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Uranium in Latin America:
Reserves, Energy, and Security Implications

Prepared by:
Concurrent Technologies Corporation
(CTC) and the Applied Research Center

August 2010

APPLIED RESEARCH CENTER
FLORIDA INTERNATIONAL UNIVERSITY

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Applied Research Center

Florida International University

10555 W Flagler Street

Miami, FL 33174

whemsac.fiu.edu

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The views expressed in this research paper are those of the author and do not necessarily reflect the official policy or position of the US Government, Department of Defense, US Southern Command or Florida International University.

EXECUTIVE SUMMARY

As the economic, social, and environmental costs to use traditional fossil fuels continue to rise, nuclear power is becoming increasingly attractive for many countries. This renewed interest in nuclear power could lead to increased demand for uranium. As demand increases, it will likely drive the exploration, development, production, and refinement of uranium reserves in Latin America. Funding for these efforts will likely be driven by foreign investment.

Latin America has significant uranium reserves that remain largely unexploited. Brazil had the largest known reserves until recently, when exploration efforts identified significant uranium deposits in Guyana along the border with Venezuela. These deposits hold promise for future uranium production. Currently, only Argentina, Brazil and Mexico have established nuclear programs. Many other Latin American countries are interested in developing nuclear programs and/or are exploring their indigenous uranium reserves.

Several countries are interested in Latin America uranium reserves and have developed strategic relationships to access uranium. Some of these countries, such as Iran and Russia, are suspected or known to be developing a nuclear weapons program or have ties to terrorist and criminal organizations. In the short term, these relationships do not pose a threat to the security of the region in relation to the availability of uranium. The mining and enrichment of uranium are costly and complex processes that will take time to develop in those countries with close relations to Iran and Russia and in the potential large reserves of uranium, mainly Guyana and Venezuela. However, in the longer term, these relationships should be closely monitored to ensure the safety and security of the United States and surrounding nations.

RECOMMENDATIONS FOR U.S. POLICY

1. ***Develop a long-term policy for nuclear capabilities in Latin America.*** Latin America is poised to increase production of uranium to meet growing world demands. It is likely that Latin American countries will leverage their natural resources to drive their own nuclear programs. The US should be proactive in developing a long-term policy for addressing an increased nuclear capability in Latin America.

2. ***Encourage non-proliferation efforts.*** Support existing and new non-proliferation efforts. This support may include programs to increase awareness of key issues related to the negative outcomes of developing nuclear weapons and the advantages of preventing proliferation of nuclear weapons capabilities.

3. ***Support nuclear safety programs.*** Support existing and promote new nuclear awareness and safety programs. This could include programs to increase public awareness of key nuclear safety issues and technical programs designed to share knowledge, resources, and capabilities related to safely developing nuclear power capabilities.

4. ***Promote exchanges with institutions of higher education.*** Promote close collaboration with universities, think tanks, and local civil society organizations in Latin America and the Caribbean to develop research and cooperation programs, similar to those that proved successful in the past.

5. ***Closely monitor uranium trade from Latin American countries.*** The import of uranium by countries with the capacity to enrich it for military purposes may pose a threat to U.S. and other regional actors' security interests. Similarly, the development of nuclear power capacity within the region for military purposes would pose a risk for the United States, as well as Latin America and the Caribbean.

6. ***Strengthen relations with Brazil in relation to its nuclear capabilities.*** Brazil is a key player in Latin America in relation to nuclear capability and a fluid dialogue. Brazilian cooperation in this area would help in maintaining transparency and accountability in this sector. The United States could work jointly with Brazil and others to further regional goals of nonproliferation.

INTRODUCTION

Uranium is a naturally occurring metallic element used for the production of nuclear power and nuclear weapons. Uranium demand is typically driven by the military or civil nuclear power. Nuclear power is “clean” energy, and many countries are interested in using it to alleviate their dependence on traditional fossil fuels and accommodate their increasing energy demand. Some countries also seek uranium to develop nuclear weapon programs.

Latin American countries have historically had little uranium production; however, they are responding to the higher demands for uranium by increasing the exploration of their uranium reserves. Argentina and Brazil have the largest reserves. More recently, Guyana discovered promising uranium reserves. As global interest in uranium continues to grow, strategic relationships are being developed with Latin American countries for access to these reserves.

This paper looks at the uses and growing demand for uranium, world reserves and production, existing and newly discovered reserves in Latin America, prospects for using uranium to develop peaceful nuclear energy in Latin America, international interest in Latin America uranium and potential security threats and related implications associated with development of Latin American uranium deposits. The paper also offers some conclusions and recommendations in the context of US security interests.

URANIUM DEMAND

Uranium demand is typically driven by the military or civil nuclear power. Nuclear weapons contain highly enriched uranium, utilizing at least 20 percent and upwards of 90 percent of uranium-235 (U-235).[1] Since 1987, the United States and countries of the former Union of Soviet Socialist Republics (USSR) have signed a series of disarmament treaties reducing the nuclear arsenals of signatory countries by approximately 80 percent,[2] thereby reducing the military demand for uranium in those countries. Despite these treaties, some countries are still interested in uranium for nuclear weapons, among them Iran, India, Pakistan, and North Korea.

Nuclear power reactors require about 68,600 tons of uranium per year.[3] Although the amount of electricity created by these reactors and their fuel requirement has been increasing, uranium demand has remained steady due to the higher burn-up of fuel and other efficiencies.[4] As of July 2010, there are approximately 439 operable reactors throughout the world, with an additional 344 expected to be operating by 2030.[5] Of the 344 additional reactors, 120 are expected for China and 40 are expected for India. These plans suggest that the uranium needs of China, India, and other developing countries will play a key role in future uranium demand. China is already stockpiling uranium, and its demand for uranium may rise to 20,000 tons a year by 2020. India's needs are estimated to grow to 8,000 tons.[6] Based on the *current* rate of uranium consumption and the *present*

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[1] WNA, 2009. "Supply of Uranium." Available: http://www.world-nuclear.org/info/inf75.html (Accessed 7/6/2010).
[2] Ibid.
[3] WNA, 2010. "World Nuclear Power Reactors & Uranium Requirements." Available: http://www.world-nuclear.org/info/reactors.html (Accessed 7/6/2010).
[4] WNA, 2009. "Supply of Uranium," opp. cit.
[5] WNA, 2010. "World Nuclear Power Reactors & Uranium Requirements," Opp. cit.
[6] Bloomberg News, 2010. "Uranium Bottoming as China Boosts Stockpiles." *Bloomberg News*, July 12, 2010. Available: http://www.bloomberg.com/news/2010-07-11/uranium-bottoming-as-china-boosts-stockpiles-with-10-000-tons-from-cameco.html (Accessed 7/18/2010).

measured resources of uranium, there is enough uranium to last for 80 years.[7] This rate will change as demand increases and/or additional uranium deposits are discovered.

Reactor fuel requirements are met by using primary supply from mines and secondary sources, including commercial stockpiles, nuclear weapons stockpiles, recycled plutonium and uranium from reprocessing used fuel, and re-enrichment of depleted uranium tails left over from original enrichment. As the economic, social, and environmental costs of generating electricity from fossil fuel rises, nuclear energy is becoming more cost competitive and will likely increase in demand, despite the relatively high capital costs, the need to internalize all waste disposal, and decommissioning costs.[8]

URANIUM RESERVES AND PRODUCTION

Concentrations of uranium that are economically recoverable relative to current costs of extraction and market prices are not uncommon worldwide. As of 2007, Australia has the greatest known recoverable reserve of uranium with 23 percent of the world's resources.[9] Currently, about 63 percent of the world's production of uranium comes from mines is from Kazakhstan (27%), Canada (20%), and Australia (16%).[10] Production from mines is expected to increase to 55,000 tons of uranium in 2010 as production is ramping up in Kazakhstan and Namibia. Further exploration and higher uranium prices will likely lead to the identification and development of additional uranium reserves.

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[7] WNA, 2009. "Supply of Uranium," opp. cit.
[8] WNA, 2010. "The Economics of Nuclear Power." Available: http://www.world-nuclear.org/info/info02.html (Accessed 7/6/2010).
[9] WNA, 2009. "Supply of Uranium," opp. cit.
[10] WNA, 2010. "World Uranium Mining." Available: http://www.world-nuclear.org/info/inf23.html (Accessed 7/6/2010).

As exploration increases, the dynamics among those countries with the greatest uranium reserves and highest production will change; in particular, exploration in 2010 suggests that Guyana may have some of the world's largest uranium reserves. The table below lists countries with a significant percentage of the world's uranium resources based on 2007 data and their associated 2009 production.

Global Known Recoverable Resources of Uranium (2007)[11] and Global Uranium Production Figures (2009)[12]

Country	Recoverable Uranium (Tons)	Percentage of World Resources	Uranium Produced (Tons)*	Percentage of Global Uranium Production
Australia	1,243,000	23%	7,982	16%
Kazakhstan	817,000	15%	13,820	27%
Russia	546,000	10%	3,564	7%
South Africa	435,000	8%	563	1%
Canada	423,000	8%	10,173	20%
USA	342,000	6%	1,453	3%
Brazil	278,000	5%	345	1%
Namibia	275,000	5%	4,626	9%
Niger	274,000	5%	3,243	6%
Ukraine	200,000	4%	840*	2%
Jordan	112,000	2%	N/D	N/D
Uzbekistan	111,000	2%	2,429	5%
India	73,000	1%	290*	1%
China	68,000	1%	750*	1%
Mongolia	62,000	1%	N/D	N/D
Other	210,000	4%	N/D	N/D
World Total	5,469,000	-	50,572	-

Notes: N/D denotes no data. ** Denotes estimated value.*

11 WNA, 2009. "Supply of Uranium," opp. cit.
12 WNA, 2010. "World Uranium Mining," opp. cit.

The majority of world uranium production previously came from underground mines. However, mining methods have been changing, and in-situ leach (ISL) mining has been increasing in popularity. ISL mining involves pumping a leaching liquid, such as ammonium carbonate or sulfuric acid, through drill holes into the underground uranium deposits, and the uranium-bearing liquid is pumped out from below.[13]

Uranium ore is a mixture of ore and host rock. If the ore is not already in solution, it is crushed, treated with acid to separate the uranium metal, and purified with chemicals. The uranium is precipitated out of the solution and dried, resulting in U_3O_8, or "yellowcake." The yellowcake is then refined to remove impurities, resulting in high-purity uranium trioxide (UO_3), which is then converted to uranium dioxide (UO_2) (used for heavy water reactors), or gaseous uranium hexfluoride (UF_6) (used for light water reactors).[14] UF_6 requires enrichment and conversion to enriched UO_2 before it can be used as fuel.

When uranium is mined, it consists of several isotopes; it is about 99.3% uranium-238 (U-238), 0.7% uranium-235 (U-235), and < 0.01% uranium-234 (U-234).[15] Uranium used as reactor fuel or uranium used to achieve the "critical mass" nuclear chain reaction of an atomic explosion require a higher concentration of U-235 than exists in natural uranium ore and requires enrichment. Uranium enrichment is the

[13] Diehl, 2004. "Uranium Mining and Milling Wastes: An Introduction." Available: http://www.wise-uranium.org/uwai.html (Accessed 7/14/2010).
[14] Cameco Corp, 2009. "Uranium 101 – Uranium Science – Nuclear Fuel Cycle." Available: http://www.cameco.com/uranium_101/uranium_science/nuclear_fuel/ (Accessed 7/19/2010).
[15] U.S. Nuclear Regulatory Commission, 2009. "NRC: Uranium Enrichment." Available: http://www.nrc.gov/materials/fuel-cycle-fac/ur-enrichment.html (Accessed 7/14/2010).

process to convert uranium powder into fissionable materials using isotope separation. Isotope separation uses gas centrifuges to cast off impurities from the natural uranium, resulting in a purer isotope that can achieve greater energy release.[16]

Uranium is unique among energy materials in that it can also be supplied by a variety of secondary sources. One such source is civil stockpiles held by utilities and governments. Although it is difficult to quantify the exact amount of uranium in stockpiles, 55,000 tons of uranium is known and 120,000 tons estimated for utilities.[17] These reserves are expected to increase to provide energy security for utilities and governments.

Military uranium is viewed as a major source of fuel for commercial nuclear power. High enriched uranium can be blended with uranium containing low levels of U-235 to produce low enriched uranium, which can be used as fuel for power reactors. Highly enriched uranium in US and Russian weapons and other military stockpiles is estimated to be about 2,000 tons, which is equivalent to about twelve times the annual world mine uranium production. Worldwide stockpiles of weapons-grade plutonium are reported to be approximately 260 tons, which, when blended with uranium oxide to form mixed oxide fuel, is the equivalent of a little over one year of world uranium production.

URANIUM RESERVES IN LATIN AMERICA

Although Brazil and Argentina have some of the largest uranium deposits, nations throughout Latin America are investing heavily in the discovery and development of

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[16] Federation of American Scientists, "Uranium Production," http://www.fas.org/programs/ssp/nukes/fuelcycle/centrifuges/U_production.htm.

[17] WNA, 2009. "Supply of Uranium," opp. cit.

indigenous sources of uranium, including Mexico, Bolivia, Chile, Colombia, Ecuador, Guatemala, Guyana, Paraguay, Peru, and Uruguay.[18] Recent exploration data indicate that a deposit in Guyana along the border with Venezuela may be one of the most promising locations in Latin America for the discovery of uranium reserves and future uranium production. Appendix I summarizes uranium deposits in several Latin American countries, while the sections below describe those countries with significant existing and potential uranium reserves in further detail.

Argentina

Argentina's Atomic Energy Commission [*Comisión Nacional de Energía Atómica (CNEA)*] estimates that Argentina has approximately 55,000 tons of uranium as "exploration targets." Although uranium exploration and mining has been conducted since the mid-1950s, the last mine closed in 1997. However, there are plans to reopen the CNEA Sierra Pintada mine in Mendoza (also known as the San Rafael mine and mill) in order to make the country self-sufficient. The total reserves at this mine and at Cerro Solo are less than 8,000 tons. In 2007, CNEA reached an agreement with the Salta provincial government to reopen the Don Otto uranium mine, which was last operated in 1981. Cauldron Energy Ltd, an Australian-based company, leases 16 km of outcropping uranium-copper mineralization at Rio Colorado, Catamarca province. This area was worked by Cauldron in the 1950s and 1960s, and Cauldron's exploration target is 6,400 tons uranium.

Brazil

Brazil has the world's fifth largest uranium reserves with demonstrated reserves of 193,000 tons of uranium. Three

[18] Berry, Ken, 2009. "Background Paper Latin America: Nuclear Facts and Figures." Available: http://www.icnnd.org/research/Berry_Latin_America_Background_Paper.pdf (Accessed 7/14/2010).

main deposits are Pocos de Caldas (closed in 1997), Lagoa Real or Caetité (operating since 1999), and Itatia, which is now called the Santa Quitéria (phosphate as co-product; production expected in mid-2012).[19] Although foreign investors are allowed to exploit Brazil's uranium resources, no more than 20 percent of the country's reserves are allowed to be exported. Most of Brazil's uranium production is supplied by *Industrias Nucleares do Brasil (INB)*, the uranium mining arm of state owned power utility company, Eletrobas Thermonuclear. INB operates the Caetete facility in the northern state of Bahia that is expected to produce 400 tons of uranium concentrate each year. INB also has access to the Itatia deposit that is situated in the state of Ceará. INB has embarked on a major expansion program at Caetete that should double production to more than 800 tons of uranium concentrate each year.[20]

Guyana

Guyana may be one of the most promising locations in Latin America for the discovery of uranium reserves and future uranium production. A resource estimate by the Canadium uranium exploration company U308 Corporation estimated that Guyana's Aricheng North and Archeng South structures have 5.8 million pounds of uranium at an average grade of 0.10%, as well as an additional inferred resource of 1.3 million pounds of uranium at an average grade of 0.09%.[21] Uranium mineralization at Aricheng South and Aricheng North lies within fracture zones and breccias within the Kurupung Batholith in the basement, which is approximately

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[19] WNA, 2010. "Nuclear Power in Brazil." Available: http://www.world-nuclear.org/info/inf95.html (Accessed 7/6/2010).

[20] MBendi Information Services, "Uranium & Thorium Mining in Brazil," 27 July 2010 http://www.mbendi.com/indy/ming/urnm/sa/br/p0005.htm.

[21] Kaieteur News Online, 2009. "Company finds some five million pounds of uranium in Guyana." Available: http://www.kaieteurnewsonline.com/2009/01/23/company-finds-some-five-million-pounds-of-uranium-in-guyana/ (Accessed 7/16/2010).

five kilometers from the Roraima Basin. Ongoing exploration in this area by U308 and its local subsidiary, Prometheus, suggests that the Kurupung Batholith may contain 50 million pounds of uranium;[22] similar albitite-hosted uranium deposits elsewhere typically hosted 50 – 130 million pounds of resources.[23] U308 is focused on expandings its pipeline of uranium-bearing structures to increase the size potential of the Kurupung system.

U308 has been exploring uranium projects in the Roraima Basin in Region 8 and at Kurupung in the Cuyuni since 2007. Different types of uranium are located at each area; at Kurupung, albitite-hosted uranium-bearing structures are being analyzed, while at the Roraima Basin, an area west of Guyana which expands into Venezuela and Brazil, unconformity-related uranium is being examined.[24] The Roraima Basin's uranium target structures are similar to the Athabasca Basin in Canada, which contains one third of the world's uranium reserves. The company is refining and ranking its uncomformity targets and will continue scout drilling the most promising areas in 2010.[25]

Bolivia

Bolivia's Ministry of Mining announced in May 2010 that it will be exploring for uranium in the central Potosí region.

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[22] Solomon, Alva. "Guyana could begin uranium exports by 2014." *guyaneseonline.* April 13, 2010. Available: http://guyaneseonline.files.wordpress.com/2010/05/guyana-could-begin-uranium-exports-by-2014.pdf (Accessed July 12, 2010).

[23] Marketwire, 2010. "U308 Corp. Intersects 2.9 Metres at 0.228% (4.6 Pounds Per Short Ton) U308 at Aricheng North, Kurupung Project, Guyana." Available: http://www.marketwire.com/press-release/U3O8-Corp-Intersects-29-Metres-0228-46-Pounds-Per-Short-Ton-U3O8-Aricheng-North-Kurupung-TSX-VENTURE-UWE-1263764.htm (Accessed 7/16/2010).

[24] Solomon, A. opp. cit.

[25] U308 Corp, 2010. "Guyana." Available: http://www.u3o8corp.com/main3.aspx?id=108 (Accessed 7/18/2010).

The Bolivian government is investing $500,000 in the project and is basing its belief that the area contains uranium reserves on a 1970 study, although the size of the reserves is unknown. The government did not specify whether there were plans to mine its uranium deposits should large deposits be found.[26]

Colombia

Significant quantities of uranium have been identified in Colombia but analyses are to be conducted by external bodies to verify as such.[27]

Mexico

Although Mexico has identified reserves of about 2000 tons of uranium, it has not been mined to date. A uranium milling plant operated on an experimental basis at Villa Aldana, in the Chihuahua region, in the late 1960s but has now been decommissioned. Tailings were disposed of at Pena Blanca. Under Mexican legislation, nuclear fuel is the property of the state and is under the control of the CNSNS.[28]

Peru

Several international companies have been exploring for uranium in Peru for several years. Canadian companies, such as Strathmoer Resources, Vena Resources and CAMECO, have been exploring in the Macusani Project. Vena Resources have reported a third quantitative result from uranium exploration and sampling at the Company's extensive uranium concessions. The project area comprises 15,500 hectares of 100% controlled land in Puno, Peru.

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[26] World Nuclear News, 2010. "Bolivia searches for uranium." Available: http://www.world-nuclear-news.org/IT-Bolivia_searches_for_uranium-1805104.html (Accessed 7/14/2010).

[27] Solomon, A. "Guyana could begin uranium exports by 2014." Opp. cit.

[28] World Nuclear Association, "Nuclear Power in Mexico, May 2010, http://www.world-nuclear.org/info/inf106.html.

Previous campaigns also found significant mineralization. These near surface exploration targets are disseminated in nature, occurring in highly porous volcanic rock formations. Given the encouraging results of the geochemical confirmation campaigns, Vena is preparing a drilling campaign to test these targets at depth. Vena is also exploring targets at Concharrumio, which extends over an area of 600 by 300 meters, with uranium mineralization ranging from 0.01% to 23.0% U3O8 at surface.[29]

Venezuela

Venezuela uranium reserves are unknown. Venezuelan government sources allege that its reserves are significant, based on initial evaluations conducted with the assistance of Iran.[30] These allegations expected to be true, given that the Roraima Basin in Guyana, with extensive reserves of unconformity-related uranium deposits, extends into Venezuela.[31]

Development of Peaceful Nuclear Energy in Latin America

Most Latin American countries are interested in uranium to develop peaceful nuclear energy to satisfy their growing energy needs. Brazil, Argentina, and Mexico currently operate functioning nuclear power facilities, while Chile, Colombia, Cuba, Jamaica, Peru, Uruguay, and Venezuela operate small scientific reactors. [32] It is anticipated that Chile will build a small nuclear energy program within the

[29] The Free Library. "Vena Finds Additional High-Grade Uranium in Macusani, Peru," http://www.thefreelibrary.com/Vena+Finds+Additional+High-Grade+Uranium+in+Macusani%2c+Peru-a0139047251.

[30] WISE, "New Uranium Mining Projects – South/Central America," last updated 22 July 2010, http://www.wise-uranium.org/upsam.html.

[31] Berry, K. "Background Paper Latin America: Nuclear Facts and Figures." Opp. cit.

[32] Ibid.

next decade. Venezuela has been unsuccessfully attempting to obtain nuclear technology from Argentina and Brazil and is thought to be considering construction of a nuclear power plant by Russia. The sections below provide an overview existing and emerging nuclear energy programs in Latin America.

Existing Nuclear Energy Programs in Latin America[33]

Latin American Nuclear Energy Programs Compared to Worldwide Programs

TABLE 2

Current Status / Item	Latin America In operation	World In operation	Share vs. World	Latin America Under construction	World Under construction	Share vs. World
Number of nuclear power reactors	6	439	1,4%	2	44	4,5%
Current nuclear electrical net capacity [GWe]	4,1	372,0	1,1%	2,0	38,8	5,2%
Contribution of nuclear power to the electrical generation 2009	2,3%	14,2%	Latin American electric generation mainly relies on hydro and gas. World reflects the broad arc from 76.8% in France to 1.9% in China.			
Contribution of nuclear power to the electrical generation 2030 Estimate	3,7% - 5,6%	12,4% - 14,4%	Contribution of nuclear power to electrical generation in Latin America is expected to follow an upward trend, mostly due to the addition of new plants to the current players' grids.			
Enrichment [Countries]	2	13	Resende, Brazil: 120 tSWU/yr and Pilcaniyeu, Argentina: 20 tSWU/yr			
Capacity [tSWU/yr]	140	55.000	0,3%			

Sources:
World Nuclear Association, April 2009.
Energy, Electricity and Nuclear Power Estimates for the period up to 2030, IAEA, 2008.
Global Fissile Material Report 2008, IPFM, 2008.

Argentina

Argentina has two nuclear reactors that generate almost one-tenth of the country's electricity. Argentina's first nuclear power reactor began operating in 1974, and its third reactor is expected to be completed by early 2011.[34] A feasibility study is also underway to construct a fourth reactor. Since 1990, electricity demand in Argentina has been steadily

[33] Table appears in Irma Arguello, "El futuro de la Energía Nuclear en América Latina," Fundación No-Proliferación para la Seguridad Global, August 2009, http://npsglobal.org/esp/component/content/article/151-analisis/760-enenucamlat.html.

[34] WNA, 2010. "Nuclear Power in Argentina." Available: http://www.world-nuclear.org/info/inf96.html (Accessed 7/6/2010).

increasing; nuclear power is intended to be part of an expansion to meet rising electricity demand. However, it is estimated that by 2010, there will already be a significant shortfall in electricity production.[35]

Argentina is investigating the feasibility of uranium enrichment. To do so, Argentina has established a partnership with Brazil. The initial enrichment would take place in Argentina, and the slightly enriched uranium would be sent to Brazil for enrichment to commercial levels (around 4%).[36]

Brazil

Brazil is one of only nine countries that can enrich uranium.[37] Two nuclear reactors operate in Angra dos Reis, Brazil, 130 km west of Rio de Janeiro: Angra I, inaugurated in 1985, and Angra II, in 2000. Together they provide about four percent of the electricity consumed in Brazil.[38] These reactors have a net capacity of 1,896 MWe. A third reactor, Angra III, with a net capacity of 1,270 MWe, is currently under construction and is expected to be operating by 2016. Four additional reactors (for a total of 7 reactors) are planned for operation by 2025.[39]

As part of its nuclear propulsion program, the Brazilian Navy developed centrifuge enrichment and built a demonstration plant at the Aramar Experiment Center in Iperó, which opened in May 2006. Using the Aramar facility's enrichment technology, an industrial enrichment plant was planned at Resende to supply the country's nuclear

[35] Berry, K. "Background Paper Latin America: Nuclear Facts and Figures." Opp. cit.
[36] Ibid.
[37] Ibid.
[38] Diego Cevallo, "Latin America: Nuclear Energy Reborn," IPS, 3 October 2006, http://ipsnews.net/news.asp?idnews=34975
[39] WNA, 2010. "Nuclear Power in Brazil." Available: http://www.world-nuclear.org/info/inf95.html (Accessed 7/6/2010).

reactors, which requires enrichment to only to 3.5% U-235. Stage 1 was opened in 2006 by the INB and full operation began in May 2009. It is expected to produce 60 percent of the reactor's fuel needs by 2012. Stage 2 will increase that capacity to 200,000 SWU.[40] It should be noted that this facility has the capability to provide fuel enriched to 10 percent uranium for use by the submarine program, which has caused significant controversy. However, due to the current financial crisis, it is unlikely that the Brazilian President's plan to launch a nuclear-powered submarine by 2015 will occur.

Chile

Chile currently has two nuclear research reactors, both of which are located in Santiago. Chile has the greatest financial and technical potential to achieve nuclear energy. Studies on nuclear options were endorsed by former President Michelle Bachelet, and international nuclear power companies have demonstrated interest in assisting Chile in these endeavors. It is anticipated that Chile will build a small nuclear energy program within the next decade. It has signed an Additional Protocol with the International Atomic Energy Agency (IAEA).[41]

Cuba

With the support of the Soviet Union, Cuba built two nuclear energy facilities at Jaraguá, Cienfuegos, in the late 1980s. These facilities were mothballed in the 1990s when the funding ended after the collapse of the Soviet Union.

Ecuador

Two Canadian companies, Spirit Exploration, Inc. and Bolivar Mining Corporation, are performing prospection

[40] Ibid.

[41] Berry, K. "Background Paper Latin America: Nuclear Facts and Figures." Opp. cit.

and/or exploration in Ecuador.[42] In 2009, Ecuador's Ministry of Electricity and Renewable Energy signed an agreement with Russia's state-controlled civilian nuclear power corporation, Rosatrom, on nuclear cooperation.[43] The International Atomic Energy Agency (IAEA) also indicated willingness in helping Ecuador explore for uranium and consider the possibility of developing nuclear energy for peaceful purposes.[44]

Mexico

Mexico has two nuclear power plants at Laguna Verde. They are 654 MWe General Electric boiling-water reactors (BWRs). Mexican companies undertook the civil engineering work, and Mexican staff maintains the reactor and are trained to operate it at CFE's simulator. In February 2007, Mexico signed contracts with Spain's Iberdrola Engineering and also Alstom to fit new turbines and generators to the Laguna Verde plant at a cost of U.S. $605 million. The main modifications consist of a turbine and condenser retrofit and the replacement of the electric generator, main steam reheater, and the feedwater heater. They will then produce 20% more power - about 285 MWe, resulting in 1634 MWe for both reactors.

High-level government support exists for an expansion of nuclear energy, primarily to reduce dependence on natural gas, but also to cut carbon emissions; the country's energy policy calls for increasing carbon-free power generation from 27% to 35% of total energy produced. Under the Energy Commission's most aggressive scenario, up to ten nuclear power plants would be built so that nuclear energy

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[42] Wise Uranium Organization, "New Uranium Mining Projects – South/Central America," opp. cit.
[43] Ibid.
[44] Ibid.

will supply nearly a quarter of Mexico's power needs by 2028.[45]

Uruguay

Uruguay is in the early stages of considering a nuclear energy program to address a decline in hydroelectric production. However, in addition to having a law in place that prohibits nuclear energy in the country, it is unlikely that Uruguay has the financial resources to invest in a nuclear energy program. [46]

Venezuela

Since about 2005, it is believed that Venezuela has been unsuccessfully attempting to obtain nuclear technology from Argentina and Brazil. In 2008, Venezuela signed a cooperation agreement with Russia for the development of a nuclear infrastructure. Iran as offered technical assistance to Venezuela in the area of nuclear energy.[47] France has also indicated a willingness to assist Venezuela develop nuclear energy. [48]

Experts agree that Venezuela has no nuclear infrastructure.[49]

EMERGING TECHNOLOGIES FOR NUCLEAR ENERGY

For many developing regions within Latin America, nuclear power has been unachievable due to the tremendous costs

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[45] World Nuclear Association, "Nuclear Power in Mexico." Opp. cit.

[46] Berry, K. 2009, opp. Cit.

[47] Bailey, Norman. "Iranian Penetration of the Western Hemisphere through Venezuela." House Committee on Foreign Affairs, Subcommittee on the Western Hemisphere; Subcommittee on Middle East and South Asia, and Subcommittee on Terrorism Nonproliferation and Trade, October 27, 2009. http://foreignaffairs.house.gov/111/bai102709.pdf.

[48] Nina Gerani and Sharon Squassoni, "Venezuela: A Nuclear Profile," Carnegie Endowment for International Peace, December 18, 2008, p. 1.

[49] Ibid.

associated with building a nuclear facility (estimated at $40 billion), a figure that fails to include costs associated with the corresponding infrastructure for electricity transmission.[50] However, advances in the field of micro-nuclear reactor technologies, which are scheduled for production within the next three years, are targeting the development of safe and efficient nuclear energy at affordable prices.

Micro-nuclear reactors potentially offer significant advantages over existing reactor technologies. Unlike gigantic nuclear facilities that can require a decade or more to construct, micro-reactors are approximate in size to a telephone booth, prefabricated, and easily transported.[51] The units are hermetically sealed by the manufacturer, shielded, and buried within a concrete sarcophagus on the installation site, which prevents tampering.[52] For enhanced safety, the solid control rods conventionally used to regulate the reaction and temperatures have been replaced by an automatic system utilizing molten lithium-6.[53] As the temperature rises within the reactor, the molten liquid expands through the reactor core, absorbing neutrons and slowing the chain reaction down to a safe rate.[54] The result is a self-regulating nuclear reactor that contains no moving parts, requires no personnel to operate, and possesses no

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[50] Steve Kidd. *"Escalating costs of new build: what does it mean?"* Nuclear Engineering International. August 22, 2008. http://www.neimagazine.com/story.asp?sectioncode=147&storyCode=2050690

[51] Black, Edwin. *Truck-delivered Micro-Nuclear Reactor for Clean Energy Within Five Years.* November 10, 2008. http://www.thecuttingedgenews.com/index.php?article=906 (accessed July 3, 2010).

[52] Ibid.

[53] BBC News. "Mini nuclear power plant proposals." *BBC News Sci/Tech.* August 22, 2001. http://news.bbc.co.uk/2/hi/science/nature/1504564.stm (accessed July 15, 2010).

[54] BBC News. "Mini nuclear power plant proposals." Opp. cit.

potential to meltdown or go supercritical.[55] Furthermore, the reactors would contain only a small amount of enriched uranium (<20% U-235) and would require being returned to the manufacturer every 8-10 years for refueling. The companies Toshiba and Hyperion are currently set to begin production in 2013, with the latter already having received over 100 orders from massive oil and industrial enterprises with tremendous power needs in remote locations.[56] The units, with an estimated cost of 25 million each, are reportedly rated at 25MW, providing enough energy to sustain 20,000 homes for 10 years.[57]

INTERNATIONAL INTEREST IN LATIN AMERICAN URANIUM

As the demand for uranium continues to grow, it is likely that clients looking for uranium will develop strategic relationships with Latin America to ensure continued supply of the resource. The interests of some of these countries in Latin America and the relationships among them are discussed below.

China

As China leads the biggest atomic expansion since the 1970s oil crisis, its demand for uranium is "insatiable." China is just starting to look abroad to buy stakes in uranium mines, but this trend is expected to become increasingly common.[58]

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[55] Black, E. opp. cit.
[56] Ibid.
[57] Interview with scientists at Los Alamos. Vidal, John. *"Mini nuclear plants to deliver power 20,000 homes".* The Guardian.co.uk/Observer November 9, 2008. http://www.guardian.co.uk/environment/2008/nov/09/miniature-nuclear-reactors-los-alamos
[58] Bloomberg News, 2010. "Uranium Bottoming as China Boosts Stockpiles." *Bloomberg News*, July 12, 2010. Available: http://www.bloomberg.com/news/2010-07-11/uranium-bottoming-as-

For now, China has not looked at Latin America for supplies of uranium. It imports uranium primarily from CAMECO (a Canadian based company), which is the world's second largest producer of uranium.

Iran

Of growing concern is Iran's interest in Latin American uranium. Iran is continuing to expand its diplomatic, trade, and presence in Latin America. [59] Iran has sought and received support in Latin America for its nuclear program. Member states of the Bolivarian Alliance of the People of Our America (ALBA) have ratified their support to "*generate atomic energy and use it with peaceful aims, the right of all the nations laid down in the NPT (Non-Proliferation Treaty).*" This declaration against United Nations sanctions to Iran was signed by Bolivia, Cuba, Ecuador, Nicaragua, Venezuela, Dominica, Antigua and Barbuda, and Saint Vincent and the Grenadines, all members of ALBA, on July 17, 2010.[60] Brazil, along with Turkey, have attempted to mediate between Iran and the international community by not condemning Iran's right to produce nuclear energy, but persuading it to store low enriched uranium in Turkey.[61]

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china-boosts-stockpiles-with-10-000-tons-from-cameco.html (Accessed 7/18/2010).

[59] Karmon, Ely, 2009. "Iran and its Proxy Hezbollah: Strategic Penetration in Latin America." Available: http://ciempre.com/bin/content.cgi?article=499&lang=en (Accessed 7/16/2010).

[60] Hamid Golpira, "The ALBA countries in Latin America voice their support for Iran's rights," The Vineyard of the Saker, 17 July 2010, http://vineyardsaker.blogspot.com/2010/07/alba-countres-in-latin-american-voice.html**.**

[61] Parsi, Trita, 2010. "The Turkey-Brazil-Iran deal: Can Washington take 'yes' for an answer?" *Foreign Policy,* May 17, 2010. Available: http://mideast.foreignpolicy.com/posts/2010/05/17/the_turkey_brazil_iran_deal_can_washington_take_yes_for_an_answer (Accessed 7/18/10).

Latin American countries have signed the following agreements with Iran related to uranium exploration or nuclear energy:

- **Bolivia:** An agreement was signed with Bolivia in 2009, during the visit of President Mahmud Ahmadinejad for cooperation on mining exploration. However, uranium reserves in Bolivia seem to be insignificant. Bolivia is more important in the exploration of lithium.

- **Guyana:** President Bharrat Jagdeo visited Teheran in January 2010 and signed several agreements with the government of Iran. The GOI indicated that the large number of Muslims in Guyana and its membership of the Organization of Islamic Countries (OIC) have prepared the ground for expansion of cooperation between the two countries.[62] The agreement calls for Iran to help Guyana map mineral resources. According to Guyana's President Jagdeo, Iranian scientists will identify uranium deposits using updated technology, replacing the current prospecting system.[63] Guyana's opposition Alliance for Change party has criticized the agreement, which has not been fully disclosed, indicating that the nuclear mapping accord contrasts with the country's standard practice of requiring investors to secure a prospecting license before mining for minerals. A Canadian company, U308, is currently in Guyana exploring for

[62] Republic of Guyana, "Guyana, Iran sign two MoUs," Office of the Presidency, 21 January 2010, http://opnew.op.gov.gy/index.php?option=com_content&view=article&id=831:guyana-iran-sign-two-mous.

[63] "Iran Assists Guyana with uranium prospection," The Post-Standard (Guyana), January 27, 2010; see also, Karmon, Ely, 2009. "Iran and its Proxy Hezbollah: Strategic Penetration in Latin America." *Frenze Patriotico.* Available: http://ciempre.com/bin/content.cgi?article=499&lang=en.

uranium and has exclusive uranium exploration rights in an area covering approximately 1.3 million hectares that straddles the edge of the Roraima Basin in Guyana.[64]

- **Venezuela:** According to President Hugo Chávez, Venezuela is working in a preliminary project for the construction of a "nuclear villa" with the help of Iran.[65] Chavez also indicated that Iran is helping Venezuela map uranium resources. There is no independent confirmation of the information provided by Chavez.

Russia: Russia has signed several nuclear-related memorandums with several Latin American countries. These agreements are as follows:

- **Brazil:** In July 2009, Russia and Brazil signed a memorandum of cooperation on peaceful uses of nuclear energy.[66] This memorandum includes the development of uranium prospecting technology, design of new reactors, and the design and construction of nuclear research reactors.

- **Ecuador:** Russia and Ecuador also signed a memorandum on civilian nuclear power cooperation in August 2009. This memorandum enables cooperation in geological research, development of uranium fields, and projecting and building nuclear

64 "Guyana opposition slams Iran uranium deal," http://www.reuters.com/article/idUSN0319086020100203.

65 MercoPress, "Venezuela announces nuclear energy cooperation program with Iran," September 11, 2009, (http://en.mercopress.com/2009/09/11/venezuela-announced-nuclear-energy-cooperation-program-with-iran)

66 WISE Uranium Project, 2010. "New Uranium Mining Projects – South/Central America." Opp. cit.

power plants and research reactors. Nuclear fuel production and the development of the legal framework for Ecuador's nuclear sector are also included.[67]

- **Venezuela:** In May 2009, Venezuela and Russia signed an agreement that includes exploration and development of uranium and thorium, development of nuclear infrastructure, safety of nuclear facilities and radioactive sources, and the industrial production of components and materials to be used in nuclear reactors.[68]

POTENTIAL SECURITY IMPLICATION

The availability and potential findings of uranium in Latin American have no serious security consequence in the short term, for several reasons:

- Volume of uranium currently available is not significant, except in the case of Brazil. Brazil does not allow foreign interests to mine for uranium.
- Exploring for uranium in Latin America is costly and mostly in the hands of Canadian companies, representing no risk for the United States.
- Only Brazil has the capacity to enrich uranium and it has taken more than 30 years to be able to do so. It is not to be expected that other Latin American countries would be able to enrich uranium in the near future. Thus, most nuclear energy development in Latin America in the short term will be for civilian uses.

[67] Ibid.
[68] Ibid.

- The capacity exists to monitor transfer of nuclear technology to the Latin American and Caribbean regions.

In the middle term, the security risks related to with uranium may increase in the region, for the following reasons:

- Guyana might have large deposits of uranium and find a market for it among countries that have nuclear weapons capacity, such as Iran, Russia, Pakistan, North Korea, and others. Guyana is already developing such links with Iran and Russia.
- If Venezuela were to find large deposits of uranium, the government of Hugo Chavez would be much inclined to strengthen ties with Iran on this item.
- Terrorist organizations that may have the capacity to develop nuclear weapons might also be interested in Latin America's uranium.
- If Brazil were to elect a new president that steered away from traditional policy on nuclear energy and became more of a Chavez-type populist, then concern would increase as to Brazil's use of its nuclear capabilities and willingness to transfer nuclear technology.

Latin America has been a nuclear weapon-free region since 1967. The Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (Spanish acronym OPANAL), commonly known as the *Tlatelolco Treaty*, was signed in 1967 and it created a nuclear weapons free region. Under this treaty, which predated the 1970 Non-Proliferation Treaty, the state parties agree to prohibit and prevent the "testing, use, manufacture, production or acquisition by any means whatsoever of any nuclear weapons" and the "receipt, storage, installation, deployment and any form of possession of any nuclear weapons." [69] Compliance with the *Treaty* obligations is overseen by the Agency for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (OPANAL), based in Mexico City. Each Party must also conclude safeguards agreements with the IAEA.[70]

Despite Latin America’s innovative achievement in creating the first nuclear free zone on a populated region of the globe and legitimizing national programs for the development of nuclear capacity for peaceful purposes, Russia was able to build two nuclear plants in Cuba in the 1970s. Therefore, while the agreements allow for monitoring and request for compliance, states can also veer away from established procedures. In the case of Cuba, however, it did not sign the Tlatelolco Agreement in 1967. The international communities, as well as the regional Latin American and Caribbean organizations need to monitor compliance with established non-proliferation accords.

Concerns over the environmental implications of the development of nuclear power in Latin America go beyond those of security considerations, yet they should also be taken into account. They are related not only to risk of accidents, such as the Three Miles Island or the Chernobyl accidents--as was one of the concerns of the United States with the Cuban Jaraguá plants because of its potential impact on Florida-- but also of a different nature. In Argentina, for example, environmentalist groups have denounced the irregular granting of land for uranium mining to foreign companies. These land grants often lead to corruption and to

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[69] OPANAL.org, “What is the Treaty of Tlatelolco?” About OPANAL (Fact Page)
http://www.opanal.org/opanal/about/about-i.htm.

[70] International Atomic Energy Agency, “Tlatelolco Treaty A Trailblazer for Non-Proliferation,” 14 February 2007,
http://www.iaea.org/NewsCenter/News/2007/tlatelolco.html.

mining without conducting environmental impact studies.[71] While use of nuclear energy in Latin America seems to respond primarily to increased demand for clean and less expensive energy, the risk of accidents remains high in the areas surrounding nuclear energy plants.

CONCLUSIONS

As the economic, social, and environmental costs to use traditional fossil fuels continue to rise, nuclear power is becoming increasingly attractive for many countries. New demands for uranium are emerging from China, India, and Russia. The increased demand will likely cause uranium prices to dramatically increase, driving exploration in Latin America and elsewhere.

Guyana, and probably Venezuela, is the new area of uranium development in Latin America. With the exception of Brazil, the region has not had considerable reserves of uranium up to now. The discovery of new reserves, particularly in Guyana, has not gone unnoticed by extra-hemispheric actors and neighboring countries. To date, both Iran and Russia have signed agreements with Guyana and Venezuela for potential access to their uranium.

Most Latin American countries are interested in uranium to develop peaceful nuclear energy to satisfy their growing energy needs. Brazil, Argentina, and Mexico currently are the only countries that operate functioning nuclear power facilities. [72] It is anticipated that Chile will build a small nuclear energy program within the next decade. In this context, and given the cost and technology required to explore for uranium and the more complex process for enrichment, the availability of uranium in Latin America

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[71] Wise-uranium, "New Uranium Mining Projects," opp. Cit. Argentina.
[72] Berry, K. "Background Paper Latin America: Nuclear Facts and Figures." Opp. cit.

does not seem to provide a serious concern in the short term. In the medium and longer term, security concerns could depend primarily on the development of the uranium industry in Guyana and Venezuela.

WORKS CITED

Arguello, Irma. “El futuro de la Energía Nuclear en América Latina.” Fundación No-Proliferación para la Seguridad Global. August 2009. http://npsglobal.org/esp/componet/content/article/151-analisis/760-enenucamlat.html.

BBC. "Mini nuclear power plant proposals," *BBC News Sci/Tech,* August 22, 2001. http://news.bbc.co.uk/2/hi/science/nature/1504564.stm (accessed July 15, 2010).

Bailey, Norman. “Iranian Penetration of the Western Hemisphere through Venezuela.” House Committee on Foreign Affairs, Subcommittee on the Western Hemisphere; Subcommittee on Middle East and South Asia, and Subcommittee on Terrorism Nonproliferation and Trade, October 27, 2009. http://foreignaffairs.house.gov/111/bai102709.pdf.

Berry, Ken. “Background Paper Latin America: Nuclear Facts and Figures,” April 2009. http://www.icnnd.org/research/Berry_Latin_America_Background_Paper.pdf (accessed July 14, 2010).

Black, Edwin. “Truck-delivered Micro-Nuclear Reactor for Clean Energy Within Five Years.” November 10, 2008. http://www.thecuttingedgenews.com/index.php?article=906 (accessed July 3, 2010).

Bloomberg News. "Uranium Bottoming as China Boosts Stockpiles." *Bloomberg News*, July 12, 2010. http://www.bloomberg.com/news/2010-07-11/uranium-bottoming-as-china-boosts-stockpiles-with-10-000-tons-from-cameco.html (accessed July 18, 2010).

Cameco Corp. "Uranium 101 – Uranium Science – Nuclear Fuel Cycle," October 21, 2009. http://www.cameco.com/uranium_101/uranium_science/nuclear_fuel/ (accessed July 19, 2010).

Cevallo, Diego. "Latin America: Nuclear Energy Reborn." IPS, October 3, 2006. http://ipsnews.net/news.asp?idnews=34975.

Diehl, Peter. "Uranium Mining and Milling Wastes: An Introduction," August 15, 2004. http://www.wise-uranium.org/uwai.html (accessed July 14, 2010).

Federation of American Scientists. "Uranium Production." http://www.fas.org/programs/ssp/nukes/fuelcycle/centrifuges/U_production.htm.

Free Library, The. "Vera Finds Additional High-Grade Uranium in Macusani, Peru." http://www.thefreelibrary.com/Vena+Finds+Additional+High-Grade+Uranium+in+Macusani%2c+Peru-a0139047251.

Gerani, Nina and Sharon Squassoni. "Venezuela: A Nuclear Profile." Carnegie Endowment for International Peace, December 18, 2008, p. 1.

Golpira, Hamid. “The ALBA countries in Latin America voice their support for Iran’s rights.” The Vineyard of the Saker, July 17, 2010. http://vineyardsaker.blogspot.com/2010/05/17/alba-countries-in-latin-america-voice.html.

International Atomic Energy Agency, “Tlatelolco Treaty A Trailblazer for Non-Proliferation,” 14 February 2007, http://www.iaea.org/NewsCenter/News/2007/tlatelolco.html.

Kaieteur News Online. “Company finds some five million pounds of uranium in Guyana” Kaieteur News, January 23, 2009. http://www.kaieteurnewsonline.com/2009/01/23/company-finds-some-five-million-pounds-of-uranium-in-guyana/ (accessed July 16, 2010).

Karmon, Ely. “Iran and its Proxy Hezbollah: Strategic Penetration in Latin America,” *Frenze Patriotico*, April 8, 2009. http://ciempre.com/bin/content.cgi?article=499&lang=en (accessed July 16, 2010).

Kidd, Steve. "Escalating costs of new build: what does it mean?” Nuclear Engineering International. August 22, 2008. http://www.neimagazine.com/story.asp?sectioncode=147&storyCode=2050690.

Marketwire. "U308 Corp. Intersects 2.9 Metres at 0.228% (4.6 Pounds Per Short Ton) U308 at Aricheng North, Kurupung Project, Guyana," *Marketwire*, May 20, 2010. http://www.marketwire.com/press-release/U3O8-Corp-Intersects-29-Metres-0228-46-Pounds-Per-Short-Ton-U3O8-Aricheng-North-Kurupung-TSX-VENTURE-UWE-1263764.htm (accessed July 16, 2010).

MBendi Information Services. "Uranium & Thorium Mining in Brazil." July 27, 2010. http://www.mbendi.com/indy/ming/urnm/sa/br/p0005.htm.

MercoPress. "Venezuela announces nuclear energy cooperation program with Iran." September 11, 2009. http://en.mercopress.com/2009/09/11/venezuela-announced-nuclear-energy-cooperation-program-with-iran.

OPANAL.org, "What is the Treaty of Tlatelolco?" About OPANAL (Fact Page) http://www.opanal.org/opanal/about/about-i.htm.

Parsi, Trita. "The Turkey-Brazil-Iran deal: Can Washington take 'yes' for an answer?" *Foreign Policy,* May 17, 2010. http://mideast.foreignpolicy.com/posts/2010/05/17/the_turkey_brazil_iran_deal_can_washington_take_yes_for_an_answer (accessed July 18, 2010).

Post-Standard, The. "Iran Assists Guyana with Uranium Prospection." Guyana, January 27, 2010.

Republic of Guyana. “Guyana-Iran Sign two MoUS.” Office of the Presidency, January 21, 2010. http://opnew.op.gov.gy/index.php?option=com_content&view=article&id=831:guyana-iran-sign-two-mous.

Solomon, Alva. "Guyana could begin uranium exports by 2014," *Guyaneseonline.* April 13, 2010. http://guyaneseonline.files.wordpress.com/2010/05/guyana-could-begin-uranium-exports-by-2014.pdf (accessed July 12, 2010).

U308 Corp. “Guyana.” http://www.u308corp.com/main3.aspx?id=108. Accessed 7/18/2010.

U.S. Nuclear Regulatory Commission. “NRC: Uranium Enrichment,” December 14, 2009. http://www.nrc.gov/materials/fuel-cycle-fac/ur-enrichment.html (accessed July 14, 2010).

Vidal, John. “Mini nuclear plants to deliver power 20,000 homes,” *The Guardian.co.uk/Observer*, November 9, 2008. http://www.guardian.co.uk/environment/2008/nov/09/miniature-nuclear-reactors-los-alamos (accessed July 19, 2010).

WISE Uranium Project. “New Uranium Mining Projects – South/Central America,” June 3, 2010. http://www.wise-uranium.org/upsam.html (accessed 7/18/2010).

World Nuclear Association. “The Economics of Nuclear Power.” Available: http://www.world-nuclear.org/info/info02.html (accessed 7/6/2010)

______ "Nuclear Power in Argentina," April 2010. http://www.world-nuclear.org/info/inf96.html (accessed July 6, 2010).

_______ "Nuclear Power in Brazil," June 11, 2010. http://www.world-nuclear.org/info/inf95.html (accessed July 6, 2010).

______ "Supply of Uranium," September 2009. http://www.world-nuclear.org/info/inf75.html (accessed July 6, 2010).

______ "World Nuclear Power Reactors & Uranium Requirements," July 1, 2010. http://www.world-nuclear.org/info/reactors.html (accessed July 6, 2010).

______ "World Uranium Mining." May 2010. http://www.world-nuclear.org/info/inf23.html (accessed July 6, 2010).

_______ "Nuclear Power in Mexico." May 2010. http://www.world-nuclear.org/info/infl106.html.

World Nuclear News. "Bolivia searches for uranium," wnn, May 18, 2010. http://www.world-nuclear-news.org/IT-Bolivia_searches_for_uranium-1805104.html (accessed July 14, 2010).

APPENDIX I

Summary of Uranium Deposits in Latin America[73]

Country	Deposit Name	Tonnage Range (t U)	Grade Range (% U)	Cumulative Production	Produced Grade (% U)	Deposit Type	Status	Date
Argentina	Cerro Solo	5,000 - 10,000	0.20 - 0.50	0	0	Sandstone - Bascal Channel	Dormant	1/1/2009
	Don Otto	500 - 1,000	0.10 - 0.20	470	0	Sandstone - Tabular	Dormant	1/1/2003
	Huemul	< 500	0.10 - 0.20	155	0	Sandstone - Tabular	Depleted	1/1/2009
	La Estrela	< 500	0.05 - 0.10	21	0	Vein	Dormant	1/1/2003
	Laguna Sirven	500 - 1,000	0.20 - 0.50			Surficial	Unknown	9/25/2009

[73] IAEA Uranium Production Table.

Country	Deposit Name	Tonnage Range (t U)	Grade Range (% U)	Cumulative Production	Produced Grade (% U)	Deposit Type	Status	Date
	Las termas	1,000 - 2,500	0.20 - 0.50			Vein	Exploration	7/6/2009
	Los Berthos	< 500	0.10 - 0.20			Sandstone - Tabular	Depleted	7/6/2009
	Rodolfo	2,500 - 5,000	0.03 - 0.05	0	0	Sandstone - Tabular	Dormant	1/1/2009
	Schlagintweit	1,000 - 2,500	< 0.03	200	0	Vein	Dormant	1/1/2009
	Sierra Pintada District	10,000 - 25,000	0.10 - 0.20			Volcanic	Unknown	9/25/2009
	Urcushum	< 500	0.05 - 0.10			Sandstone - Tabular	Dormant	7/6/2009
Brazil	Amorinopolis	2,500 - 5,000	Unknown			Sandstone - Tabular	Dormant	1/1/2009
	Araxa	10,000 - 25,000	< 0.03			Other	Dormant	9/8/2009

Country	Deposit Name	Tonnage Range (t U)	Grade Range (% U)	Cumulative Production	Produced Grade (% U)	Deposit Type	Status	Date
	Campos Belos	< 500	0.10 7-0.20			Vein	Closed	1/1/2009
	Espinharas	5,000 - 10,000	0.05 - 0.10			Metasomatite	Dormant	1/1/2009
	Figueira	5,000 - 10,000	0.10 - 0.20	0	0	Sandstone - Tabular	Dormant	1/1/2009
	Gandarela	1,000 - 2,500	0.20 - 0.50			Quartz-pebble Conglomerate	Dormant	1/1/2009
	Itataia-Santa Quiteria Distr.	> 100,000	0.05 - 0.10	0	0	Metasomatite	Development	1/1/2009
	Lagoa Real-Caetite District	> 100,000	0.10 - 0.20	1441	0	Metasomatite	Operating	1/1/2009
	Olinda	25,000 - 50,000	< 0.03			Phosphorite	Dormant	9/8/2009

Country	Deposit Name	Tonnage Range (t U)	Grade Range (% U)	Cumulative Production	Produced Grade (% U)	Deposit Type	Status	Date
	Pocos De Caldas	10,000 - 25,000	0.20 - 0.50	0	0	Volcanic	Reclamation	1/1/2009
	Serra Des Gaivotas	5,000 - 10,000	< 0.03			Quartz-pebble Conglomerate	Feasability Study	1/1/2009
Bolivia	Cotaje	500 - 1,000	0.05 - 0.10	0	0	Sandstone - Tabular	Dormant	1/1/2003
Chile	Algorrobo-Al Robie	500 - 1,000	Unknown			Vein		9/8/2009
	Bahia Inglesia	Unknown	< 0.03			Phosphorite	Dormant	1/1/2003
	Carizal Alto	1,000 - 2,500	Unknown			Vein		9/8/2009
	Chuquicamata	2,500 - 5,500	< 0.03			Metasomatite	Unknown	9/8/2009

Country	**Deposit Name**	**Tonnage Range (t U)**	**Grade Range (% U)**	**Cumulative Production**	**Produced Grade (% U)**	**Deposit Type**	**Status**	**Date**
	Estacion Romero	500 - 1,000	0.20 - 0.50			Metasomatite	Dormant	1/1/2003
	Mejillones	Unknown	< 0.03			Phosphorite	Dormant	1/1/2003
	Prospecto Cerro Carmen	2,500 - 5,000	Unknown			Metasomatite	Dormant	1/1/2003
	Sierra Gorda	500 - 1,000	Unknown			Intrusive		9/8/2009
Columbia	Berlin	2,500 - 5,000	0.10 - 0.20			Black Shales	Exploration	9/8/2009
Guyana	Aricheng	2,500 - 5,000	0.05 - 0.10			Vein	Exploration	9/8/2009
Paraguay	Yuti	2,500 - 5,000	0.20 - 0.30			Volcanic	Exploration	9/8/2009
Peru	Bayovar	10,000 - 25,000	< 0.03			Phosphorite	Dormant	9/25/2009

Country	Deposit Name	Tonnage Range (t U)	Grade Range (% U)	Cumulative Production	Produced Grade (% U)	Deposit Type	Status	Date
	Colibri II	2,500 - 5,000	< 0.03			Volcanic	Exploration	9/8/2009
	Colquijirca	500 - 1,000	0.20 - 0.50	0	0	Other	Dormant	1/1/2003
	Corachapi	2,500 - 5,000	0.20 - 0.50			Volcanic	Exploration	9/8/2009
	Macusani District	1,000 - 2,500	0.10 - 0.20	0	0	Volcanic	Exploration	1/1/2003
	Turmalina	500 - 1,000	0.20 - 0.50		0	Collapse Breccia Pipe	Dormant	1/1/2003
	Vilacabamba	500 - 1,000	1.00 - 5.00	0	0	Vein	Dormant	1/1/2003

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