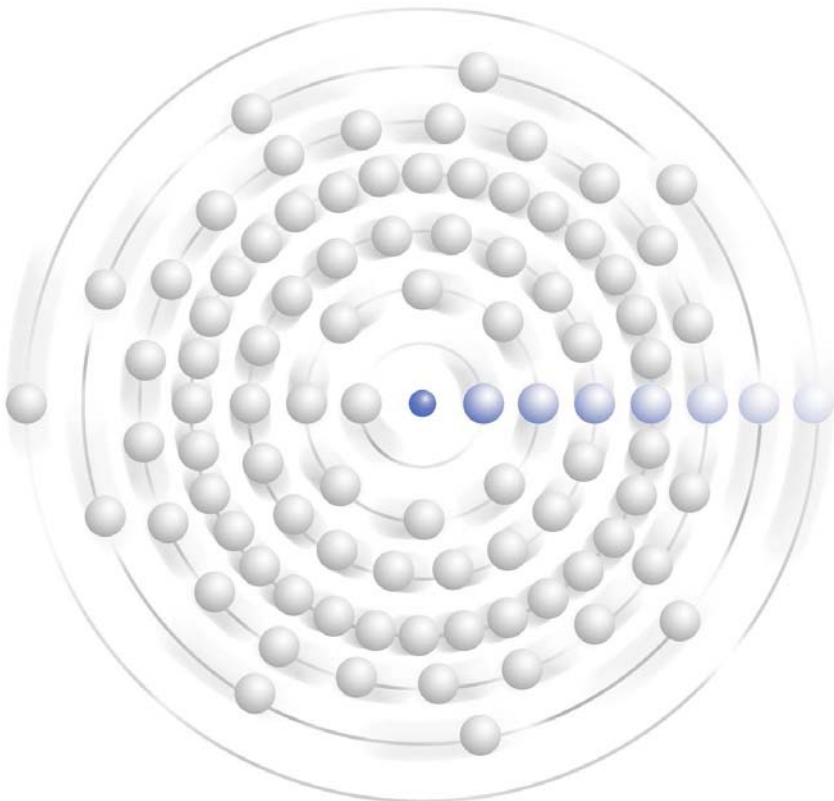




---

# Impact of Kazakh Production on the Uranium Market: Past and Prospective

---



**Ux Consulting**  
1501 Macy Drive  
Roswell, GA 30076  
(770) 642-7745  
[www.uxc.com](http://www.uxc.com)

**– NOTICE –**

The Ux Consulting Company, LLC (“UxC”) shall have title to, ownership of, and all proprietary rights in this Report. Under United States federal copyright law (17 USC 101 et seq.) it is illegal to reproduce this Report by any means without written permission from UxC.

The information contained in this Report is obtained from sources that UxC believes to be reliable. UxC makes no warranty or representation, express or implied, with respect to the accuracy, completeness or usefulness of the information contained in this Report and UxC, to the maximum extent permitted by law, assumes no liability for the use or effects of any of the information or data contained in this Report.

It is UxC’s strict policy not to endorse, promote, or recommend any particular securities, currencies, or other financial products or instruments. Nothing contained in this Report is intended to constitute investment, legal, tax, accounting or other professional advice and the reader should not rely on the information provided in this Report for making financial decisions.

The Ux U<sub>3</sub>O<sub>8</sub> Price<sup>®</sup> and other Ux Price indicators are developed by The Ux Consulting Company, LLC (UxC) and are proprietary and exclusive intellectual property of UxC. These price indicators are provided to UxC’s customers through the Ux Weekly<sup>®</sup> publication and are made available on UxC’s public website solely at UxC’s discretion. They may not be reproduced or otherwise used without UxC’s express permission.

UxC<sup>®</sup>, Ux Weekly<sup>®</sup>, Ux U<sub>3</sub>O<sub>8</sub> Price<sup>®</sup>, Ux<sup>®</sup>, and Ux Consulting<sup>®</sup> are trademarks of The Ux Consulting Company, LLC.

# Table of Contents

<b>1 – Introduction &amp; Overview</b>	<b>6</b>
Structure of Report.....	7
• Part 1 .....	7
• Part 2 .....	7
• Part 3 .....	8
<b>2 – Historical Perspective</b>	<b>9</b>
<b>3 – Assessing the Impact on Price</b>	<b>12</b>
The Nature of the Impact .....	12
• Rate of Expansion.....	12
• Cost.....	13
• Longevity.....	14
<b>4 – Measuring the Price Impact</b>	<b>16</b>
Survey Approach.....	17
• Observations and Limitations of Approach .....	17
Production Cost Approach .....	18
• Observations and Limitations of Approach .....	20
Econometric Approach.....	23
• Observations and Limitations of Approach .....	25
Comparative Approach .....	26
• Observations and Limitations of Approach .....	27
Summary of Impacts .....	28
<b>5 – Future Outlook and U.S. Case Study</b>	<b>30</b>
The Case of the United States .....	31
<b>6 – Resource and Project Analysis</b>	<b>33</b>
Resource Size and Classification.....	33
• Reserve Classification Methodology in Kazakhstan .....	34
Geographic Distribution of Resources .....	36
Type and Distribution of Production.....	39
• Size Distribution .....	39
• Mining Method .....	39
• Cost of Production .....	39
Summary.....	40
<b>7 – Kazatomprom’s Strategic Market Approach</b>	<b>41</b>
Overview .....	41
• Key Strategic Initiatives.....	41
• Stages of Development.....	42
Joint Venture Approach to Expanding Production .....	43
• Producer Involvement .....	44
• ARMZ Control of Uranium One.....	47
• Consumer Involvement.....	48
Pursuing Vertical Integration .....	50
• Conversion.....	50
• Enrichment.....	51
• Fabrication .....	51
• Analysis.....	52
Marketing Approach.....	53
• Establishing Market Presence .....	53
• Asian Success .....	53
• Russian Connections .....	54
Rosatom and Kazatomprom Sign Cooperation Agreements .....	55
Joint Marketing Company .....	55
Enrichment .....	55
Russian Partner: ARMZ or TENEX?.....	55
Analysis .....	56

• Diversification in Marketing .....	57
• Experience in Europe .....	58
• Targeting the U.S. Market .....	58
Production Decisions .....	61
• The Important Role of China .....	62
• Control Over Production .....	63
• Following the URENCO Model? .....	64
Recent Developments .....	66
Summary .....	67
<b>8 – Factors Impacting Production Growth</b> .....	<b>68</b>
Transportation .....	68
Geopolitical Risk .....	69
• Case Study: Kyrgyzstan .....	70
Political Risk .....	71
Legal/ Regulatory Risk .....	71
• Tax Code .....	72
• Transfer Pricing Law .....	72
• Investment and Mining Regulation .....	73
Labor .....	74
Financing .....	74
Technology/Operational Risk .....	75
• Lack of drilling and pumping equipment .....	75
• Sulfuric Acid Production .....	75
Infrastructure .....	76
International Perception .....	76
Economic Risks .....	77
Exchange Rate Risk .....	77
<b>9 – Analysis of Market Impacts</b> .....	<b>79</b>
Current and Prospective Supply/Demand Balances .....	79
• Observations .....	81
• Limiting Production to 20,000 MTU .....	82
Price Impacts .....	84
Summary and Additional Observations .....	90
<b>10 – Long-Term Sustainability</b> .....	<b>92</b>
• Sustainability of Production Expansion .....	94
• Impact on the Market over the Longer Term .....	95
• Comparison of Future Outlook with Other Countries .....	96
Other Factors Impacting Kazakh Production Sustainability .....	97
• Consumer Involvement .....	97
• Supplier Involvement .....	97
• Political Stability .....	97
The Case of Niger .....	98
<b>Appendix A – Essay: The Kazakh Phenomenon</b> .....	<b>99</b>
Introduction .....	99
History of Kazakhstan’s Uranium Production .....	100
• Production during the Soviet Era (Up to 1990) .....	100
• Production during Post-Soviet Era, Pre-Market Recovery (1990-2000) .....	100
• Recent Production (2000-2007) .....	102
Joint Venture Approach to Expanding Production .....	103
• China .....	104
• Canada .....	105
• Japan .....	105
• Russia .....	106
• United States .....	107
• France .....	107
Kazatomprom’s Current Developments and Expansion Plans .....	108
• Production Targets for 2010 and Beyond .....	108

• Factoring in the Market Dimensions .....	109
Potential Shortcomings in Meeting Production Goals .....	110
• Infrastructure-Related Issues.....	110
Supply of Sulfuric Acid.....	110
Labor .....	110
Electricity Supply .....	111
• Transportation.....	111
• Government and Policy Related Shortcomings .....	112
Taxes and Export Duties .....	112
Nationalization Risk .....	112
Security Challenges.....	113
Financial Constraints .....	113
• Can Kazakhstan Realize Its Production Goals? .....	114
Kazakhstan's Output Decisions and Price Formation .....	115
• A Simplified Market Analysis.....	115
• Kazakh Behavior and Dominant Firm Theory .....	115
Diversification Plans Beyond Uranium Production .....	119
• Conversion .....	119
• Enrichment.....	119
• Fabrication .....	120
• Nuclear Power Development .....	121
Conclusion .....	122
<b>Appendix B: Excerpt from Production Plans vs. Realities .....</b>	<b>123</b>
Projecting Production Expansion Using Regression Analysis .....	123
• Regression Analysis .....	123
• Approach.....	123
• Results .....	124
Eastern Production .....	124
Western Production .....	125
Total Production .....	127
• Limitations of the Regression Approach .....	128
General.....	128
Insufficient Time Series on Eastern Production .....	128
Impact of Mega-Projects.....	128
<b>Appendix C: Excerpt from Q1 2010 UMO Essay .....</b>	<b>131</b>
Uranium "Great Game" .....	131
• Russia .....	131
• China.....	133
• The Great Clash.....	134
• Japan .....	136
• India .....	136

## List of Figures

Figure 1. Changes in Production Rate by Country, 2009 vs. 2000 .....	9
Figure 2. Kazakh Production Gains versus Other Supply Developments.....	10
Figure 3. Kazakhstan Uranium Production Plans, 2006-2050 .....	10
Figure 4. Likelihood of Kazakhstan Producing 39 Million Pounds by 2010 .....	11
Figure 5. Kazakh Production Expansion vs. Price .....	12
Figure 6. Kazakh Costs Relative to the Rest of the World .....	13
Figure 7. Reasonably Assured Uranium Resources by Country as of Jan. 2007 .....	14
Figure 8. Alternative Expansion Paths for Kazakh Production vs. Actual.....	16
Figure 9. Price Impact of Kazakh Production Expanding by Just 15 Million lbs. ....	17
Figure 10. Base Case Production vs. Demand Scenarios .....	18
Figure 11. World Production with Kazakhstan Production at 20 Million Pounds .....	19
Figure 12. UxC Base Production Case as of 2005.....	20
Figure 13. Uranium Price Spike.....	21
Figure 14. 2005 Production Plans with Cigar Lake Delayed.....	22
Figure 15. World Production vs. Price.....	24
Figure 16. Spot Price Trend and the Cigar Lake Flood.....	26
Figure 17. Progression of Price vs. Kazakh Production Expansion Post 2007.....	27
Figure 18. Historical U.S. Uranium Production vs. Spot Price (Constant \$2009) .....	31
Figure 19. Ranking of Kazakhstan in World Uranium Resources .....	33
Figure 20. Location of Kazakh Uranium Projects .....	36
Figure 21. Base Case Projection of Kazakh Production by Cost.....	40
Figure 22. Map of Central Asia.....	54
Figure 23. Uranium Purchased by Owners and Operators of U.S. Civilian Nuclear Power Reactors by Selected Country Origin and Delivery Year, 2004-2008 .....	59
Figure 24. Uncovered Utility Uranium Requirements, 2010-2020.....	60
Figure 25. Potential Revisions in Expansion Plans for Kazakh Production .....	61
Figure 26. China Demand Growth vs. Kazakh Production Growth .....	63
Figure 27. Utility Rating of Kazakh Supply Risk, Summer 2009 .....	77
Figure 28. Tenge/Dollar Exchange Rate, 2005-2009.....	78
Figure 29. Low Production Case vs. Demand.....	79
Figure 30. Base Production Case vs. Demand .....	80
Figure 31. High Production Case vs. Demand.....	80
Figure 32. Base Production Case with Kazakhstan Limited to 20 Million Pounds.....	81
Figure 33. High Production Case with Kazakhstan Limited to 20 Million Pounds.....	82
Figure 34. Low Production Case with Max Kazakh Production at 20,000 MTU .....	83
Figure 35. Base Production Case with Max Kazakh Production at 20,000 MTU.....	83
Figure 36. Base Production Case by Cost .....	85
Figure 37. Modified Base Production Case by Cost .....	85
Figure 38. Price Projections for UxC Base Production Case .....	86
Figure 39. Price Projections with Kazakh Production Limited to 20,000 MTU.....	86
Figure 40. Price for Base vs. Modified Production – Low Demand.....	87
Figure 41. Price for Base vs. Modified Production – Mid Demand.....	88
Figure 42. Price for Base vs. Modified Production – High Demand.....	88
Figure 43. Kazakhstan Uranium Production Plans, 2006-2050 .....	92
Figure 44. UxC Extended Base Projection of Kazakh Production .....	93
Figure 45. Can Kazakhstan Sustain Its Production Growth? .....	94
Figure 46. Base Production to 2030 by Country .....	95
Figure A-1. Kazakhstan Uranium Production Plans, 2006-2050.....	108
Figure A-2. Likelihood Kazakhstan produces 39 million pounds by 2010?.....	114

Figure A-3. World Production Since 1998 With and Without Kazakhstan.....	116
Figure A-4. Mid-Case Supply vs. Demand with Kazakhstan at 17M Pounds .....	117
Figure A-5. Mid-Case Supply vs. Demand with Kazakhstan at Maximum Increase .....	117
Figure A-6. Kazatomprom's assessment of world conversion supply and demand.....	120
Figure B-1. Comparison of Regression Results with UxC Mid-Case Projection for Eastern Production.....	125
Figure B-2. Comparison of Regression Results with UxC Low and Mid-Case Projections for Western Production.....	126
Figure B-3. Comparison of Projected World Production vs. Requirements .....	127
Figure B-4. Historical and Projected World Production, 1947-2020.....	127
Figure B-5. Comparison of Augmented Regression Results with UxC Mid-Case Projections for Western Production.....	129
Figure B-6. Comparison of Supplemented World Production vs. Requirements .....	130
Figure C-1. Location of Dornod Uranium in Mongolia .....	134

## List of Tables

Table 1. Annual Production for Major Uranium Producing Countries, 2005-2009 .....	23
Table 2. Uranium Reserve Classification in Kazakhstan.....	34
Table 3. Comparison of Key Uranium Reserve Classification Systems with Kazakhstan .....	35
Table 4. Kazatomprom Mill/Production Center Summary .....	37
Table 5. Kazatomprom Mine/Project Summary.....	37
Table 6. Kazakhstan Uranium Projects .....	43
Table A-1. Historical Uranium Production in Kazakhstan, 1991-2007 .....	102
Table A-2. Kazatomprom Mine/Project Summary .....	103
Table C-1. ARMZ Foreign Mine/Project Summary .....	132
Table C-2. China's Foreign Mine/Project Summary .....	134

## 1 – Introduction & Overview

One of the most significant developments in the history of uranium production has been the dramatic increase in Kazakh production over the past decade. At the beginning of the decade, annual production was less than 5 million pounds  $U_3O_8$ , increasing to over 36 million pounds  $U_3O_8$  by 2009. Importantly, the increase in Kazakh production accounted for 81% of the overall net increase in world uranium production over this period. This increase came at a time when uranium supplies were under considerable pressure, as evidenced by the dramatic increase in uranium prices that occurred during the last decade. It also came at a crucial juncture when the nuclear renaissance was just getting underway, and when questions of future uranium supply availability overhung the market.

To put the increase of Kazakh production into perspective, it is greater than the 24 million pounds  $U_3O_8$  associated with the HEU deal. In fact, given the 14 million pound expansion and the 10 million pound expansion expected this year, in just two years the growth in the rate of Kazakh production will have equaled the uranium contained in the HEU deal. Further, by the end of this year, the rate of Kazakh production will be close to double the annual uranium supply from HEU.

The Kazakh “phenomenon” does not stop with the past and currently planned expansion for this year. In fact, Kazatomprom, the national uranium producer of Kazakhstan, indicates that plans are for Kazakhstan to contribute fully one-third of world uranium production/supply in the future. If Kazakh production expands as indicated this year, Kazakhstan will account for almost 32% of world production, so this claim is not that farfetched. In order to maintain this goal, Kazakhstan will have to continue to expand production, but not to the extent that it has achieved over the past decade. Kazakhstan clearly has the necessary resource base to support future growth. Kazatomprom notes that the country has sufficient resources to sustain its 2009 production level for 149 years.

Indeed, a number of countries are counting on Kazakh production to fuel their growing nuclear power programs. These countries include those with the world’s fastest-growing nuclear power programs: China, India, Korea, Russia, and Japan. These countries have interests or are considering taking interest in various Kazakh uranium projects. Major producers, such as AREVA, Cameco, ARMZ, and Uranium One are counting on getting a large share of their future supplies from joint ventures in Kazakhstan.

More recently, the Kazakh government has begun to rethink their expansion plans, as uranium prices have been under downward pressure, although planned expansion of nuclear power is still largely intact. Some of the newer Kazakh projects are deeper and thus uranium recovery will be more costly, requiring higher prices and long-term contracts to support development.



This discussion brings up a number of questions, including:

- What was the past impact of Kazakh production on the uranium market and price? To put it another way, how much higher would price be today or in the intervening years had Kazakh production not expanded as much as it did?
- How does Kazakh production impact the market today and what is its likely impact in the future?
- What are the various factors that will determine the level of Kazakh production, both internal and external to the country?
- What strategies have been employed by Kazatomprom and the government of Kazakhstan to expand production and how might they impact future production growth?
- Can Kazakhstan sustain the higher rate of production it hopes to achieve?

This study proposes to examine these questions from a number of perspectives in order to provide the reader with a thorough understanding of Kazakhstan's past and prospective impact on the market and the key drivers behind this impact.

---

## Structure of Report

---

In order to best address the points identified above, this report has been organized in three main parts. The first looks at the historical impact of Kazakh production expansion on price. The second examines the future of Kazakh production and how it might impact the market. The third consists of three appendices which provide additional background and detail to the discussions that appear in the report

Each of these parts is organized as follows:

- **Part 1**

**Chapter 2** provides an historical perspective of Kazakhstan production expansion relative to the expansion achieved by other countries and other market developments.

**Chapter 3** lists the factors to be considered when assessing the impact of Kazakhstan's production expansion on the market.

**Chapter 4** measure the past price impact of Kazakh expansion using four measures: 1) survey results, 2) production cost analysis, 3) econometric (regression) analysis, and 4) a comparative approach.

- **Part 2**

**Chapter 5** provides an overview of the second part of the report and presents a case study of the United States, a country that greatly expanded production but was not able to sustain its production gains.

**Chapter 6** details the nature of Kazakhstan’s resource base and projects that form the foundation for future expansion.

**Chapter 7** looks at the policies pursued by the government and the actions that it is taking now and may likely take in the future that will impact production.

**Chapter 8** addresses the other factors impacting production growth, including infrastructure issues, tax and transfer pricing policy, political risk, financing, and international perception.

**Chapter 9** examines the impact of future Kazakhstan production on the market through 2020 under different demand and production scenarios. The potential price impact of Kazatomprom not expanding beyond 20,000 MTU per year is analyzed here as well.

**Chapter 10** looks further into the future and considers the question of the sustainability of Kazakh production and the factors that are most likely to impact that sustainability.

- **Part 3**

**Appendix A** contains an essay from our Q2 2008 Uranium Market Outlook (UMO) report entitled “The Kazakh Phenomenon” that presents a detailed look at Kazakhstan’s production situation in early 2008.

**Appendix B** presents an excerpt from the essay in our Q1 2008 UMO that provides background on how regression analysis can be used to project uranium production.

**Appendix C** presents an excerpt from our Q1 2010 UMO essay that provides additional information on consumer interest in Kazakh production.