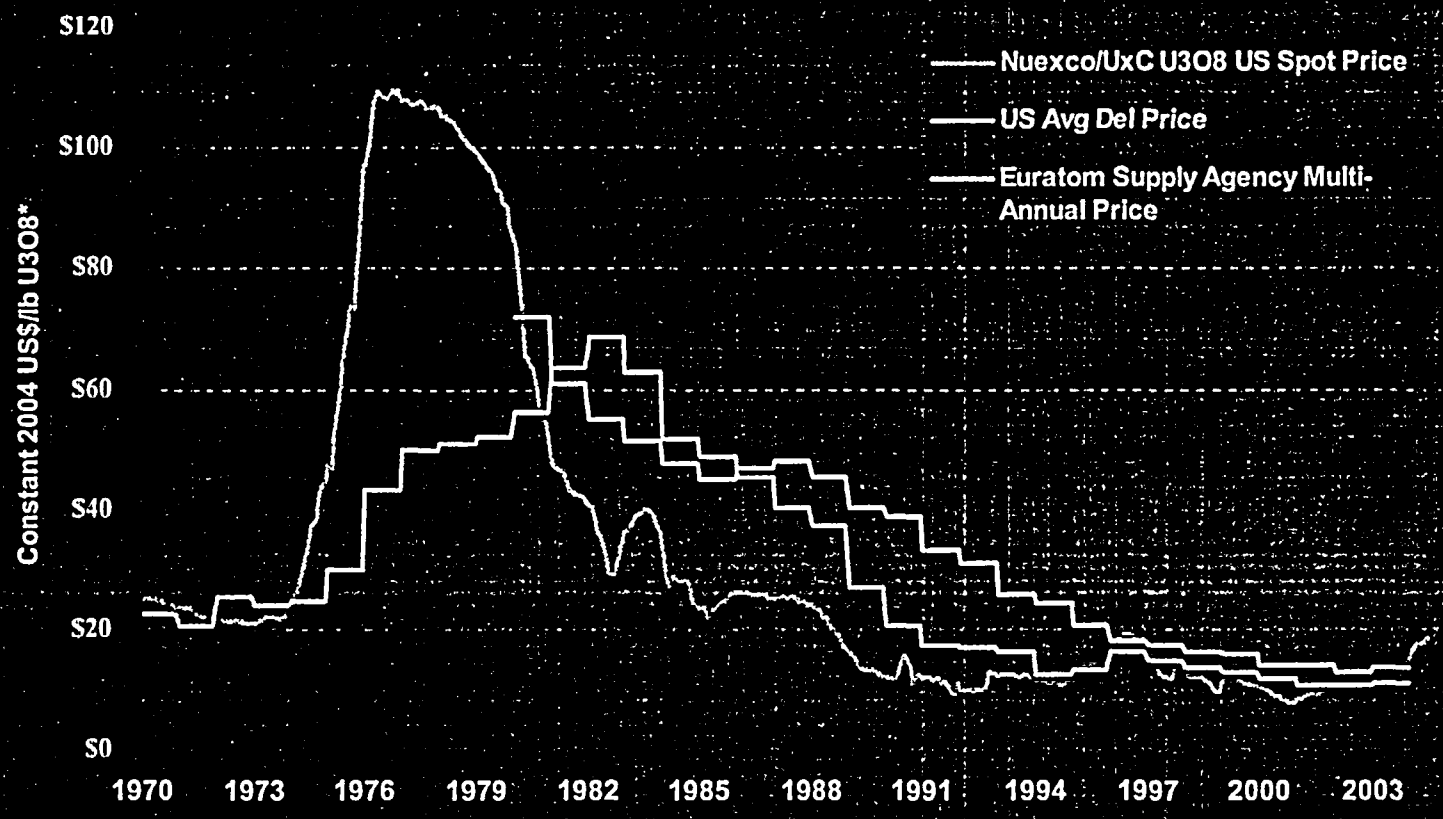
UNITED STATES	**153,600**	
AEC Purchases	146,000	(95%)
Commercial Purchases	7,600	(5%)
CANADA	**84,500**	
U.S. AEC Purchases (1956 – 1967 only)	54,200	(64%)
Canadian Gov. Stockpile (to Eldorado)	6,500	(8%)
Britain & Unaccounted*	23,800	(28%)
AUSTRALIA / S. AFRICA / BELGIAN CONGO	**80,200**	
U.S. AEC Purchases	35,500	(44%)
Britain & Unaccounted*	44,700	(56%)
FRANCE & GABON	**18,500**	
WESTERN WORLD TOTAL	**336,800**	
U.S. AEC Purchases	235,700	(70%)
Reported Commercial Purchases	14,100	(4%)
Britain, France & Unaccounted	87,000	(26%)

*The U.S. AEC may have purchased up to 4,000 MTU from Canada prior to 1956 and up to 15,000 MTU from Australia, S. Africa and Congo prior to 1956 – actual purchases have not been disclosed.

COMMERCIAL INVENTORY ACCUMULATION ERA (1970 – 1984)

- Price Reaches Low of $20.90/lb in January 1973
- Price Rises to $110/lb 45 Months Later (September 1976) – Expectations Driven
- Production Revives From Existing Centers, Not New Mines
- Production Lags Price Increase by Four Years
- Production Exceeds Requirements for Entire Period – Surplus 170,000 tU
- Long-Term & Multi-Annual Prices Moderate Price Swings

U.S. AVERAGE DELIVERED & EURATOM MULTI-ANNUAL PRICES (Constant 2004 US$)



*Adjusted by U.S. GDP IPD, 2nd Q, 2004

U.S. Avg delivered price paid to domestic suppliers through 1993, weighted avg delivered price for domestic and foreign purchases 1994-2004

INVENTORY SITUATION AT END 1984

	tU
U.S. Commercial Inventory	71,000
Other Excess Production	99,000
Pre -1970 Production Used Commercially	30,000 – 80,000
TOTAL INVENTORY	**200,000 – 250,000**

INVENTORY LIQUIDATION ERA
1985 - 2003

- Production Below Requirements Despite Central Asia Addition
- Cumulative Shortfall of 339,000 tU
- Long-Term Secular Decline in Price

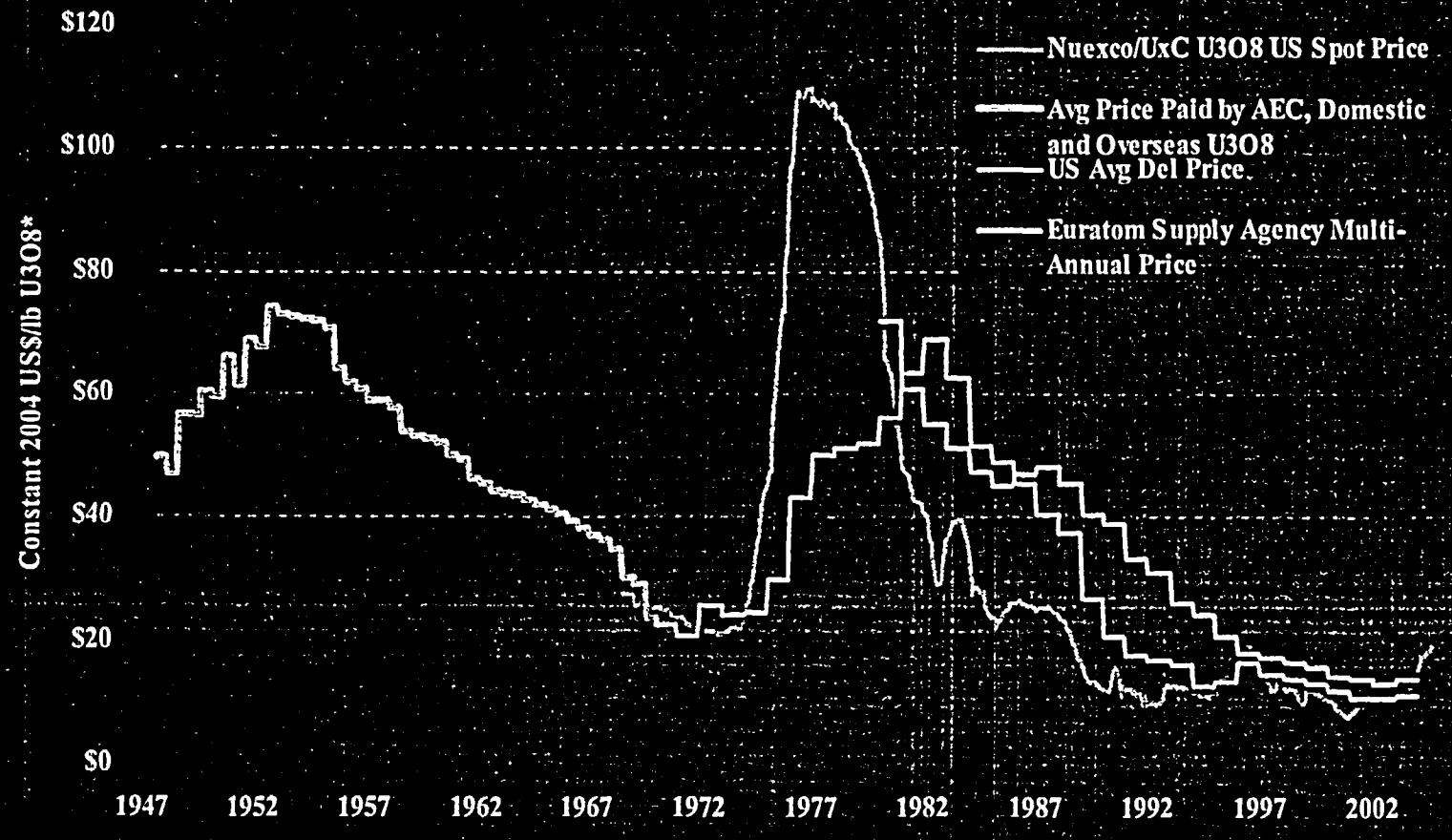
CHANGE IN COMMERCIAL INVENTORY SITUATION 1985 - 2003

	tU
Beginning Inventory 1/1/85	200,000 - 250,000
USEC Addition to Inventory	28,600
Ending Inventory	
U.S.	32,600
Europe & Asia	80,000
Net Reduction In Commercial Inventory	**116,000 - 166,000**

SUPPLY TO FILL PRODUCTION DEFICIT
1985 - 2003

	tU
Production Deficit	**339,000**
Sources of Supply:	
Inventory Drawdown	116,000 – 166,000
HEU Feed	20,000
Re-Enriched Tails	6,000
MOX	8,000
Remaining Deficit	**139,000 - 189,000**
WNA Estimated Supply From Russia	150,000

U.S. AVERAGE DELIVERED & EURATOM MULTI-ANNUAL PRICES

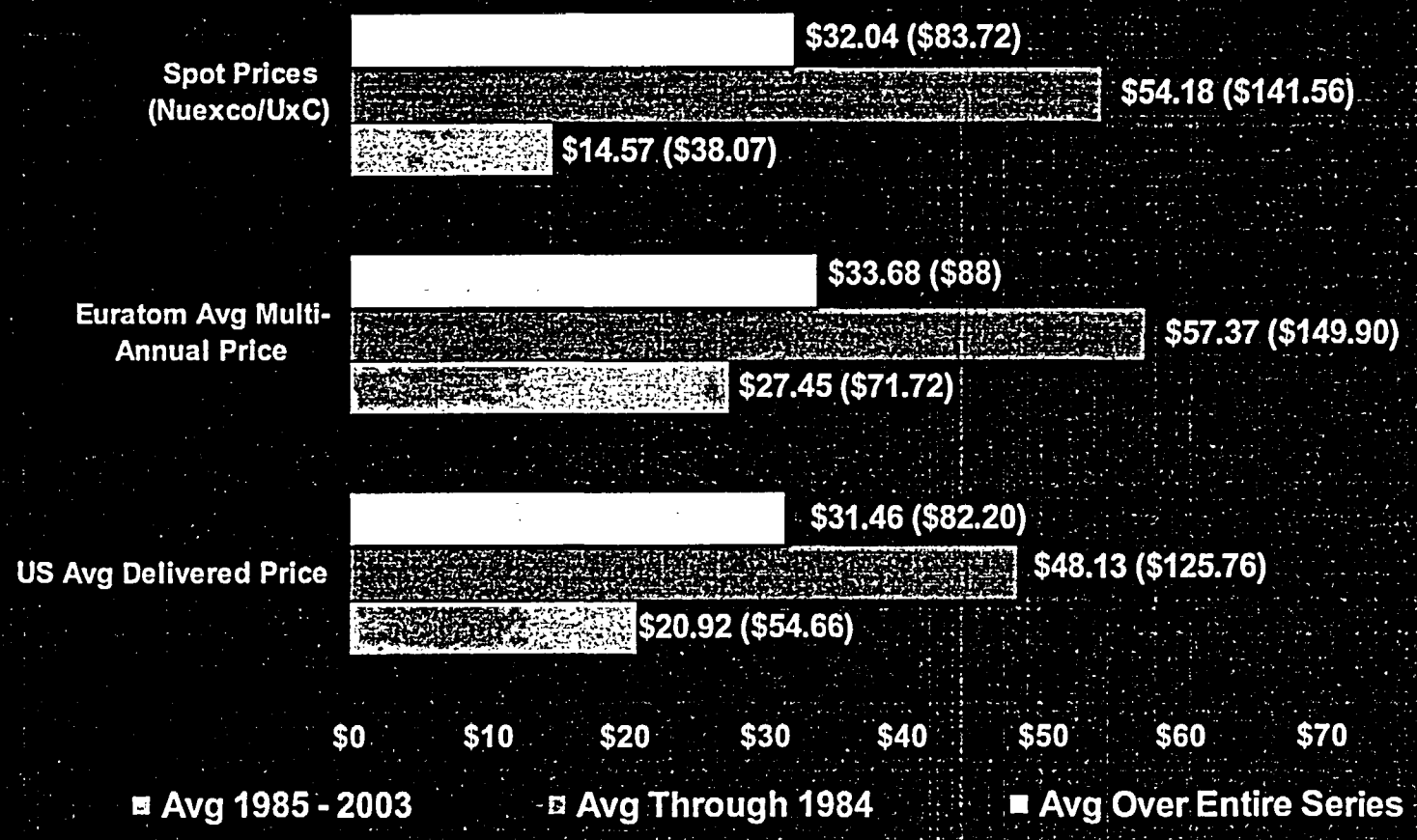


*Adjusted by U.S. GDP IPD, 2nd Q.

US Avg delivered price from Domestic suppliers through 1993, weighted avg delivered price from domestic and foreign purchases 1994-2004

HISTORICAL AVERAGE URANIUM PRICES

Simple Average in Constant 2004 U.S. $/lb (U.S. $/kgU)

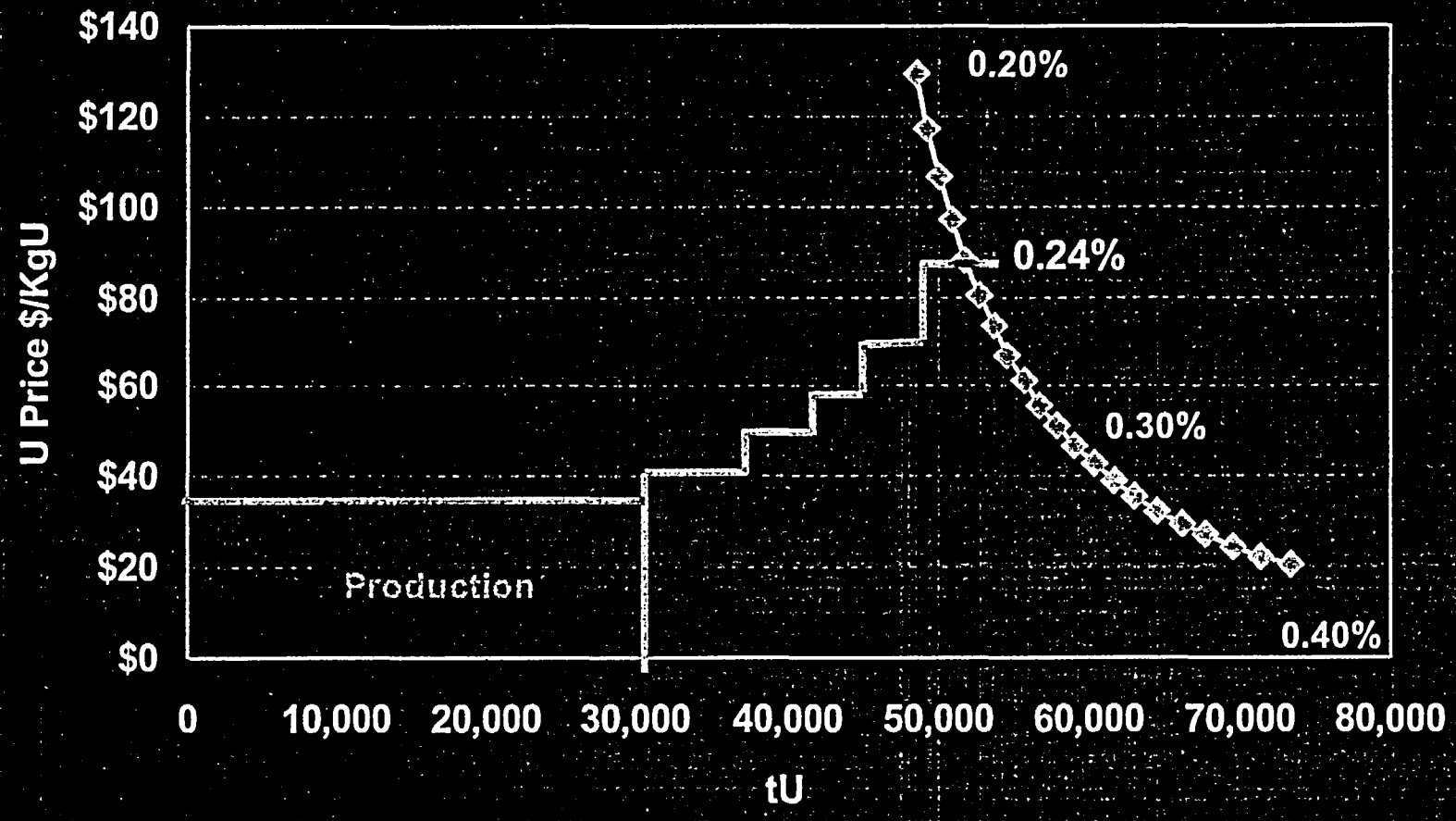


PRICE FORMATION

"Price Formation Refers To How Price Is Set In A Market"

- Weapons Era:
  - Government Sets/Adjusts Price Needed to Bring Forth Desired Supply
- Inventory Accumulation Era:
  - Reactor Orders, U.S. Enrichment Contract Requirements, Westinghouse Default, Expectations of Future Shortfall—Expectations Drive Price Up
- Inventory Liquidation Era:
  - Expectations of Future Surplus Supply Based on Commercial and Russian Inventory Liquidation

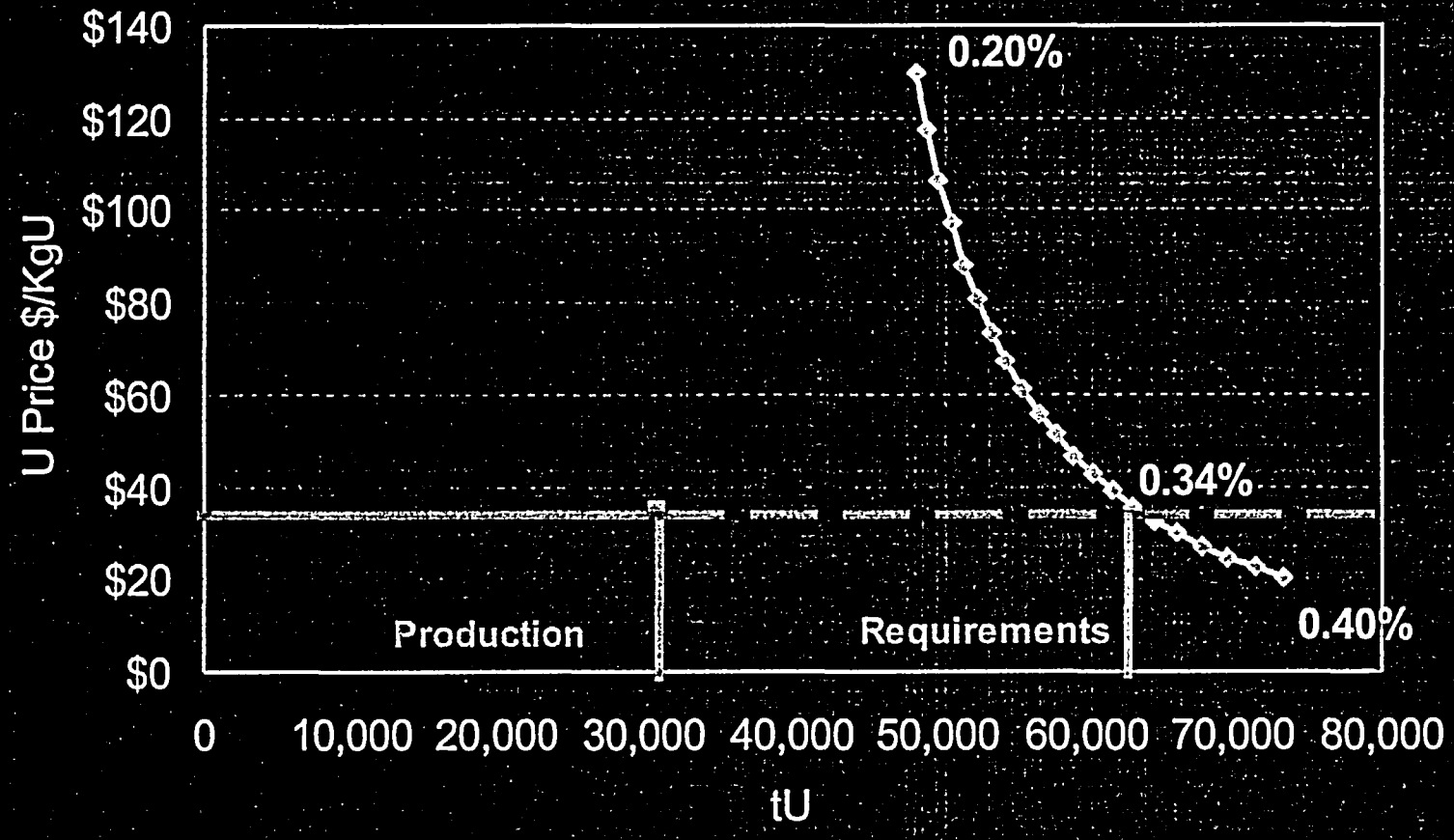
PRODUCTION-BASED PRICE FORMATION
(Based On LT Avg. $32/lb U & $100 SWU)



PRODUCTION BASED MARKET

- Market Price Set By Highest Cost Production Needed to Meet Requirements
- Producer Surplus Invested in Exploration/New Mine Development
- Higher Uranium Market Price Means Lower Tails Assay, Reduced Uranium Requirements
- Lower Economic Tails Assay Stimulates Expansion of Enrichment Capacity

INVENTORY-DRIVEN PRICE FORMATION



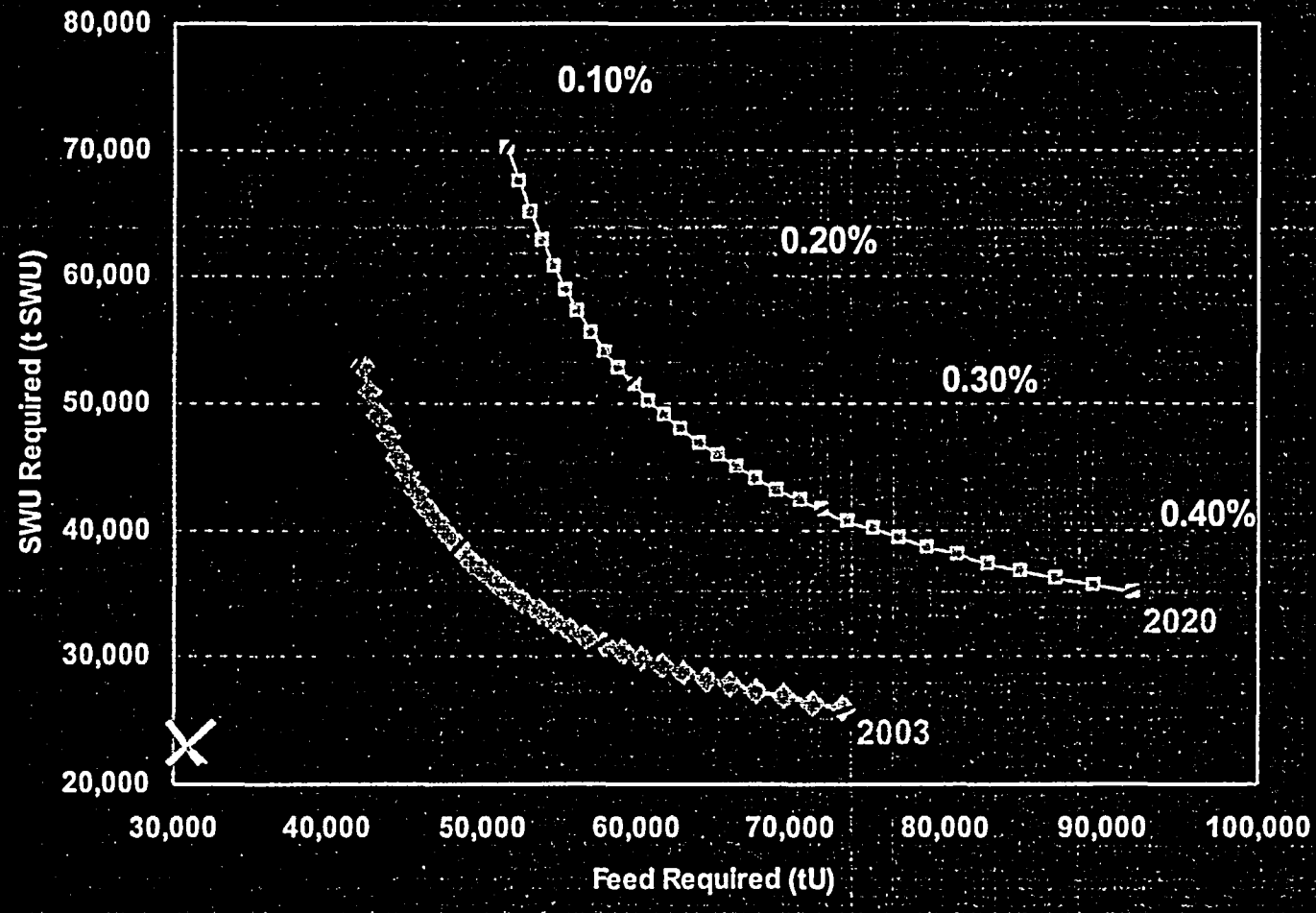
INVENTORY LIQUIDATION MARKET

- Inventory Sellers Sold Below Long-Run Replacement Cost & Discounted Present Value Of Higher Future Price
- Low Prices:
  - Drove All But Lowest-Cost Production Centers Out of Business
  - Discouraged Exploration/Too Few New Mines In Pipeline
  - Reduced Mine/Mill Investment (& Maintenance)
  - Undermined Investment In Enrichment (High Tails)
- Little Chance of Rebound in Production as in 1970s

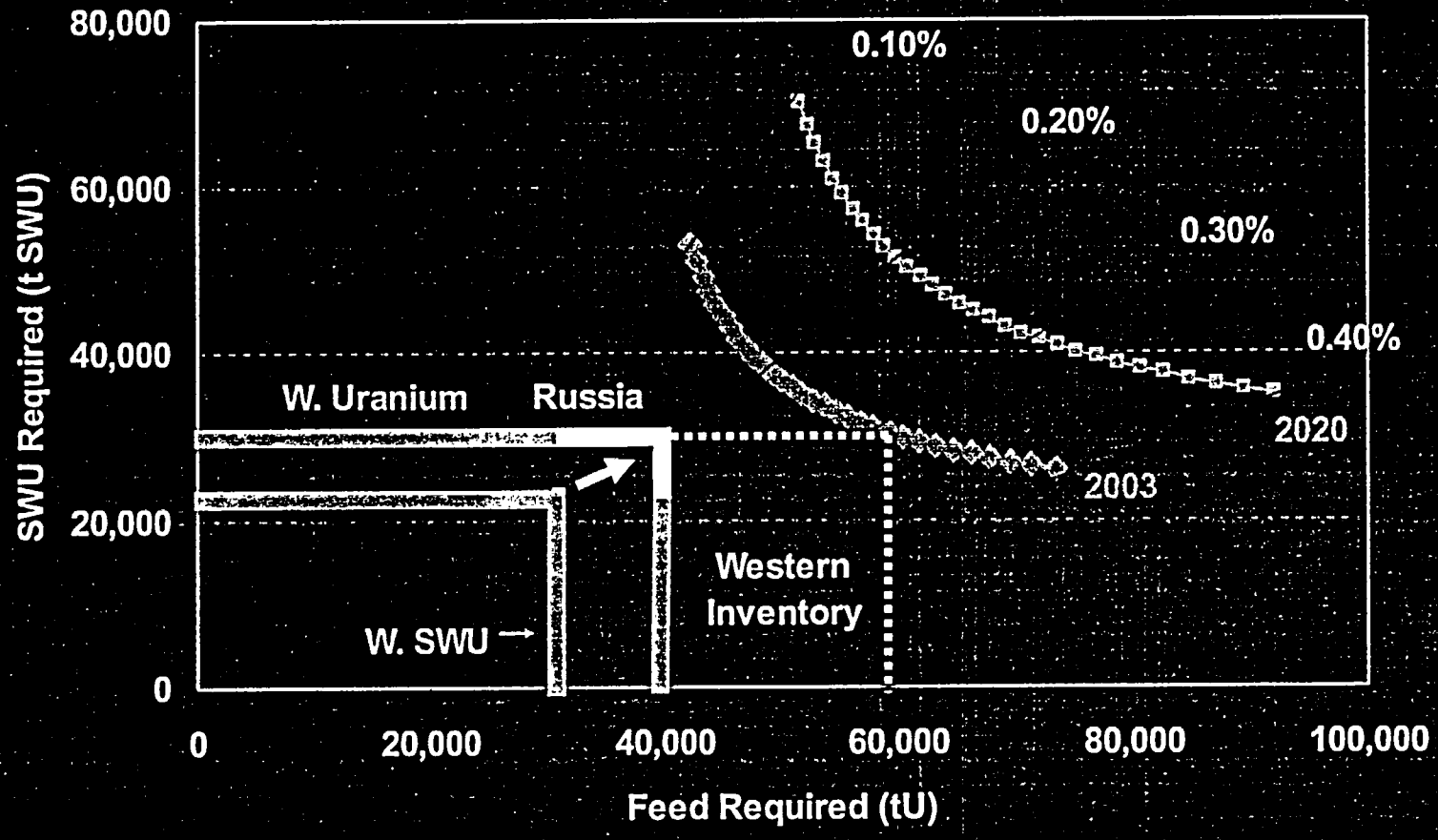
FILLING THE GAP WITHOUT INVENTORY SUPPLY

- Commercial Uranium Inventory Liquidation Appears to Be Ending
- SWU & Uranium Are Substitutes
- Need Combination of Additional SWU & Uranium to Meet Requirements:
  - Increase Enrichment Capacity & Reduce Tails Assay
  - Expand Uranium Production
  - Draw On Government Inventories

SWU/U COMBINATIONS TO MEET WNA REQUIREMENTS—2003-2020



SWU & URANIUM SATISFYING WNA REQUIREMENTS 2003 & 2020



CLOSING THE GAP

- Russian Supply (7.5 MM SWU, 9,000 tU) Does About Half the Job—Until 2013
- To Reach Closest Point On Requirements Curve Need Additional 8 MM SWU + 8,000 tU
- Alternatively, More SWU (Less U) or More U (Less SWU)
- Requirements Horizon Moving Out Over Time
- Where Will Required U/SWU Supply Come From?

RUSSIA

- Already Large Contribution To Western Supply
- SWU Capacity Fully Utilized (HEU Blendstock, RET, Reprocessed Uranium, Domestic & Export Requirements)
- China & Russia Short Of Uranium—Compete for Western Supplies
- End Of HEU Deal Approaching—Mines & Enrichment Plants To Replace HEU Need to Start Now

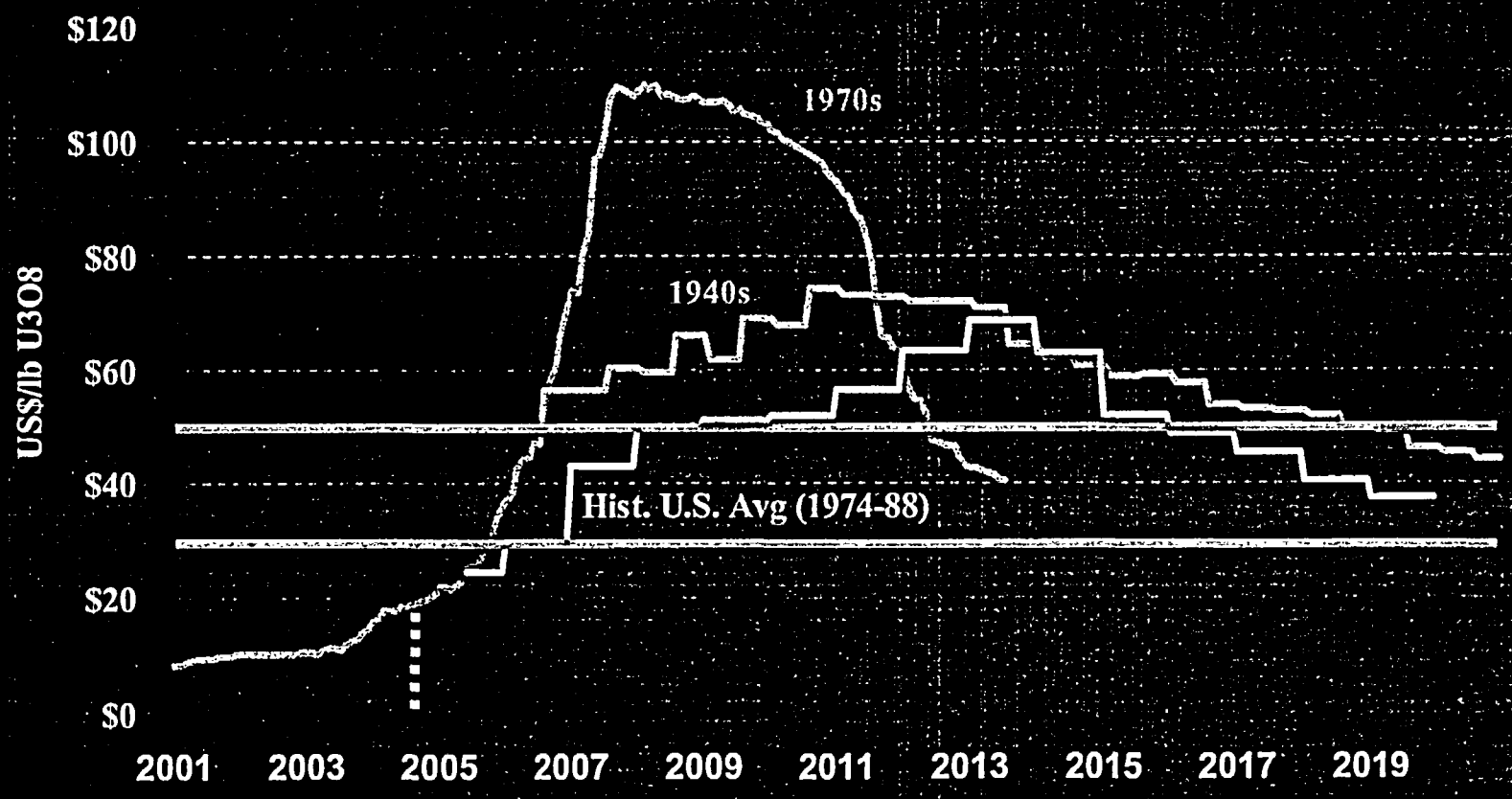
U.S. GOVERNMENT INVENTORIES

- Natural Uranium Stocks Are Small and Contaminated or Locked Up
- Cleanup Possible But Slow (2,000 t/yr)
- U.S. HEU Cleanup & Blending Capacity Limited (No U.S. Fluorination Capacity)
- DOE Tails Mostly Below 0.30%--Not Enough Enrichment Capacity To Process Them
- But Government Inventory Uncertainties Threaten New Mines

ALTERNATIVE FUTURES

- Smooth Price Path Difficult w/o Inventory Bridge
  - Not Enough Uranium or SWU Projects In Pipeline
  - Long Lead-Times for SWU & U Projects
- Higher Prices Needed to Induce Needed Investment
- Historical Averages Between $30-$50/lb.
- Possibility of Transient High Prices, As In 1970s

HISTORICAL PRICE CHANGES: A MODEL FOR THE FUTURE?



LONG-RUN PICTURE IS GOOD-- HARD PART IS GETTING THERE

- Uranium Is Not Scarce, But Time Is Required to Bring On Large Amounts of New Production
- Enrichment Can Be Expanded Greatly, With Enough Time
- But Time Appears to Be Running Out
- May Have Squandered Opportunity Provided By Inventory Liquidation Era