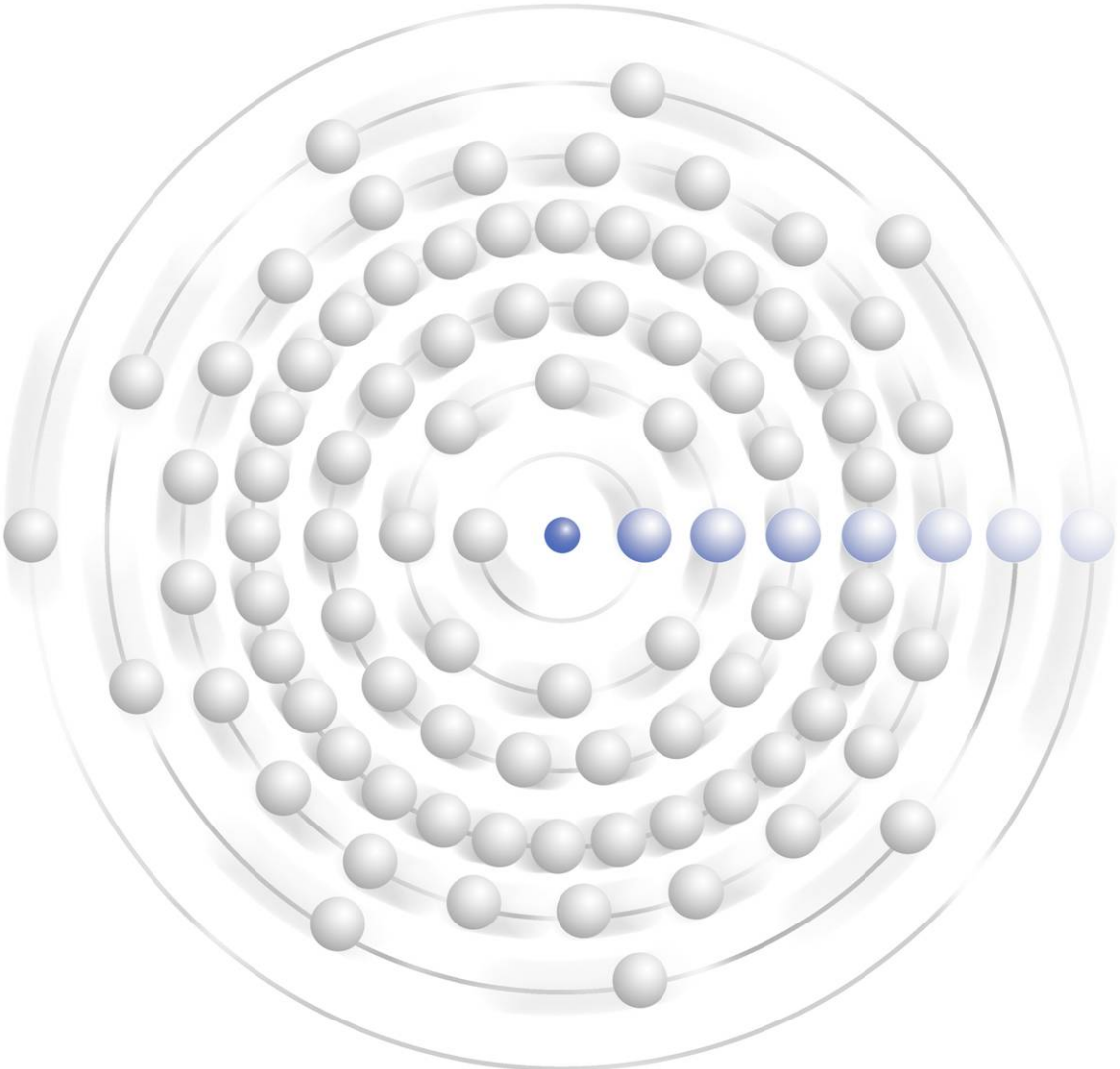
UxC Special Report **April 2008**

Evaluating Nuclear Energy Possibilities: Belarus, Chile, Turkey & Vietnam



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Acknowledgements

Over the past year, The Ux Consulting Company LLC (UxC) sponsored a group of graduate-level students from The George Washington University's Elliot School of International Affairs in their Capstone Project for the completion of a Masters of Arts degree in International Trade and Investment Policy (ITIP). The culmination of this two-semester project is this report, which was designed by UxC and implemented by the following four students, who each covered a separate country:

Anna Bryndza – Belarus

Ellis Chaplin – Turkey

Giselle Cubillos – Chile

Michael Lowe – Vietnam

Each of the students showed tremendous enthusiasm and interest in the subject matter, and UxC was extremely pleased to have the opportunity to work with these four bright scholars on this important project. Through their hard work, we believe they accomplished an impressive report, which should help all readers greatly enhance their knowledge and understanding of the growth of nuclear power around the world, especially in the four countries that this report analyzes.

We wish Anna, Ellis, Giselle, and Michael all the best of luck and success in their future careers in the world of international trade and investment policy, or wherever their paths may eventually lead them.

1 – Introduction & Overview

This report was written for the The Ux Consulting Company, LLC, which is a leading consulting company in the nuclear industry, and provides perspectives on market trends and developments that affect the front-end nuclear fuel markets. The Ux Consulting is a publisher of many nuclear industry publications, such as *The Ux Weekly, Uranium, Conversion, and Enrichment Market Outlook* reports, *Uranium Suppliers Annual*, *Nuclear Power Outlook*, *SpentFUEL*, and various other information services.

Recent years have seen resurgence in the popularity of nuclear power due to two main factors: increasing demand for energy, which has increased prices for traditional inputs for electricity production (natural gas, oil, and coal) and increasing concern about emissions of greenhouse gases. Thus, for many rapidly growing developing countries, nuclear power, which often proved to be too costly before, has became a viable option.

Commencement of new nuclear programs will inevitably impact the long-term price movements in the various nuclear fuel commodity markets as well as the direction of nuclear power industry worldwide. Thus, this project assesses the viability and potential for the development of commercial nuclear energy generating capacity by the year 2030 for four countries: Belarus, Chile, Turkey, and Vietnam. None of these countries presently makes use of nuclear power, although all have expressed varying degrees of interest in initiating a nuclear program.

In addition to conducting assessments of the individual countries, our goal was also to determine the necessary conditions for initiation of a nuclear program. These findings are summarized in the form of a comparative matrix. We found that the main necessary preconditions for a nation to develop commercial nuclear power are strong economic growth, which is expected to continue, strong political will, and reliance on foreign suppliers for a substantial share of energy needs. The latter is deemed a potential impediment to future economic growth. Interestingly, all four of the countries studied have, or have had in the past, nuclear research reactors, which may serve as a precursor to a country's full-scale nuclear program.

2 – Belarus

Author: This chapter was written by Anna Bryndza.

Country Overview

Figure 1. Map of Belarus

Source: CIA World Factbook

Belarus is a land-locked country in Eastern Europe. As a former Soviet Republic, the country retains strong ties to Russia and other surrounding states (Ukraine, Poland, Lithuania, and Latvia). The country is approximately 207,600 square kilometers in size and is predominantly a flat land with much marshland. The population is around 9.7 million people, although this is shrinking at a slow rate. The country is led by President Aleksandr Lukashenko, who, while nominally elected to power since 1994, is considered by most to be an authoritarian leader. In terms of the economy, the latest estimates from 2007 show a GDP of around US$38.72 billion by the official exchange rate. Trade with Russia still dominates the economy.[1]

Rationale for Nuclear Power

After more than a decade of consideration, Belarus finally made an official political decision in favor of nuclear energy on January 15, 2008.

The two major reasons for construction are the *lack of available domestic energy resources* and *the desire to reduce dependence upon imported energy*. Alternatively,

[1] All information taken from CIA World Fact Book, 2008.

the rationales for construction of a nuclear power plant could be conceived as political (energy security) and economic.

Belarus has no domestic energy resources to speak of (other than large deposits of peat). Currently, 93 percent of energy is generated by combined heat and power (CHP) plants in Belarus using natural gas. Vladimir Semashenko, the first vice-premier of Belarus, stated that Belarus could save 4.5-5 billion cubic meters of gas annually by constructing a 2,000 MWe nuclear power plant (NPP). This would allow the portion of electricity produced using gas to be reduced to 65 percent. In fact, the government of Belarus estimated that the net cost of electricity after a NPP begins generating, will be 0.016 -0.017 dollars per kWh, in contrast to the current cost of 0.04 dollars per kWh, resulting in a savings of 200-400 million dollars annually.[2]

Belarus has been heavily dependent on the discounted prices of gas from Russia to keep its isolated economy operational. Energy disputes with Russia and severe macroeconomic shocks led the Belorussian leadership to realize that reliance on a single supplier undermines the sovereignty of Belarus. In August 2005, a new energy security program for Belarus for 2006-2010 was adopted. The integral part of the vision for the future is construction of a nuclear power station. The strategy was adopted to create a solution to Belarus' dependence on the Russian Federation for energy. Thus, the primary goal of the program is diversification of supply and increasing the share of energy produced domestically to 25 percent. In addition to an NPP, the strategy outlines an increase in the use of domestically produced coal for electricity generation as well as construction of two hydro power plants (on the Dvina river in Polotsk and on the Neman river near Grodno).

Actions regarding construction of an NPP were put in place after various gas disputes with Russia. Despite some political drivers behind the disputes, they are economic in principle: increases in prices of natural gas have immediate economic implications for Belarus.

However, the political aspects of the disputes should not be overlooked. Economic dependence means political dependence as well. Even when relations between Russia and Belarus were at their lowest levels, President Lukashenka continuously stressed the fact that Belarus had no option other than good relations with Russia. After all, Russia's Gazprom is a state-controlled company that reflects government policies towards other countries. Thus, the lines between economic and political rationales are often difficult to draw.

However, what we can distinguish is the economic rationale for building an NPP as far as non-macroeconomic costs are concerned. With the prices of energy continually increasing and surpassing any past projections, the government of Belarus argues that electricity produced by an NPP would reduce costs. A 2005 study by Belarus' "Sosny" institute shows that construction of an NPP would reduce the cost of the production of electricity by 15-20%, allowing it to replace the use of 3.51 billion cu-

[2] "Belarus Plans to Bring Nuclear Plant Forward to 2013." *European Daily Electricity Markets*. December 4, 2006.

bic meters of natural gas and reduce the emission of greenhouse gases by 7-10 million tons.[3]

These results were challenged by a study by the German Economic Group in Minsk addressing the economic aspects of construction of an NPP in Belarus. Their results found that from an economic standpoint, nuclear energy would not be economical. While Belarus' dependence on energy imports from Russia is inevitable in the short run, it can be reduced in the medium run by measures other than nuclear power: increase in prices, energy efficiency, and diversification of energy supplies.[4]

In reality, it is unclear whether the plant would be a decision that would be made only for economic reasons. Both studies appear to carry significant biases in terms of assumptions and approaches. In a situation characterized by uncertainty, it was the political factor that truly was the primary reason for the decision.

Supporting this is the fact that Belarus decided to construct its own NPP instead of buying into construction of a reactor in either Russia (Smolensk or Kursk NPP) or in Lithuania, which would have likely required much smaller capital expenditures.

Regardless of whether the major determinants were political or economic factors, the two reasons for nuclear power in Belarus are the *lack of available domestic energy resources* and *the desire to reduce dependence upon imported energy*.

Historical Background on Nuclear Energy in Belarus

The idea of building an NPP in Belarus is by no means new. The first studies on the feasibility of nuclear power in Belarus were conducted in 1978-79, based on which the construction of two 1,000 MWe VVER reactors outside of Minsk (Minsk 1 and 2 nuclear heat and electricity plant) commenced in 1983. Additionally, another NPP was in the design stages as well. However, after the Chernobyl accident in 1986, strong public opposition to the construction led to the abandonment of the projects in 1988. Minsk NPP, which was 80% complete at the time of closure, was converted to a thermoelectric power station running on natural gas.

Yet shortly after gaining independence in 1991, Belarus was confronted with the reality of minimal domestic sources for electricity generation. Thus, the 1990s witnessed yet another resurgence of the idea. In 1992, Belarus announced plans to build an NPP and began a site search, examining 15 possibilities, with the idea of building three reactors with a total capacity of 1,500 MWe. Belorussian officials held meetings with nuclear power plant builders in 1994. In 1996, Belarus Energy Minister Gerasimov said that the country was seeking aid to fund the construction of an NPP, which was to be completed in 2005.

[3] Yakushev A. P. "Yadernaya Energetika v Belarusi." Materials of International Conference, Mink, 2 November, 2005.
[4] Kristian von Khirkhausen et al. "Ekonomicheskiye Aspekty Razvitiya Atomnoi Energetiki v Belarusi." *German Economic Group in Belarus*. March 2006.

However, less then a decade after the Chernobyl accident in next door Ukraine, the country was unified in its opposition to the project and such a level of public opposition was impossible to ignore.

In response, in 1998, a committee composed of scientists and politicians convened to determine whether there was a necessity to construct an NPP, or whether there were alternative means to meet the country's electricity demand. The committee provided projections of Belarus' electricity consumption in the year 2015 and examined ways to meet the rise in demand. The prognosis of the committee was that consumption of electricity and heat in Belarus will reach 55 billion kWh and 99 Gcal respectively by 2015 (the projections take into account a decrease in energy consumption per GDP by 27% due to energy savings). Yet another conclusion was that there was no necessity for an NPP in the immediate future. Thus, the discussion about nuclear power was temporarily put to an end with the institution of a 10-year moratorium on nuclear construction, and approved by parliament (to expire January 1, 2009).[5]

There was a public discussion in March 2003 at the Ministry of Energy with President Lukashenka present to advocate the nuclear project. However, at the time, the officials and the scientists were divided in their opinion for and against the project. It was not until February 2004 that a fresh impetus to the idea was given as a result of a little publicized gas dispute between Russia and Belarus, which took place when Belarus refused to import Russian electricity after a 28% price increase. The event swayed the opinion of the political elites (though not the general public) in favor of the nuclear option as the construction of the NPP became enshrined in the "National Concept" for development of the energy sector before 2020. 2005 also became a year of improved relations between Minsk and the International Atomic Energy Agency (IAEA). In fact, Minsk became a member of IAEA's governing board. Belarus' active role in the IAEA indicates significant preparation of the government to put an end to the opposition to nuclear power on the territory of Belarus prior to the expiration of the moratorium on January 1, 2009.

Present Level of Preparedness and Current Initiatives

- **Legislative Framework**

There are two documents that provide a framework for government policy in the energy sphere: "Concept of Energy Security and Increasing Energy Independence" and "State Complex Program of Modernization of Main Production Funds of Belorussian Energy System, Energy Efficiency and Increasing a Role of Using Domestic Heating and Electricity Resources in 2006-2010." These documents outline the main strategy in the energy sphere, which encompasses several simultaneous approaches: increasing the share of domestic energy sources to 25%, increasing the energy efficiency of the Belorussian economy, and upgrading the present energy infrastructure. Furthermore, these documents instruct the government to study the possibility of an NPP in Belarus to fulfill the strategic goals.

[5] V.T. Kazazyan. "Conclusion of the Commission on the Assessment of the Advisability of Nuclear Power Development in the Republic of Belarus." December 1998.

Even prior to the official decision to construct an NPP, President Lukashenka issued Presidential Decree No. 565 "Regarding Some Measures on Construction of a Nuclear Power Plant" (15 November, 2007). The decree created a Directorate of Construction of a Nuclear Power Plant (within the Ministry of Energy) to perform the client functions, conduct preparatory and research work; prepare tender documentation, etc.

According to the presidential decree, a nuclear and radiation safety department is also to be set up within the Ministry of Emergencies to act as a licensing authority and a state nuclear regulator.

While preparatory work for the construction of a nuclear power plant has been ongoing for some time, the final political decision was made on January 15, 2008 by the Security Council of the Republic of Belarus.

President Lukashenka has recently criticized the slow progress in conducting preparatory work. The president's concern is to speed up the process to meet the tight deadlines that he set out. Notwithstanding the president's criticism, preparation for holding a tender, site selection and a legislative framework are being prepared in an expedited manner. The major piece of legislation is expected in 2008: a law "On the Use of Nuclear Energy," which will be all-encompassing and will provide a regulatory framework for everything from export and import of nuclear materials and equipment to the principles of liability in the sphere of nuclear energy.

- **Personnel**

President Lukashenka gave a direct order to the government to ensure domestic supply of personnel for the NPP. To that extent, a committee has been created and the Ministry of Education began collecting information regarding the needs of the future power plant.[6]

It has been estimated that the necessary number of personnel is approximately 1,500-2,000 people. While Belarus still possesses some qualified nuclear engineers and physicists from Soviet times (within the national Academy of Science, Joint Institute for Power and Nuclear Research—"Sosny"), this resource is aging due to a halt in such programs at the universities. Those programs that were retained, refocused on the pressing matter for Belarus at the time – nuclear safety issues.

Beginning in September 2009, three leading Belorussian institutes will create departments to produce specialists in the nuclear field: construction in the energy sphere, nuclear physics, and operation and safety.

There is already extensive cooperation between Belarus and Russia in the area of nuclear power. Presently, Sosny Institute's nuclear projects are carried out jointly with specialists from the Russian Federation. Thus, it would appear likely that former

[6] "Uchebno-Trenirovochnyi Tsentr Budet Sozdan pri Belorussko AES." Belta. 12 March, 2008. http://news.belta.by/ru/print?id=205021

training programs with Russia would be revitalized, especially considering the convenience of a common language.

In 2008, Russia used the Council of Eurasian Economic Community on the Use of Nuclear Energy for Peaceful Purposes to propose an agreement on the creation of an International Innovation Consortium of the Eurasian Economic Community, to involve universities of the signatories, which include Belarus. Russia is making efforts to establish itself as a regional nuclear knowledge and training center, creating both a Federal Nuclear University and an International Center for Preserving Nuclear Knowledge for Personnel Training.

Belarus will also have to attract experienced personnel from the Russian and Ukrainian nuclear industry, at least at the initial stages. Iran has also expressed interest in training personnel for Belarus, though Belarus is highly unlikely to cooperate with Iran in the nuclear sphere.

Political Situation

The domestic political climate in Belarus is stable, with the executive maintaining effective control of all the branches of power and society. The president remains popular with the majority of the electorate. Such a situation ensures short-term stability and continuity in Belarus. Furthermore, an authoritarian regime creates the strong political will necessary for the project and suppresses the opposition, both of which lead to expedited progress in construction.

Political considerations remain major determinants in choosing a company to construct an NPP and it is important to examine foreign relations of the Republic of Belarus. Despite the fact that the Russia-Belarus relationship reached its lowest point in 2007, Russia remains a principal partner in foreign relations, with the Union of Russia and Belarus under active consideration. Any significant further progress in unification would virtually predetermine the choice of a company to construct the proposed NPP. Various Russian politicians have stated that Belorussian energy problems would be resolved immediately once the Constitution of the Union State is adopted. However, at present there is still no date set for the referendum. In 2007, Russian Prime-Minister Zubkov announced that the Union State's budget is to grow by at least 10 percent in 2008, increasing funding for common projects. Additionally, speculation surrounded President Putin's trip to Minsk, alleging that he is slated to become the president of the Union. At the same time, such breakthrough progress remains unlikely due to differences in opinion between Russian and Belorussian elites as to the form the Union State is to assume. At various times President Lukashenka stated that the Russian Federation is aimed at absorbing Belarus', which is not an acceptable option. In turn, President Putin recently stated that "we are willing to go as far as our Belorussian partners are prepared to."

The most likely scenario is continuing economic integration of the two countries within the framework of the Eurasian Economic Community (EurAsEC). In 2007, Belarus, Kazakhstan and Russia formalized an agreement to create a customs union

by 2011 and are in the process of negotiations to enhance energy cooperation between the member-states.

The relationship between Belarus and Ukraine gained momentum in 2007, when Belarus was searching for partners to partially replace Russia, especially in the economic sphere. Enhanced cooperation continues until this day. While the countries have always remained close, President Lukashenka stresses the importance of this relationship as both Ukraine and Belarus are important transit states for Russian energy destined to Europe. Thus, it is not surprising that Ukraine was chosen as a contractor to help Belarus in preparation of tender documents and site selection.

Relationship with the West remains tense, though last year Belorussian authorities made attempts to improve the state of affairs. Belarus-U.S. relations remain severely strained, with both countries recalling their ambassadors in March 2008 as a result of what Belarus referred to as "new sanctions." Specifically, Belarus recalled its ambassador immediately after the U.S. Treasury Department's Office of Foreign Assets Control (OFAC) issued a statement regarding the applicability of financial sanctions imposed by the department against Belorussian petrochemical concern Belnaftakhim. In March 2008, the U.S. embassy in Belarus halted issuance of a visa regime for Belorussian citizens.

While relations with the European Union also remain far from amicable, they hold much more promise than Belarus-U.S. relations. Belarus remains part of the European Neighborhood Policy (ENP), though there is currently no Action Plan. The step-by-step approach adopted by the EU allows for more flexibility in its relations with Belarus. Belarus made an attempt to improve relations with the EU as its relations with Russia deteriorated. Thus far, the EU has refrained from any comments regarding the U.S. economic sanctions. President Lukashenka stated that Belarus-EU relations could improve if the EU followed its own policies rather than following the lead of the United States: "As for our relations with the European Union, then frankly speaking, I would like them better. It is absolutely unacceptable when the EU dances to the tune of the Unites States."[7] Such a statement appeared to be preemptive of a 2006 situation, when both the U.S. and the EU placed a ban on some Belorussian official's travel.

Tense relations with the West have prompted Belarus to establish contacts with "rogue" states, especially Iran and Venezuela. One of the primary reasons for such new ties is the ability and willingness of these countries to supply Belarus with energy commodities. President Lukashenka characterized the relationship with Iran as a "strategic partnership" in 2007, while President Akhmadenijad referred to Lukashenka as "one of his best friends."[8] In 2007, Iran granted Belorussian state-owned oil company Belarusneft rights to produce oil at the Iranian Jofeir deposit. Belarus has a similar joint oil venture in Venezuela as well.

[7] Andrei Makhovsky. "Belarus Warns West About Closer Moscow Ties." Reuters. March 20, 2008.
[8] "Belarus to Start Oil, Gas Production in Iran soon—Lukashenko." RIA Novosti. 21 August, 2007. http://en.rian.ru/world/20070521/65821235-print.html

Recent escalations in tension between Belarus and the West, especially with the U.S., led to an immediate shift in the tone of statements coming from Minsk. President Lukashenka stated that "I think that in the near future, under such huge pressure from the West on Belarus, our relations with Russia will become even closer."[9] While Belarus' relations with Russia may be periodically improving or deteriorating, it is undeniable that under the present political regime Russia is the only steady political and economic partner.

Imposition of economic sanctions by the U.S. has important political implications in the sphere of nuclear nonproliferation. Belarus cites the sanctions as a breach of a 1994 Budapest Memorandum, which provided Belarus with security guarantees in exchange for joining the Treaty on the Non-Proliferation of Nuclear Weapons. The memorandum stipulated that no signatory will impose economic sanctions to achieve any means. Thus, Minsk argues, the U.S. breach of international law gives Belarus a legal right to deploy Russian nuclear weapons on its territory.

It appears that Belarus' relations with the West will only continue to deteriorate, which leaves Russia as the only strategic partner of true significance.

Economy and Trade

Macroeconomic performance of Belarus has been robust, with GDP growth of 9.9% in 2006. At the same time, inflation remained relatively low at 7%.[10] Despite such encouraging indicators, it is important to understand that the primary drivers of such positive economic performance were external factors: high prices for commodity exports (fertilizers and oil products) and strong demand from Russia.

In 2007, the Belorussian economy experienced deterioration in economic performance as GDP growth decreased to 8.9%, which can be expected to continue. From the demand side, the reason for such a slowdown is decrease in the investment growth rate due to increases in gas and electricity prices. Also, Belarus continues to experience a current account deficit. 2005 was the only year there was a current account surplus. However, in 2005 Belarus was still receiving gas at preferential prices. Subsequent natural gas price increases led to a continually growing deficit. In January-November 2007, the trade deficit increased to USD 3.7 billion, significantly larger than during a corresponding period in 2006.[11] The biggest causal factor of trade balance deterioration is that the average prices of imports of energy grew at a significantly faster rate than the average export energy prices.

The discussion above illustrates that while Belarus has no domestic energy resources to speak of, the energy sector plays a key role in trade and the country's economy in general. Thus, when in January 2007 the price of gas more than doubled (from USD 46.7 per thousand cubic meters (TCM) to USD 100/TCM), the economy of Belarus experienced a sudden energy shock. Taking into consideration that, according to a

[9] Andrei Makhovsky. "Belarus Warns West About Closer Moscow Ties." Reuters. March 20, 2008.
[10] "Ezemesyachnyi Obzor Ekonomiki Belarusi," No. 2 (65), Issledovatelski Tsentr IPM, February 2008. http://research.by
[11] Ibid.

2007 agreement with Russia, the price of natural gas is to gradually increase until 2011, when it is expected to equal the European price, we can confidently state that the shock will increase in magnitude. This will not allow for the economy to adjust in such a short and medium run, resulting in decreasing GDP over the course of the next several years. In March 2008, the Russian price of gas will increase from USD 119 to USD 128 per TCM to reflect an increase in the average European price of gas.[12]

According to a study by the German Economic Group in Belarus, GET, increase in prices from the 2006 level of USD 46.68 per thousand cubic meters (TCM) to USD 200/TCM would result in a 14% decline in GDP.[13] The biggest impact is observed in the energy-intensive sectors (chemical, petrochemical industries, electricity and heat production, glass production). This would also lead to the deterioration of trade balance. The study illustrates the high sensitivity of the economy of Belarus to natural gas prices. Furthermore, price increases would necessitate a significant reduction in consumption of natural gas. Such reductions could be reached by increasing the energy efficiency of the Belorussian economy as well as replacement of gas with other sources of energy, such as nuclear energy.[14]

For Belarus, Russia remains the most important trade partner. In 2006, imports from Russia accounted for 58.7% and 34.7% of total imports and exports of Belarus respectively.[15] However, the EU also remained very important, being the main destination for Belorussian exports (45.6%). On the other hand, the United Stated accounted for only 1.3% of imports and 2.3% of exports.[16]

Belarus' trade relations with the West are following the same course as the political relations. It is important to underline the economic impact of sanctions against the concern Belneftekhim. The company accounts for 25% of the industrial output of Belarus and 30% of export.[17] While the U.S. accounts for a relatively small share of Belorussian trade, similar restrictions by the EU would have tremendous consequences for the economy of Belarus. Trade with the EU has been progressively growing throughout the 1990s and 2000s and it is yet unclear as to what has been the impact of the suspension of the Generalized System of Preferences (GSP) by the EU. We would expect the impact to be small since only about 12% of Belorussian exports to the EU benefit from the system.[18] However, one needs to consider the importance of Belarus as a transit state for Russian oil and gas destined to Europe: after all, approximately 20% of Russian oil for the EU transits Belarus and 1/3 of oil.

[12] "Russia to Raise Gas Prices for Belarus to $128." RIA Novosti. March 21, 2008. http://en.rian.ru/russia/20080321/101958337.html
[13] Irina Tochitskaya. "Ekonomicheskiye Poslyedstviya Povysheniya Tsen na Gaz dlya Belarusi: Kolichestvennaya Otsenka." *German Economic Group in Belarus.* October, 2006.
[14] Ibid.
[15] The European Commission. "Belarus. EU Bilateral Trade and Trade with the World." http://trade.ec.europa.eu/doclib/docs/2006/september/tradoc_113351.pdf
[16] Ibid.
[17] Embassy of the Republic of Belarus in the United States of America. "Concern Belneftekhim: Results in Activities in January-July 2005, Goals and Main Directions of Development." http://www.belarusembassy.org/economic/foreign_trade/950.pdf
[18] Luke Allnutt. "Belarus: No More EU Trade Preferences." *Radio Free Europe/ Radio Liberty*. June 20, 2007.

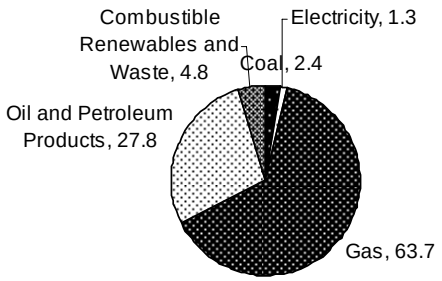
Because trade and economic measures are used by the West to achieve political goals, Belarus is prompted to secure its role in regional economic integration, such as the customs union within EurAsEC. Being part of the customs union would partially isolate Belarus from international economic pressure as well as boost trade with the partner-states (Russia and Kazakhstan).

Energy Demand

Belarus does not have significant energy resources other than biomass (peat). The country's oil deposits, a source of revenue at the beginning of the century, are near exhaustion. At this time domestic oil production satisfies approximately 30% of domestic oil consumption. There is virtually no domestic gas, with 99% of gas consumed being imported from Russia.

The composition of total primary energy supply of Belarus in 2005 illustrates the importance of natural gas in gross consumption of energy resources of the country. The share of gas is 63.4%, higher than any country's in the region. See Figure 2 below.

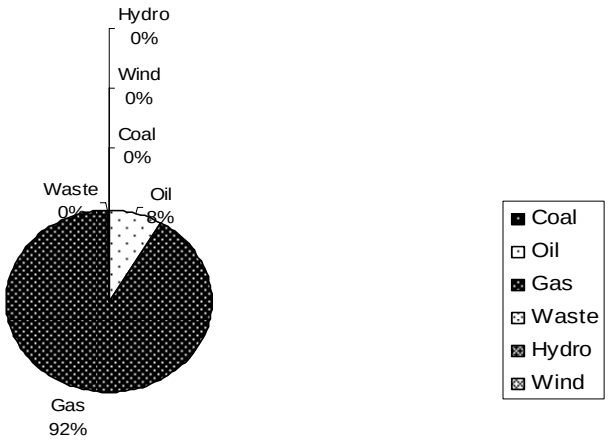
Figure 2. Total Primary Energy Supply in Belarus, 2005



Source: IAE, Energy Statistics, Author's Calculations

The importance of gas specifically for electricity production is even more staggering: 92% of all electricity is produced from gas. In 2005, 74% of gas was used for production of electricity and heat. See Figure 3 below.

Figure 3. Electricity Production by Source in Belarus, 2005



Source: IAE, Energy Statistics, Author's Calculations

Taking into consideration the importance of natural gas for production of electricity, the important aspect is the fact that 92.6% of natural gas is imported from a single supplier, Gazprom. See following Table 1 for the details on Belarus' natural gas imports and domestic supply.

Table 1. 2005 Energy Balance for Belarus: Natural Gas (%)	
Production	1.1%
Import	98.6%
Stock Changes	0.3%
Total	**100%**

Source: IEA, Energy Statistics, Author's Calculations

In recent years Russia's energy policy towards Belarus shifted as Russia decided to bring to an end its policy of subsidizing the Belorussian economy with prices below European prices. Thus, it is planned that by 2011, Belarus will be paying European prices for natural gas.

While above we analyzed the role and dependence of natural gas, 86% of crude oil is also imported from Russia. The situation with oil is more complex though due to the fact that Belarus is a major transit state for Russian oil destined for Europe (approximately 1/3 of the total) and the country has a large refining capacity, which allows for exports of petroleum products.

In 2005, Belarus' net imports of electricity were 4,999 gigawatt-hours (GWh), adding to the total production of 30,961 GWh. 48% of the total electricity consumption was by the industrial sector.[19]

[19] IEA Energy Statistics. "Electricity/ Heat in Belarus in 2005." http://www.iea.org

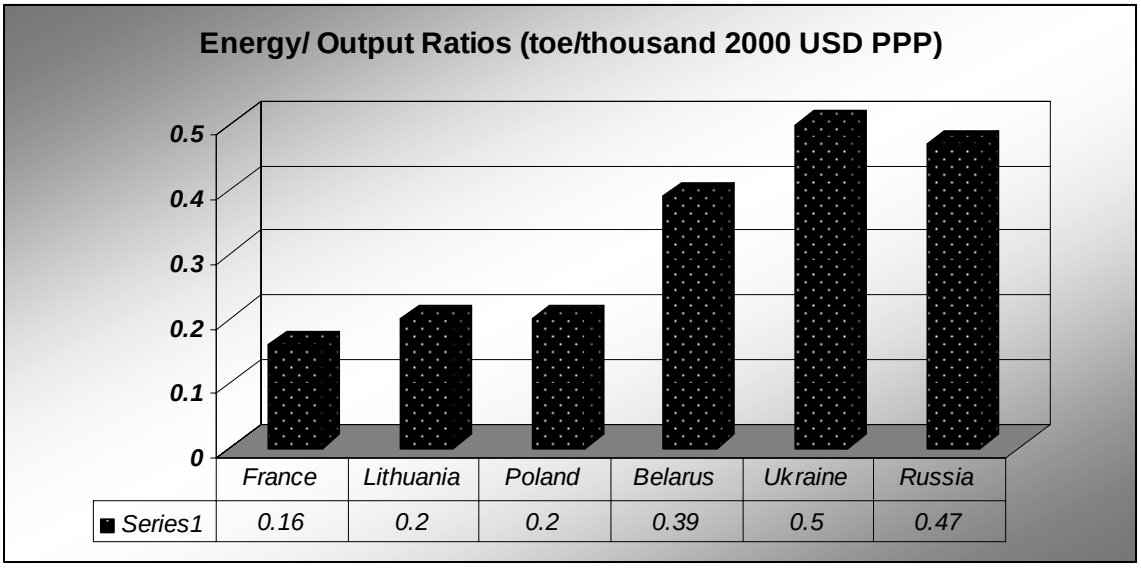
The electricity sector in Belarus is united in "Belenergo," which is a vertically integrated company that performs generation, transmission, distribution and supply of electricity. According to the company's website the installed capacity of the system is 7,913.8 megawatts-thermal (MWt) and it is capable of supplying 100% of demand for electricity and 50% of demand for heat in the country.[20] Despite such capabilities, Belarus continues to import electricity from neighboring states (Russia, Ukraine and Lithuania) due to cost considerations.

The problems with the outdated energy infrastructure became apparent in the early 1990s. During this time, prior to country's fall out with the international community, Belarus turned towards international institutions to help it with modernizing its outdated energy infrastructure. In 1993, the European Bank for Reconstruction and Development (EBRD) provided a loan to the Ministry of Energy of Belarus to assist in modernization of the Orsha power plant to help decrease Belarus' dependence on energy imports. According to some sources, the wear level of the power sector equipment is over 60%. Thus, seeming overcapacity possessed by Belenergo is actually not available due to it being outdated.

- **Energy/Output Ratio**

The economy of Belarus is very energy intensive – a legacy of Soviet times. The graph below (Figure 4) illustrates energy intensity (TPES/ GDP) for six countries in the region. Ukraine, which has the distinction of being the most energy-intensive economy in the world, is followed by Russia and Belarus. At the same time, the comparison should be conducted with France, Lithuania and Poland, whose economies are half as energy intensive as Belarus'.

Figure 4. Energy/Output Ratios of Select Countries



Source: IAE, Energy Statistics

[20] Belenergo Official Website. http://www.energo.by/okon/p21.htm

Improving this ratio has been one of the key parts of the national energy strategy and some progress has indeed been made, which is seen in the fact that GDP growth in the last several years has exceeded the growth in energy demand.

- **Impact of Price Increases on Electricity and Heat Production**

Taking into consideration Russia's policy to bring the price of gas in Belarus to European levels, we would expect a significant reduction in sector output. According to a study by the German Economic Group in Belarus, GET, increase in prices from the 2006 level of USD 46.68 per thousand cubic meters (TCM) to USD 200/TCM would result in a 50% decline in output.

Currently, the government sets residential prices for electricity and they continue to be below cost. Such subsidizies places a significant burden upon the country's budget. Importantly, heavy subsidizing leads to wasteful use of energy. Calls to increase residential rates in order to provide incentives to save energy are, however, ignored due to fears of increasing inflation and potential political effects.

- **Projected Energy Demand**

The Sosny Institute study evaluates the projected growth in electricity demand of 1.9-2.9% per year. Using this range and total final consumption in 2005 of 27,674 GWh, we expect electricity demand in 2020 to be in the range of 36,702-42,492 GWh.[21] The current capacity of Belenergo is sufficient to meet this demand if its infrastructure and equipment is upgraded and/or replaced.

The national energy strategy to meet this demand while decreasing energy reliance on foreign sources involves increased electricity production and energy efficiency. Belarus is looking to tap two domestic sources of energy: biomass and hydropower. In 2007, Belarus began construction of two hydroelectric power stations (on the river Dvina in Polotsk and on the river Neman in Grodno). There is also a national program to increase the use of biomass. However, both of these sources of energy have significant limitations, thus construction of an NPP is an integral part of the strategy.

Various statements by Belorussian officials indicate that atomic energy is viewed as a way for the future. For example, Vladimir Bobrov, the head of the Energy Ministry's strategic development department, said that "Belarus will meet up to 85% of its electricity needs with atomic energy by 2050. The atomic strategy will dominate in Belarus by that time."[22] The implication being that once the first two planned reactors are constructed, we could expect discussion about a third and fourth.

There are various measures that in theory could be implemented to meet the projected demand:

- Construction of a nuclear power plant

[21] A.P. Yakushev. "Yadernaya Energetika v Belarusi." Materials of the International Conference, Minsk, November 2, 2005.
[22] "Atomic Energy to Cover 85% of Belarus Electricity Needs by 2050." Redorbit News. June 2, 2006. http://www.redorbit.com/news/display/?id=524003

- Imports of electricity
- Increase the use the domestic fuels
- Reduction of energy consumption (including through increased tariffs)

In reality, all these measures could and should be combined to meet the demand and achieve the political and economic goals of Belarus. However, we would like to emphasize the major issue that needs to be addressed for the overall strategy to work: technologically outdated overcapacities in the power sector. The sector is in dire need of major investments and while the issue is being addressed, the rate of investment is below the rate of the wear of the equipment and infrastructure.

Public Attitudes

While public opinion is always a crucial factor, it is even more so in Belarus due to the fact that the country was disproportionately impacted as a result of the 1986 Chernobyl nuclear power plant accident in Ukraine. The consequences of the accident still significantly affect the population, environment and economy of Belarus. More than two decades later, approximately 20% of the country remains contaminated with above acceptable levels of caesium-137. Chernobyl had a tremendous psychological impact on the population, leading to a vast majority of the population opposing construction of an NPP.

The most recent public opinion surveys conducted in 2005 by the energy ministry indicate an increase in support for nuclear power as approximately 47 percent of the population supported the construction of an NPP (33% expressed complete support, and 14% with the stipulation that the plant was not constructed in their immediate vicinity). While such numbers indicate that the public is still wary of the plans to construct a nuclear power plant on the territory of Belarus, opinion has been gradually shifting.

In an attempt to sway public opinion, President Lukashenka and the government emphasized the fact that Belarus is already surrounded by the NPPs and is exposed to risk of another nuclear accident. Most of Belarus' neighbors do not only possess NPPs, but also plan to construct new ones.

Public opinion should be closely monitored as the construction of a nuclear power plant is potentially a project that could mobilize opposition. In March of 2008, a group of Belorussian scientists made a decision to create a movement "For Nuclear-Free Belarus."[23] This group of scientists suggests creating a commission to evaluate the desirability of construction in the first place. After all, such a commission was created in 1998, and based on the results of their study Belarus instituted a 10-year moratorium on NPP construction.

[23] Natalya Korotkaya. "Uchenyye Khotyat Zashchitit Belarus of 'Chernobylskogo Ada' i 'Yadernogo Raya.'" *Belorusskiye Novosti*. March 10, 2008.

Furthermore, the group argues that Belarus should only proceed with construction if the project is approved in the national referendum. After all, President Lukashenka repeatedly promised to do so, but has no intentions to conduct a referendum.

Reactor Vendors and Designs

• Vendor Selection

At this time, Belarus is preparing documents for official tender and no company or reactor design has been selected. In fact, Belarus has placed considerable emphasis on the fact that the tender would be open to all interested parties and the decision will be made only based on bid submission. This approach is part of Belarus' tactics to achieve its political goals during the process. Belarus has several potential options, which have been narrowed down in official statements to Westinghouse, AREVA, and Atomstroyexport.

Westinghouse Electric Company

The Belorussian authorities continue to include Westinghouse in their short list. However, the current political situation between the United States and Belarus makes even submission of a bid by Westinghouse appear unlikely. In March 2008, both countries recalled their ambassadors after the U.S. Treasury Department's Office of Foreign Assets Control (OFAC) issued a statement regarding the applicability of financial sanctions imposed by the department against Belorussian petrochemical concern Belnaftakhim.

Westinghouse was never considered as a serious option judging by official statements made over the course of the last few years. The company has been mentioned lately mainly to augment the list of contenders, though numerous statements by Belorussian officials mentioned only AREVA NP and Atomstroyexport as candidates.

We do not expect the company to submit a bid.

AREVA NP

There have been ongoing negotiations regarding the construction of an NPP between France and Belarus. In 2007, the Ambassador of France to Belarus, Mireille Musso, stated that France is prepared to continue negotiations, which will take time to be settled, listing such inter-state issues as signing an inter-governmental non-proliferation agreement and for Belarus to meet certain financial, technical, and legal conditions.[24] Furthermore, a delegation of Belorussian experts and politicians traveled to France in 2006 to meet with the managers of AREVA.

As Lithuania prepares to conduct an open tender for its replacement of Ignalina NPP, the Lithuanian ambassador suggested that if Belarus chooses to build two French reactors, then Belarus and Lithuania could submit a joint order for four reactors to AREVA and could receive better conditions than if they were to submit separate or-

[24] "France is Ready to Continue Negotiations with Belarus on Nuclear Plant Construction." *Belarussian Telegraph Agency*. April 20, 2007.

ders. We expect AREVA to submit a bid and estimate the company's chances of being selected as medium-low.

Recognizing the Russian advantage in the selection process, AREVA attempted to leave room for maneuver with its announcement that if there were sufficient interest from a few states, the company would be willing to manufacture fuel for Russian designed VVER reactors. This might sound like a defeatist statement, but it would most likely generate interest in Eastern European states that desire to decrease their reliance on Russian energy supplies and would welcome alternative sources of nuclear fuel.

In February, an international exhibit "Nuclear Energy-2008" took place in Minsk. Interestingly, there were no French participants, which might be indicative of AREVA's hesitation given the present political climate.

While it is difficult to predict whether AREVA NP will submit its bid due to the rapid deterioration in the relationship between Belarus and the West, we estimate the possibility of the company being selected as a reactor vendor as *medium-low.* However, we believe that there is a slightly higher probability of the company participating in the construction by supplying equipment or fuel.

Rosatom/Atomstroyexport

Though Russia appears to be the natural partner for the construction of the NPP, Belarus has placed considerable emphasis on availability of other options. This has primarily to do with political relations between Russia and Belarus, especially in the energy sphere.

Negotiations with Rosatom have been ongoing and so far unsuccessful. The talks between the Belorussian Fuel and Energy Ministry and Rosatom held in July 2006 were suspended the same day they began and Belarus announced that this leaves a French company to be considered.

When Belarus announced plans to hold a tender in 2007, Russian Prime-Minister Zubkov immediately signaled Russia's interest. Mr. Zubkov's announcement yet again illustrates the political considerations as the driving force for Belarus in choosing a partner. The announcement took place following the meeting of the Council of Ministers of the Union State of Russia and Belarus in October 2007. There was considerable progress made in political integration of the two countries under the auspices of the Union State at the end of 2007. Interestingly, in response to the indication of Prime-Minister Zubkov that Russia would like to return to the negotiating table, Belorussian PM Sergei Sidorski was unwilling to give up the only semblance of leverage that Belarus had by announcing that while Belarus would consider a bid from Russia, there are also other interested countries that will be considered. In either case, the result of political rapprochement was commencement of a new round of talks between Atomstroyexport and Belarus.

As an isolated state, Belarus is forced to rely heavily on the Russian Federation and the regional economic alliances, especially Eurasian Economic Community (EurAsEC). The role of the latter should also be highlighted since it provides an alternative to reliance on Russia exclusively by expanding cooperation with Kazakhstan. In fact, in 2006, President Lukashenka urged the adoption and implementation of a single energy policy in the EurAsEC, especially those points pertaining to nuclear energy.

One important consideration is the cost of construction. Russian nuclear products tend to be less expensive and are considered by the specialists in Belarus to be nearly as good as others. The cost consideration makes it more likely that Russian VVER-type reactors will be chosen for construction in Belarus.

While Russia emerges as by far the likeliest partner, it is important to note the contradiction inherent in this choice. The goal of Belarus is to decrease its reliance on Russian energy. Thus, an operational NPP is seen as achieving this goal. However, all the critical aspects connected to the project, such as fuel supply and, potentially, safety maintenance, would be controlled by Russia.

From Soviet times to the present, there has been a significant level of cooperation between Belarus and Russia in the energy sphere. Presently, Sosny Institute's nuclear projects are carried out jointly with its Russian counterparts. Yet another important consideration is the shared language and the ease of training of future Belorussian experts.

We have a *high* level of confidence Atomstroyexport will be chosen as the reactor vendor.

- **Reactor Design**

Overall desired specifications regarding the reactor design have already been considered in Belarus and two important informal decisions have been made: first, Belarus would like a pressurized-water reactor (PWR); secondly, it should be a third generation reactor.

Thus, if the bids were to be submitted, we would expect the proposals for Westinghouse's AP1000, AREVA's EPR, and Russia's VVER-1000.

While the model numbers of Russian third generation reactors vary, they are commonly known as VVER-1000/ V-392 designed by GIDROPRESS. There are four sites where models based on this design have been constructed (or are in the process of construction): China, India, Iran, and Bulgaria. In all instances the reactor is customized, with the primary difference being the design life, though safety features also differ. NPP Tianwan-1/2 in China (known as AES-91 model) has a design life of 40 years, installed capacity of 2 x 1,060 MWe and annual generated electricity of 14 billion kWh.[25] AES-91 has also been constructed in Kudankulam in India. The only

[25] Antonia Wenisch. "AES-92 for Belene: The Mystery Reactor." Austrian Institute for Ecology. Vienna, February 2007.

known AES-92 model is NPP Bushehr. Though in 2006, Bulgaria decided to award the contract in Belene to Atomstroyexport and its ASE-92 model for two 1,000 MWe reactors with a 60 year design life and improved safety features. Framatome ANP (AREVA) would supply instrumentation and control systems. Thus, we expect AES-91 or AES-92 reactor models most likely to be selected by Belarus.

Construction Time Horizon and Location

• Construction Time Horizon

Initially, the plans included the construction of 2 nuclear reactors to be simultaneously constructed, the first to be commissioned in 2017 and the second in 2020. However, as energy disputes with Russia intensified and the price of gas increased considerably, these estimates were revised to bring the commissioning date closer. Belarus' energy security program for 2006-2010 envisions the commissioning date to be 2015. However, in 2006, President Lukashenka instructed the government to submit a new proposal for the construction of an NPP so as to make the first block operational in 2013.

The question arises as to whether such dates are realistic or are they simply wishful thinking? The latter appears to be true. 2008 will be the year for selecting a site, preparing tender documents and a legal framework. At best, construction will begin in 2009 despite the orders of President Lukashenka that construction is to begin in 2008. Thus, the expectation is to build a reactor in 4 years. The only reactor from the three vendors to be potentially considered with projected timeframe to fit this right now is Westinghouse AP1000 (construction time 36 months).[26] For Russian VVER reactors the construction time is approximately 5.5-6 years. Alexander Glukhov, the first vice-president of Atomstroyexport, noted that if the goal is to have the first block operational in 2017, then the design process must begin no later than 2009.[27]

Thus, recent calls by President Lukashenka to speed up the construction process are designed to add political urgency and are wishful thinking. This appears to be realized within Belarus as the official January 2008 posting by the Embassy of Belarus in the Russian Federation indicates a timeline of 2017 and 2020.[28]

• Construction Site

The final site of the NPP has not yet been chosen. While it was expected to be chosen this spring, the goal is now year's end. While technical difficulties have been encountered during site evaluations, the final choice also has to be politically acceptable so as to minimize public opposition.

[26] Australian Uranium Association. "Advanced Nuclear Power Reactors." Nuclear Issues Briefing Paper 16. March 2008. http://www.uic.com.au/nip16.htm
[27] Alexander Yemelyanenkov. "Usloviya Dictuyet Zakazchik." *Rossiyskaya Gazeta*. 25 October, 2007. http://www.rg.ru/2007/10/25/aes.html
[28] Embassy of the Republic of Belarus in the Russian Federation. "Glava Belorusskogo Gosudarstva Alexander Lukashenko Provyol Zasedaniye Sovyeta Bezopasnosti Respubliki Belarus." 16 January, 2008. http://www.embassybel.ru/press/soft/2008/01/16/15847/

Selection of the site has been taking place on and off over the course of the last decade. While several potential sites have been named at various points, the two primary sites have always been Kukshynovkaya and Krasnopolyankaya project sites (named after the closest villages). These two sites remain the most likely locations at present as well.

Krasnopolyanskaya project site was the first to be considered with work commencing in 2006. It is located in an empty field contaminated by the Chernobyl accident with no infrastructure nearby. However, in 2007, media reported that the ground on this site is unsuitable for the NPP construction, with the speculation of contamination levels being too high.

Kukshynovkaya project site appears to be the most likely to be chosen. Evaluation of this site began in September 2007. In contrast to Krasnopolyanskaya, there is a railroad and a paved road nearby and it is located in an area with more human presence. Another important consideration is the proximity to Russia, which is only 30 km away. Since there has been no official decision announced yet, it is difficult to predict Russia's reaction to the site being virtually on its border. Reportedly, however, there have been technical hurdles with this site as geologists discovered chalk deposits under the intended construction site, calling for site transfer or additional reinforcement of the ground.

There are also two sites that were considered based on political considerations. The first one, Ostrovyetskaya, is in Grodno region. This site is considered in retaliation for Lithuania's decision to construct a radioactive waste storage facility within 700 meters of border with Belarus. While the immediate retaliation was a threat to construct a giant pig farm on the river flowing into Lithuania, a NPP appeared to be even more threatening. Belarus and Lithuania reached an agreement in February of 2008 regarding the storage facilities, now to be placed 4 km away from the border.[29] The site is unlikely since there are many lakes in the area and there is a national park Naroch nearby. The second potential site, Verkhnedvinkaya, is in Vitebsk region, though there has been no evaluation of this site yet.

Thus, the likeliest site at this time is Kukshynava, and the official decision is expected by the end of 2008.

Proposed Locations of a Nuclear Power Plant in Belarus

See the following Figure 5 for the four highest potential NPP sites in Belarus *(numbers correspond to site on map).*

1. Ostrovyetskaya project site
2. Verkhodvinkaya project site
3. Krasnopolyankaya project site
4. Kukshynovkaya project site

[29] "Belarus, Lithuania Agree Radioactive Waste Storage Location." Gomel Oblast Executive Committee. 13 February, 2008. http://www.gomel-region.by/en/bottom_menu/news/economics?ns_id=10022

Figure 5. Proposed Nuclear Plant Sites in Belarus

Costs and Funding

- **Costs**

There have been a few estimates of the costs associated with construction. The government of Belarus approximated the costs to be: 1.3-1.7 billion dollars for one 1,000 MWe reactor and 3-3.5 billion dollars for two 1,000 MW units. Yet the latest 2007 assessment of costs of the two-reactor NPP was increased to 3.3-3.7 billion dollars.

To estimate the costs, we took into account comparable projects by Atomstroyexport. Belene NPP in Bulgaria is projected to have a cost of 3.997 billion Euros (approximately USD 6 billion) for capacity comparable to that desired by Belarus.[30] Originally, the cost was estimated to be 2.5 billion Euros. Looking at an EPR reactor being built in Finland, NPP Olkiluoto (1,600 MWe reactor), the project is also being delayed by 2 years and is currently 50% over its original 3 billion Euros budget.[31]

[30] "Belene Nuclear Power Plant Will Cost 4 billion Euros." *New Europe*. 20 January, 2008. http://www.neurope.eu/articles/82132.php
[31] "East Europe Nuclear Plants Face Many Obstacles." *BBJ*. 20 February, 2008. http://www.bbj.hu/news/news_36407_east%2Beurope%2Bnuclear%2Bplans%2Bface%2Bmany%2Bobstacles%2B-%2Banalysis.html

Consultants from Wood Mackenzie estimate that capital costs for a 1,000 MW reactor have increased to USD 2.5-3.5 billion and project upward pressure on this number as the cost of construction, uranium and steel continue to climb.[32]

Thus, the cost projected by Belarus is most likely underestimated and the price range can be expected to be USD 4.5-6.0 billion.

- **Funding**

Part of the reason for the ambiguity about projected costs is uncertainty about the sources of funding as the cost of borrowing can vary.

Officials in Belarus stated that the country will fund part of the project from its own budget. While the budget deficit of the Republic of Belarus has been relatively low, it has been steadily increasing and is projected to amount to 2% of GDP in 2008. It is certain that in order to finance the project, Belarus will have to borrow money. Taking into consideration significant restrictions on borrowing faced by the country due to political reasons, Russia yet again appears to be the logical choice for a partner.

Russia has been the source of loans to Belarus in the last several years. Russia has also been willing to provide Belarus with loans to pay for energy imports. In December 2007, Russia agreed to provide Belarus with a USD 1.5 billion stabilization loan. Belarus is hoping to receive yet another USD 2 billion loan in 2008, and raise another USD 400 million in the Russian debt market. In an effort to secure contracts, Russia is willing to provide loans on favorable terms. This has been the case with Kudankulam NPP in India.

First vice-president of Atomstroyexport, Alexander Glukhov, addressing Russia's willingness to bring a credit plan to the table in the case of Belarus, stated that "it could be a direct issuance of government credit, and provision of government guarantees for attracting credit."[33] Russian ambassador to Belarus Alexander Surikov also stated that "If necessary, Russia can offer a credit for the entire sum."[34] In 2007, Russia's state-owned Eximbank offered a USD 2 billion credit line to enable purchase of equipment from Russia's Power Machines Company.

One option for funding is the newly created Eurasian Development Bank (EDB). Created in 2006 by Russia and Kazakhstan, the EDB focuses on infrastructure, especially on energy-related infrastructure. While until now the Bank issued USD 270 million loans, it is looking to significantly expand its portfolio. Igor Finogenov, the head of the EDB, noted that the Bank has experience working in Russia-Kazakhstan nuclear projects and "If Belarus has interest to participate in this program, then a given project will be based on those best practices that we have in this area."[35] In February 16, 2007, Belarus requested the EDB to consider co-financing the NPP.

[32] Ibid.
[33] Alexander Yemelyanenkov. "Usloviya Dictuyet Zakazchik." *Rossiyskaya Gazeta*. 25 October, 2007. http://www.rg.ru/2007/10/25/aes.html
[34] Ibid.
[35] Vladimir Glod. "Akademik Voitovich: 'Boyus, Chto na Belorusskoi AES Mozhet Poiti Somoobogashcheniye Urana." 22 February, 2007. http://www.w-europe.org/?p=1563&m=20070222

However, this source of funding would only be available if Russia is chosen to construct the NPP.

However, President Lukashenka is unwilling to admit the limitations of external construction faced by Belarus: "There were several financing offers – from the countries of Near East to the European ones."[36] Specifically, Iran is willing to serve as a creditor or investor, provided that the government of Belarus officially invites the country.

While one might remain skeptical regarding Belarus' willingness or ability to attract private capital, President Lukashenka recently noted that he would not exclude private capital as a potential source of funding. It is yet unclear as to what region of the world such potential investors would come from.[37]

Fuel Supply, Nuclear Waste Disposal, and Nonproliferation

- **Fuel Supply**

While the choice of Atomstroyexport is highly likely, the choice of a fuel supplier remains open for negotiations due to its political sensitivity. The main argument for construction of an NPP is to reduce reliance on Russian energy. Thus, choosing Russian TVEL to be a fuel supplier would appear to be counterproductive.

Ukraine found itself in similar position to Belarus in terms of dependence on Russia for its energy supplies, including nuclear fuel. Thus, the national diversification strategy requires for at least three reactors to be supplied by non-Russian nuclear fuel by 2011. The country embarked on the U.S.-Ukraine Nuclear Fuel Qualification Project (UNFQP), whereby Ukraine embarked on installing nuclear fuel assemblies manufactures by Westinghouse Electric Company. In turn, Ukraine agreed to purchase at least USD 42 million worth of low enriched uranium.[38] The Russian response was less than favorable as TVEL announced that it would withdraw its guarantees on nuclear fuel assemblies. This situation could signal to Belarus the implications of a high degree of dependence on Russia for all types of energy.

AREVA has noted its willingness to produce fuel for VVER reactors if Belarus is joined by other states with this type of reactor. Alexander Mikhailevich, an academic of the National Academy of Sciences of Belarus, noted that there is no longer a monopoly on the fuel supply and named France and China as potential suppliers.[39]

Even if the fuel is supplied by Russian TVEL, dependence upon Russia will decrease. The problem with dependence is framed incorrectly as the reliance is, in fact, on a single source of energy – natural gas, and a single company – Gazprom. Thus, a decrease in the share of natural gas in the energy complex of Belarus would decrease

[36] Embassy of the Republic of Belarus in the Russian Federation. "Glava Belorusskogo Gosudarstva Alexander Lukashenko Provyol Zasedaniye Sovyeta Bezopasnosti Respubliki Belarus." 16 January, 2008. http://www.embassybel.ru/press/soft/2008/01/16/15847/
[37] "Lukashenko Gotov Dovyerit Stroitelstvo Pervoi Belorusskoi AES Chasnikam." Lenta.ru. 21 March, 2008. http://lenta.ru/news/2007/12/03/aes/_printed.htm
[38] "U.S. Commits $14 million to U.S.-Ukraine Fuel Qualification Project." U.S. Department of Energy. 15 March, 2007. http://www.energy.gov/news/4878.htm
[39] "Vozmozhnym Postavshchikom Yadernogo Topliva dlya Belorusskoi AES Mozhet Vystupit Frantsia." Gazeta 24. 16 November, 2007.

Gazprom's leverage. Besides, it is much easier to diversify supplies of nuclear fuel than supplies of gas.

Westinghouse is not mentioned anywhere among potential suppliers of fuel. This is not surprising considering present sanctions by the U.S. against Belarus as the U.S. by no means could serve as a reliable supplier while present relations between the countries hold. This also underlines that while Westinghouse is mentioned as a potential bidder in the construction of the NPP, it is unlikely to even submit a bid, much less be considered.

President Lukashenka stressed the importance being prompt determining the source of fuel supplies: "Because everyone threw themselves into construction of such reactors, and also the deficit and high price of hydrocarbon products make projects of development of domestic nuclear energy rather attractive, but this leads to increase in prices for nuclear fuel."[40]

- **International Uranium Enrichment Center (IUEC) and Nonproliferation**

Yet another development in the region needs to be carefully examined and taken into consideration when discussing the fuel supply: The International Uranium Enrichment Center in east Siberia was officially established in 2007.

Originally, the idea of the IUEC arose as a proposed solution to the Iranian nuclear issue. While the solution was rejected by Tehran, the idea was given a fresh impetus and Russia is currently in negotiations with the IAEA to make the center piece of the Agency's Multilateral Nuclear Approaches (MNA) initiative. While negotiations with the IAEA are ongoing, the IUEC is currently a commercial joint venture between Russia and Kazakhstan.

In theory, a nuclear fuel center like the IUEC would conduct both front and back-end operations to minimize technology transfer. Furthermore, one of the goals of such center is to ensure fuel supplies to mainly developing states if fuel is denied to them for political reasons thus preventing such states from pursuing their own enrichment and reprocessing programs. Currently, it appears that IUEC will conduct only the front-end operations and it is yet unclear whether increasing reprocessing of spent nuclear fuel is politically feasible in Russia.[41]

At this time, the IUEC is a joint venture between Russia and Kazakhstan, with Kazakhstan having a 10% ownership stake. However, Armenia has recently made a political decision to join the center and Ukraine has expressed interest as well.

It would not be surprising if Belarus joined the center in the near future, though we would probably expect this decision to be made at the same time the vendor is selected. There are several reasons why the country would be interested in the project.

[40] "Belarus: Razvitie Yadernoi Programmy—Strategicheskaya Zadacha." Belta. 15 January, 2008. http://zadonbass.org/news/message.html?id=70602

[41] Anya Loukianova. "The International Uranium Enrichment Center at Angarsk: A Step Towards Assured Fuel Supply?" Newly Independent States Nonproliferation Program, The James Martin Center for Nonproliferation Studies. October 2007. http://www.nti.org/e_research/e3_93.html

First, Belarus would buy into the IUEC, which would decrease its feared dependence on Russia. Secondly, the IAEA would serve as an independent observer, assuring that the Center is not guided by political decision-making. Furthermore, since Belarus has no intentions to either enrich or reprocess fuel, the Center would provide one-stop services for nuclear fuel.

Belarus has been a proponent of the creation of the IUEC and refrained from joining it for political reasons. At the time of the Center's creation, there had been no official decision made regarding construction of a NPP. Most importantly, however, is the fact that the proposal was put forward by President Putin on January 25, 2006 at the Council of the Eurasian Economic Union Meeting – a time of ongoing energy disputes between Russia and Belarus.[42]

- **Nuclear Waste Disposal**

All official pronouncements by Belorussian officials indicate the intention of Belarus to ship nuclear fuel to the supplier for reprocessing. The low level waste will be stored at the plant facility in repositories for 5 to 10 years. The deputy minister of energy, Mikhail Ivanov, indicated that Belarus intends to follow the traditional scheme: wet then dry storage at the plant, returned to the supplier for reprocessing, and either receiving the reprocessed fuel back or leaving it with the supplier, depending on the arrangement.[43]

Reprocessing plans likely limit the choice of a fuel supplier to Russia and France. In 2001, President Putin signed into law shipments of spent nuclear fuel (SNF) for "technical storage" and "reprocessing."[44] Russia considers importation of SNF as one of its advantages that can help it win NPP bids as well as be a significant source of revenue of approximately USD 1 billion per year. At the same time, Russia is currently reprocessing fuel only from VVER-440 reactors, the BN-600 and from naval reactors.[45] SNF from the VVER-1000 reactors is stored mostly at reactor sites. In fact, 93% of the Mayak plant's feed consists of Ukraine's and Russia's VVER-440 SNF.[46] Russia has also made it know that it would not take in any foreign-origin fuel for reprocessing, agreeing only to take in Russian-produced fuel.

In the past, some European states sent their SNF to France or Great Britain for reprocessing, but have decided to store them domestically instead. Japan also opened a domestic reprocessing plant to replace the services provided by AREVA and the UK. While in theory AREVA NP would be able to take in Belorussian spent fuel, it is unclear whether the necessary agreements could be reached. Additionally, the costs of reprocessing by AREVA would most likely be prohibitive for Belarus.

[42] Ibid.
[43] "Beloruskaya AES Budyet Bezopasnoi i Ekonomichnoi." http://energetiku.info/article-88-43-67.html
[44] Cristina Chuen. "Russian Spent Nuclear Fuel." Center for Nonproliferation Studies, Monterey Institute of International Studies. February 2003. http://www.nti.org/e_research/e3_25a.html
[45] World Nuclear Association. "Nuclear Power in Russia." March 2008. http://www.world-nuclear.org/info/inf45.html
[46] Ibid.

Belarus is currently studying the Swedish experience with waste management and has formed a joint group with Swedish scientists. It has been indicated that Sweden's plans for a final deep repository are of special interest to Belarus.

In February, first deputy prime-minister of Ukraine, Alexander Turchynov, indicated that there are future possibilities for cooperation in the area of nuclear waste, though the issue needs further discussion. It would appear to be logical for Ukraine, with its 15 reactors, to begin considering SNF reprocessing, including possible imports from countries such as Belarus, but the issue is not currently under consideration.

Thus, while Belarus emphasizes its desire to reprocess spent nuclear fuel on the territory of the supplier country, it is most likely that it would be looking at domestic storage.

International Activities and Nonproliferation

Belarus acquired membership in the International Atomic Energy Administration (IAEA) at the time of its creation in 1957. Belarus was represented on the Board of Governors of the IAEA in 1999-2001 and 2006-2007.

Belarus is party to all major multinational nuclear agreements: the Convention on Early Notification of a Nuclear Accident, the Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency, the Convention on Nuclear Safety, the Convention on Physical Protection of Nuclear Material, the Vienna Convention on Civil Liability for Nuclear Damage, the Joint convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

The agreement between Belarus and IAEA for the application of safeguards in connection with the Treaty on the Non-Proliferation of Nuclear Weapons defines cooperation with the Agency in the nuclear non-proliferation sphere. The Safeguards Agreement was furthered by the Additional Protocol in 2005. According to the Safeguards Agreement, Belarus is subject to regular inspections by the IAEA.

Jointly with IAEA, Belarus prepared a framework of technical cooperation. Technical cooperation has been focused on radioactive waste management, radiation safety and emergency preparedness, all of which became a national priority in the aftermath of the Chernobyl accident. To that extent, Belarus hosted a number of training activities within the IAEA program, becoming a regional Russian-speaking training center in the field of radiation protection. In fact, a new IAEA's five month training course began in Minsk in January 2008.

Belarus has been working with the IAEA for over a year on issues connected with the construction of the NPP. The country has been advocating the IAEA placing greater emphasis on providing assistance for states that decided to construct nuclear power plants for electricity generation purposes.[47] Belarus has been an opponent of what it

[47] "Belarus Vystupayet za Rasshiryeniye roli MAGATE v Razrabotkye Yadernykh Program v Mirnykh Tselyakh." The UN News Service. October 29, 2007. http://www.un.org/russian/news/printnews.asp?newsID=8510.

sees as reduction of the role of the IAEA to monitoring and enforcement, instead advocating more technical assistance and a proactive role for the Agency.

In 2008, Belarus sent official notification to the IAEA following the January 2008 final political decision regarding NPP construction. Apart from personnel training, the IAEA will conduct final evaluations of potential sites and will help Belarus in preparation of a legislative framework in the sphere of nuclear energy.

Conclusion for Belarus

On January 15, 2008, Belarus made a final political decision to construct a nuclear power plant. Nuclear energy is deemed to be desirable, and even necessary, due to a lack of available domestic energy resources and the desire to reduce dependence upon imported energy from a single supplier – the Russian Federation. With the project backed by strong political will, the legislative framework and preparatory work are being conducted in an expedited manner. Preliminary work has also been conducted on all major potential sites of a NPP.

Current plans include construction of two 1,000 MWe PWR reactors, with the first block becoming operational in 2017 and the second block coming online in 2020. Official cost estimations (USD 3.3-3.7 billion) are underestimated, with the most likely final cost falling in the range of USD 4.5-6 billion.

While Belarus continues to emphasize that there are three major vendors that are to be considered during the tender process (Westinghouse Electric Company, AREVA NP and Atomstroyexport), political and economic factors favor the selection of Atomstroyexport. Economic sanctions imposed on Belarus by the U.S. as well as the diplomatic standoff that ensued, make submission of the bid by Westinghouse unlikely.

Among the numerous factors that favor Atomstroyexport are funding and fuel considerations. Despite strong economic growth, Belarus runs budget deficits and has a limited ability to raise capital in international markets. Russia expressed a willingness to offer a loan for the entire amount if necessary. Yet another potential source of funding, the Eurasian Development Bank, is also dominated by Russia, which has a 90 percent ownership stake in the EDB.

When considering fuel supply for the proposed NPP, one has to pay close attention to the International Uranium Enrichment Center (IUEC), a commercial joint venture between Russia and Kazakhstan. Belarus has been an ardent proponent of IUEC and the Center would provide Belarus with a reliable source of supply of fuel. Addressing Belarus' concerns regarding reliance of Russia for uranium in addition to present dependence for natural gas and oil, AREVA offered to produce fuel for VVER reactors. The question of disposal is as of yet unresolved and will be determined at the time of the signing of the contract. While Belarus made pacifying promises that spent fuel would not be stored on the territory of the country, fuel reprocessing might be unviable due to cost and political factors.

Finally, Belarus has increased its cooperation with the International Atomic Energy Administration (IAEA) and has ascertained the IAEA's involvement in various planning and preparatory processes. Belarus is also a signatory to all major multinational agreements.

We project with high level of certainty that by the year 2025 Belarus will have two 1,000 MW reactors (total output of 2,000 MWe). We are also highly certain that Russia's Atomstroyexport will be chosen as a contractor for construction with its VVER-1000 (AES-91 or AES-92) reactor design.

3 – Chile

Author: This chapter was written by Giselle Cubillos.

Introduction

In order to evaluate the viability and potential for the development of commercial nuclear energy generating capacity of a country, it is important to examine various factors that will affect the choice that the country makes toward implementing a commercial nuclear energy program. In the case of Chile, we can look at the incentives that exist for the country to adopt nuclear energy. These include economic, geopolitical and other factors that make it likely that in the future Chile will begin building commercial nuclear reactors. There are also factors that may deter a country from developing a nuclear program. These factors are important due to the unique nature of nuclear power: the need for long term planning and commitment, and the roles and responsibilities demanded of the State by the use of complex technology.

To better understand the factors that influence any decision made by Chile, one must establish some background information. Chile is a country located on the southwest coast of South America. It is a country isolated by natural borders, the Andes mountain range to the East, the Atacama Desert to the North, and Oceans in the West and South. Due to the geographical features of the country, Chile's population of slightly over 16 million[48] is concentrated in the central area of Chile, from

Figure 6. Map of Chile

Source: CIA World Factbook

[48] CIA The World Factbook. https://www.cia.gov/library/publications/the-world-factbook/geos/ci.html.

Coquimbo to Puerto Montt. This is less than half of the total land area. The Northern portion of Chile, while less populated, contains most of Chile's mining activity. Here the country's rich copper mines are located.

Although Chile does not currently have any commercial nuclear reactors, the country is not entirely inexperienced with nuclear reactors. The Chilean Experimental Reactor (RECH-1) is located at La Reina Nuclear Center in Santiago and the Chilean 2 Experimental Reactor (RECH-2) is located at Lo Aguirre Nuclear Center, between Santiago and the coastal city of Valparaíso.[49] The first reactor, RECH-1, has been operational since October 13, 1974.[50]

Chile first considered a nuclear energy program in the late 1970s, but it was decided that is was not an economically viable option.[51] However, economic factors have changed since then and once again a Chilean leader is exploring the energy options, including nuclear, that are before Chile.

President Michelle Bachelet in March 2007 set up the Nucleoelectric Working Group, known as the Zanelli Commission.[52] The commission was tasked with advising the government "in the evaluation of studies towards the identification of opportunities, advantages, challenges and risks that would be involved in the use of nuclear energy for production of electricity in this country, within the framework of international treaties that rule in this matter (Article 1º Decree Nº 49, 2007)."[53]

In November 2007, the Commission publicly released its report. Many of the findings of the Zanelli commission relate directly to the focus of this report, the viability and potential for the development of commercial nuclear reactors.

Rationale for Nuclear Energy Program

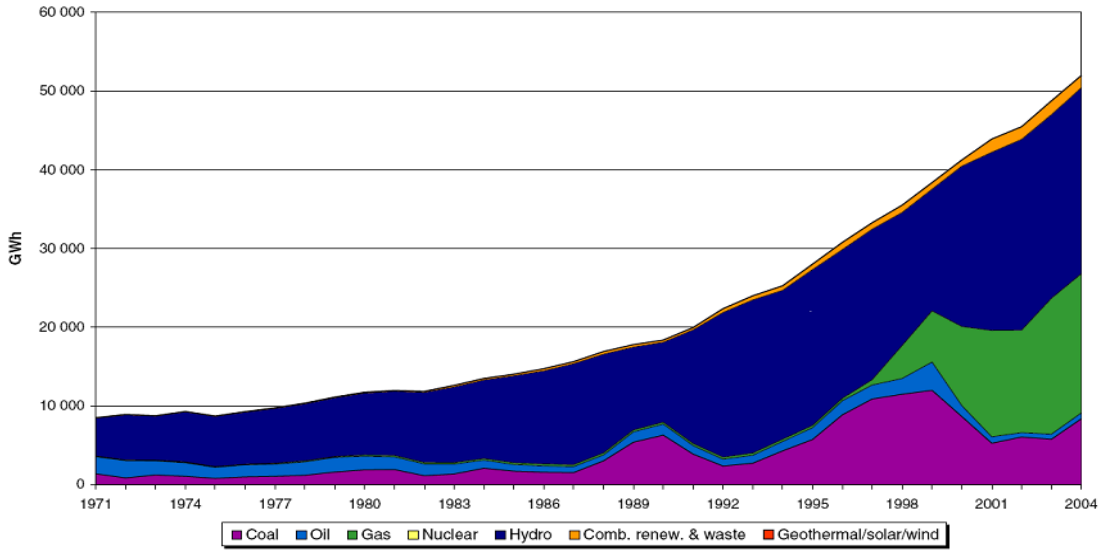
The reasons for which Chile has now begun to consider nuclear energy are many and varied, but can be divided into four principle motivations. First, the country's increasing energy demands. Second, the country's limited resources translate into an increasing reliance on foreign energy sources. Third, there is the rising price of oil and natural gas. The final motivation is environmental concerns, both from a global and country specific perspective.

Chile, from 1987 to 2006, saw all forms of energy consumption increase at an average annual rate of 5.7 percent.[54] Over this same time span, the increase in electric energy consumption increased at an average of 7.5 percent annually.[55] This rise in energy demand and electricity consumption specifically, has been driven largely by economic growth, primarily in the mining industry.

[49] Comisión Chilena de Energía Nuclear. http://www.cchen.cl/index.php
[50] *Ibid.*
[51] Long, Gideon. "Strapped for energy, Chile looks at nuclear option." Reuters. March 9, 2007. http://uk.reuters.com/article/oilRpt/idUKN0917630320070309
[52] La Comisión Chilena de Energía Nuclear. Nucleoelectric Working Group. "The Nucleoelectric Option in Chile." September 2007. http://www.cchen.cl/mediateca/PDF/report_zanelli.pdf
[53] *Ibid.*
[54] BP Statistical Review of World Energy 2007. http://www.bp.com/productlanding.do?categoryId=6848&contentId=7033471
[55] Nucleoelectric Working Group, op. cit. September 2007.

This rise in energy demand has naturally strained traditional energy sources due to the limited conventional resources available within Chile.[56] Chile was able to historically provide for its energy needs largely through domestic hydropower from dam and run-of-river hydroelectric power plants.[57] In 1970, over half of Chile's electricity was generated using hydropower, and the rest was generated from thermal sources, oil and coal. (See Figure 7) In the mid 1990s growing energy demand, combined with drought conditions, provoked the government of Chile to reassess its energy policy and, as a result it began encouraging the use of natural gas.[58]

Figure 7.Evolution of Chile's Electricity Generation by Fuel, 1971-2004



Source: International Energy Agency (IEA)

Where previously domestic production constrained consumption, with natural gas only constituting 8 percent of total energy consumption in 1996, Chile began large-scale imports of natural gas for the first time in 1997. Since then, the country's natural gas consumption has increased by an average of 21.7 percent annually through 2004.[59] Figure 7 shows the growing importance of natural gas (*in green*) in electricity production since 1996.

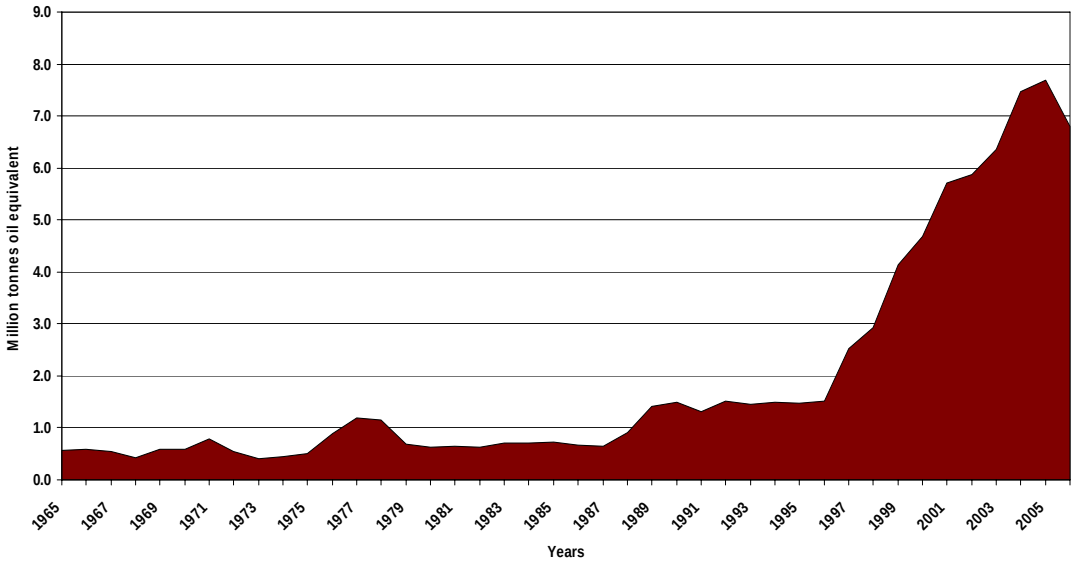
In 1995, an agreement with Argentina was reached by which Chile would begin to import natural gas from Argentina from pipelines constructed to connect Argentine gas to Chile's electrical grid. Imports began in 1997. Since then, Argentina provides 100 percent of Chile's of natural gas imports. After one of the worst droughts on record, between 1998 and 1999, diminished the amount of hydropower available to Chile, the government was prompted to place greater reliance on other sources of energy.[60]

[56] Speiser, Robert M., "Energy Security and Chile: Policy Options for Sustainable Growth." January 17, 2008. http://Chicago.ssrn.com
[57] Nucleoelectric Working Group, op. cit. September 2007.
[58] U.S. Department of Energy, Energy Information Administration. http://www.eia.doe.gov/emeu/cabs/Chile/Full.html
[59] *Ibid.*
[60] Galetovic, Alexander and Fischer, Ronald D., "Regulatory Governance and Chile's 1998-1999 Electricity Shortage" (November 2001). World Bank Policy Research Working Paper No. 2704; CEA Working Paper No. 84.

Imports of gas replaced the use of other fossil fuels and successfully provided for an increasing share of energy demand until 2004. However, in 2004 Argentina faced domestic pressure and "Argentina's energy ministry promulgated Resolution No. 659/2004, which gave it the authority to grant natural gas supply privileges to domestic consumption rather than to exports."[61] This resulted in cuts of exports to Chile. Since 2004, imports of Argentine natural gas to Chile have been between 20-50 percent less than contracted volumes.[62]

Figure 8 illustrates the sharp increase in natural gas consumption that began in 1997, the year that imports from Argentina began. Although Figure 8 only shows natural gas consumption until 2006, the decrease in consumption from 2004 onward is clear and this trend has continued and sharpened as exports to Chile were cut further in 2007.

Figure 8.Chile's Natural Gas Consumption, 1965-2006



Source: BP Statistical Review of World Energy 2007

In 2007, Argentina made further cuts to the quantity of the natural gas it sends to Chile and as a result, power plants and factories in the capital were forced to switch to diesel and fuel oil.[63] In fact, natural gas flows ceased completely for a brief time during the bitter winters of 2006 and 2007.[64] The necessity of switching fuels during a period of high world oil prices nearly quadrupled the cost of producing electricity.[65] An additional cost has been the deterioration in air quality in Santiago. Natural gas is a much cleaner fuel than diesel and oil. As a result of Chile switching to these fuels

[61] Chile's Uncertain Energy Landscape in 2008, November 28, 2007. http://www.wharton.universia.net/index.cfm?fa=viewfeature&id=1443&language=english
[62] Speiser, op. cit. January 2008.
[63] Barrionuevo, Alexei. "Energy Crunch Threatens South American Nations." *The New York Times*. October 13, 2007.
[64] Speiser, op. cit. January 2008.
[65] Barrionuevo, op. cit. October 2007.

to make up for natural gas reductions, an unprecedented number of dangerous smog days were reported in 2007 compared to the past seven years.[66]

It is clear that there is pressure for the Chilean government to look to new and diversified energy sources. What is not clear is whether a nuclear energy program is the solution that Chile will ultimately adopt.

Analysis

To better evaluate the likelihood of Chile developing a commercial nuclear energy program in the future, further analysis is needed as to aspects that may facilitate or hinder the implementation of a nuclear program within Chile.

• Economic Drivers

Chile is a country that has experienced steady economic growth for over 20 years and which is projected to continue to have solid growth for many years in the future. This growth is largely a result of good economic policies that the government has adopted. These policies include maintaining a relatively small debt, encouraging international trade, private competition and a commitment to an open economy, which has attracted foreign investment.

From 1986 to 2005, Chile's gross domestic product (GDP), adjusted for inflation, grew at an average annual rate of 6 percent.[67] At this rate, Chile nearly doubles its GDP every 10 years. Projections for future economic growth are estimated at about 4.9 percent annually until 2030.[68] However, these projections hinge on the ability to secure energy supplies for energy intensive industries, which are the main contributors to economic growth.

Chile, for many years has adopted various measures to eliminate market inefficiencies, promote competition and strengthen institutions.[69] These include adopting a floating exchange rate, modernizing regulation of the electricity industry, passing laws concerning international commercial arbitration. All these steps have been taken while at the same time increasing per capita income and reducing poverty.[70]

Despite strong economic factors there are reasons for concern. Although difficult to calculate, it is thought that already Argentine gas cuts have triggered a slowdown of economic growth.[71] There are also several industries that are especially vulnerable to energy cuts, including copper mining and methanol production, which have experienced economic setbacks.[72] These industries contribute a great deal to GDP growth, especially as demand for commodities continues to rise. The Central Bank of Chile estimates that the direct effect on industry alone reduced GDP by at least 0.2% per-

[66] *Ibid.*
[67] Calculations for average annual growth use yearly GDP levels obtained from: Development Data Group, The World Bank. 2007. 2007 World Development Indicators Online. http://go.worldbank.org/3JU2HA60D0.
[68] APEC Outlook
[69] Gobierno de Chile, Chile foreign Investment Committee. http://www.foreigninvestment.cl
[70] Ibid.
[71] Speiser, op. cit. January 2008.
[72] Ibid.

centage in 2006.[73] Additionally, there is the potential for reduced international investment in Chile if increasing energy costs and concerns over energy shortages lead investors to conclude that the risks are too high in Chile.[74]

Both the historic and projected economic growth, as well as concerns that the projected growth may be limited due to a lack of energy security will likely encourage the Chilean government to adopt plans for commercial nuclear reactors.

- **Finances – Funding Nuclear Energy**

While Chile has not yet come to a decision about whether to build commercial nuclear reactors, there are concerns that have been expressed by the Zanelli Commission that would need to be addressed prior to any decision about nuclear power.

The Zanelli Commission reasons that building a nuclear reactor is too costly and too risky for private investment alone to provide all the funding necessary. Therefore it is likely that the Chilean government would have to provide public funds for any nuclear project. However, by providing government funding, Chile would have to change the current regulatory framework for electricity generation, which the government considers to be efficient.[75] Under the current legal framework, it is private business that makes decisions about investment in new generation plants through consideration of expected profits over a determined time period. By changing the model for electricity generation, the government could include priorities such as environmental, public health and national security objectives that necessitate a government role in order to be met.[76]

The concerns over how commercial nuclear reactors are funded and how that will affect the current privatized structure in Chile do not preclude a further analysis of the future of nuclear reactors in Chile. Rather, it indicates that there is a serious discussion within the country's government about how nuclear energy would necessitate certain changes in current regulation and the need to examine how Chile might respond to these changes.

- **Energy Demand**

Currently, Chile's electricity demands are met through four electric grids with a total installed capacity of 12,370 MWe. The Northern Interconnected System (Sistema Interconectado del Norte Grande, SING), the Central Interconnected System (Sistema Interconectado Central, SIC), the Aysén System (Sistema de Aysén) and the Magallanes System (Sistema de Magallanes).[77]

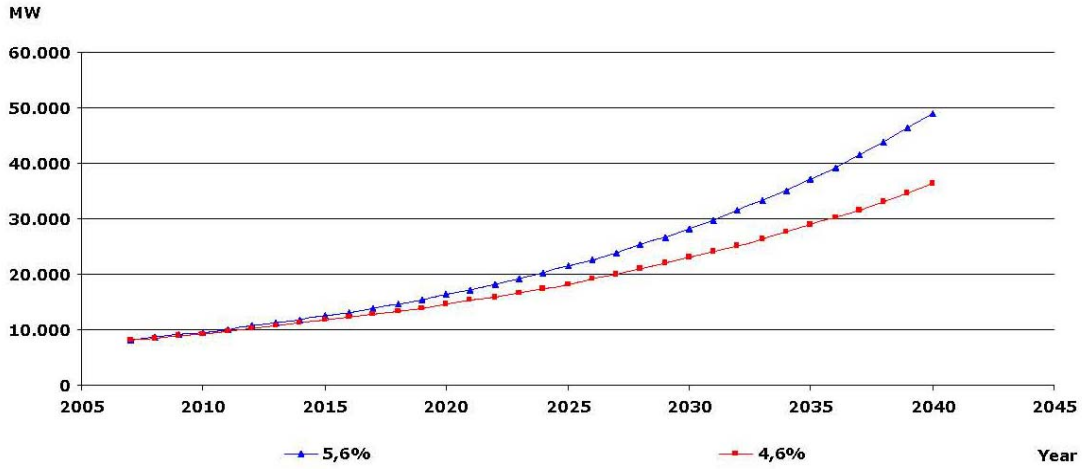
SING covers the northern territory and accounts for 29.12 percent of the national installed capacity with 90 percent of consumption by the mining and industrial sector. Electricity generation for SING is 99.6 percent thermal power and .4 percent hydroe-

[73] Ibid.
[74] Speiser, op. cit. January 2008.
[75] Nucleoelectric Working Group, op. cit. September 2007.
[76] *Ibid.*
[77] *Ibid.*

lectric power. The SIC grid is the country's main electric system with 70.09 percent of national installed capacity. It is also the system that provides electricity to the majority of the Chilean population (90 percent of population). The composition of electrical generation for SIC is 55.2 percent hydroelectric and 44.8 percent thermal. The Aysén System and the Magallanes System both are located in the south, providing electricity to the two southern most regions of Chile, and together these systems provide less than 1 percent of national installed capacity. The Aysén System is 41.5 percent thermal and 58.5 percent hydropower while the Magallanes System is entirely thermal power.[78]

Primary energy consumption has been growing at an annual rate of nearly 5.6 percent from 1987 through 2007. Yet over this same time period the increase in electricity consumption has increased at an average annual rate of 7.5 percent. Thus electricity consumption is increasing faster than all forms of energy consumption and faster than growth in the economy. Future electricity demand is projected to grow between 4.6 to 5.6 percent annually. Using the conservative estimate of 4.6 percent annual increase would have demand for electricity doubling by 2023 and tripling by 2032.[79] See Figure 9 below.

Figure 9. Chile's Future Electricity Demand Scenarios



Source: Nucleoelectric Working Group, September 2007

The Chilean National Energy Commission has plans to increase the national installed capacity by about 10,000 MWe by the year 2018. These plans include hydroelectric projects with a capacity of 1,100 MW, thermal generation providing 8,500 MWe, geothermal generation 260 MWe, and wind generation 150 MWe.[80]

[78] Nucleoelectric Working Group, op. cit. September 2007.
[79] *Ibid*
[80] *Ibid*

• Domestic Politics and Geopolitical Situation

While Chile's stable return to democracy after a prolonged military dictatorship has helped to attract foreign investment and reassure the international community, the current elected president may be the biggest hurdle to proceeding with a nuclear energy program.

Since 1990, when democracy was restored, Chile has enjoyed an extended period of political stability. Representative government has strengthened and successful elections have brought to power politicians from the left and the right. The elections in 2006 led to the current president, Michelle Bachelet. President Bachelet, before winning the presidency, pledged that her government would refrain from nuclear energy.[81] At the same time, there have been statements made by the president that have indicated she is nervous about nuclear energy. All this means that during her government a decision about nuclear energy will not be made. Since the current government will be in office until 2010, planning for building a nuclear energy reactor will not begin until that time.[82]

In addition to the opposition from the current President of Chile, there is domestic opposition that arises from concerns of environmentalists, who are opposed to nuclear power and stress that energy relief can be found in the promotion of wind and solar power.[83] Furthermore, the Zanelli Commission pointed to the possible domestic resistance to nuclear that could occur due to the fear that surrounds the impact of radioactive accidents and the threats posed by nuclear waste both now and for future generations. There is also the issue that in the public mind there is an association of nuclear power with images of Hiroshima, Nagasaki and the Chernobyl disaster.[84]

While domestic politics may hinder or delay action on any nuclear energy projects, geopolitics may help to urge Chile to find more ways in which to diversify its energy sources. Tense relationships with Bolivia and Argentina may become the motivation needed in the future.

The relationship between Chile and Bolivia has been cool since 1879, when the War of the Pacific was fought between Chile, Peru and Bolivia. At that time Chile annexed some of Bolivia's land; part of that land gave Bolivia its only access to sea. Since then, Bolivia has demanded a land passage to the Pacific but Chile has not met this demand. So, Bolivia, which is thought to have the largest reserves of natural gas in the region, refuses to export gas to Chile and has in fact forbidden Argentina from re-exporting Bolivian gas to Chile.[85]

With Chile's other neighbor, Argentina, relations had been improving. However, since Argentina's actions in cutting exports of natural gas to Chile, the relationship

[81] Bartlet, Rob. "International Nuclear Energy Lobby Visits Chile." The Santiago Times. December 11, 2007. http://www.santiagotimes.cl/santiagotimes/index2.php?option=com_content&do_pdf=1&id=12490
[82] Long, Gideon. "Strapped for energy, Chile looks at nuclear option." Reuters. March 9, 2007. http://uk.reuters.com/article/oilRpt/idUKN0917630320070309
[83] "Chile's nuclear decision to take years-Bachelet." Reuters. September 25, 2007.
[84] Nucleoelectric Working Group, op. cit. September 2007.
[85] Barrionuevo, op. cit. October 2007.

has worsened.[86] These regional conflicts directly impact Chile's ability to secure energy supplies from abroad and may encourage Chile to develop nuclear energy in the future.

- **Trade and International Agreements**

Chile for many years has encouraged greater trade, using an export driven economy as its development strategy. One step it has taken to encourage trade is the adoption of a flat tariff for all goods entering Chile. The country's main export partners include the United States, Japan, Brazil and France. Additionally, Chile has sought out free trade agreements with the United States, Canada and is in negotiations with Australia. Both Canada and Australia have large reserves of Uranium and these established relationships could aid Chile if the country decides to have nuclear energy.

Chile is also a signatory to many international agreements including some that relate to nuclear technology, science and safety. Some important multilateral agreements that Chile has signed are: the Nuclear Non-Proliferation Treaties, the Comprehensive Nuclear-Test-Ban treaty, the Convention on Civil Liability for Nuclear Damage, Convention on the Physical Protection of Nuclear Material, Convention on Early Notification of a Nuclear Accident, Convention on Nuclear Safety, and the Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL).[87]

In addition to being a signatory to many multilateral agreements concerning nuclear energy and technology, the Chilean government in the Zanelli Commission report has made it clear that they are aware of legal and regulatory requirements that they are presently lacking and which would need to be adjusted before proceeding with a nuclear energy program.

- **Building a Nuclear Power Plant**

While the ultimate decision of whether or not to build a nuclear power plant will be left for a future administration, the Zanelli Commission points out several issues that must be resolved. First, there is the fact that the current regulatory and legal frameworks are inadequate to those needed with a nuclear program. They must be adjusted in order to meet international norms and practices. There are currently institutions in Chile that perform everything from promoting and operating to regulating.[88] These would have to be reassigned to avoid conflicts with international requirements.

Next, there is the problem that Chile lacks the needed human resources. At the moment, although Chile in general has a skilled work force, there is little experience with nuclear technology. The Commission recommends that Chile develop a domestic training program to build human resources to support areas related to nuclear technology. It also suggests that there might be a way to gain specialization through

[86] Barrionuevo, op. cit. October 2007.
[87] International Atomic Energy Agency, Country Factsheets: Chile. http://ola.iaea.org/FactSheets/CountryDetails.asp?country=CL
[88] Nucleoelectric Working Group, op. cit. September 2007.

a scheme sponsored by the IAEA where Chileans could gain experience at nuclear reactors in other countries.[89]

Finally, there is the issue of deciding where to place a nuclear power plant. Chile is a country with a great deal of geographical diversity with an extensive coastline and vast areas with very low population density. This should provide the government with plenty of locations that it can consider for any proposed nuclear power plant. One important consideration that will need to be included in any analysis of nuclear energy is the nature of seismic activity in Chile.

According to national experts, Chile is the country that releases the larges amount of seismic power worldwide.[90] Yet the Zanelli Commission clearly emphasizes that seismic risk should not be an obstacle for the construction of a nuclear power plant.[91] Chile can look at other countries that also have seismic activity (Japan and USA) and the standards used there are sufficient for Chile.[92]

- **Nuclear Fuel: Supply, Waste and Spent Fuel**

Due to the fact that Chile has not made the decision to begin a nuclear program, there is not yet a definite idea of where Chile would obtain Uranium or how it would deal with waste and spent fuel. Some ideas that have been discussed for the future include participation by Chile in the Global Nuclear Energy Partnership (GNEP). This initiative would make fuel-supplying countries responsible for the removal of spent fuel from user countries. But in actuality, by whom Chile is supplied with Uranium will likely depend on what type of reactor is built and the company that builds the reactor.

So, if Chile builds a reactor, who will build it? Recent articles have mentioned that there is strong lobbying by various parties in Chile. This includes talks between the Russians and Chile as well as reports that a major Chilean business group has already had discussions with France's AREVA about building a nuclear power plant to connect Chile's northern and central power grids.[93]

Conclusion for Chile

With President Bachelet delaying any decision to build a nuclear power plant until 2010, it would be unlikely that Chile would be able to build a reactor before 2020. This also happens to be the date that Jorge Zanelli, in an interview with Business Chile, mentioned as the date by which Chile would be ready for a nuclear power plant. However, it is dependent on the next administration having the political will to make a final decision about nuclear energy. So, it cannot be said with any certainty that Chile will build a nuclear power plant.

[89] Nucleoelectric Working Group, op. cit. September 2007.
[90] *Ibid.*
[91] *Ibid.*
[92] Long, Gideon. "Strapped for energy, Chile looks at nuclear option." Reuters. March 9, 2007. http://uk.reuters.com/article/oilRpt/idUKN0917630320070309
[93] World Nuclear Association. "Emerging Nuclear Energy Countries." http://www.world-nuclear.org/info/inf102.html

4 – Turkey

Author: This chapter was written by Ellis Chaplin.

Introduction

In this report we assess the viability and potential for the development of commercial nuclear energy generating capacity in the Republic of Turkey. The twenty-first century has the markings of being a very successful period for this pivotal nation. With a population of over 75 million, Turkey is strategically located, controlling the Dardanelles that link the Black and Aegean Seas.[94] In effect, Turkey is located at the cross-hairs of the European Union, Middle East and Russia.

Figure 10. Map of Turkey

Source: CIA World Factbook

Turkey's Economy

Turkey's economy has experienced healthy growth over the last decade. Her people are well educated and the population base is growing.[95] The economy is a complex mix of industry and trade together with a strong agriculture sector which employs over 35% of the population.[96] Over the last decade there has been a growth in the private sector despite the significant role played by the central government in the energy, communication, and banking industries.

Despite economic downturns in 1994, 1999, and 2001, Turkey's economy has prospered with reforms meant to bolster the private sector. In 2004 the nation's GDP grew by 9%, but dropped back down to 5% by 2007. Inflation has been down over

[94] World Bank Country Brief 2007: Turkey.
[95] CIA world fact book.
[96] CIA world fact book.

the last four years, although it is still loomed large at 8.5% in 2007.[97] Additional data on Turkey's economy is found in the following Table 2.

Table 2. Economic Data for Turkey[98]

	2003	2004	2005	2006	2007
GDP at market prices YTL m	359,763	430,511	487,202	576,322	653,114
GDP US$ m	239,700	302,000	362,614	403,459	490,031
Real GDP growth (%)	5.8	8.9	7.4	6.1	5.2
Consumer price inflation (avg %)	25.3	10.6	10.1	10.5	8.5
Population (m)	71.3(b)	72.3(b)	73.3(b)	74.3(b)	75.2
Exports of goods fob (US$ m)	51,206	67,047	76,949	91,889	105,861
Imports of goods fob (US$ m)	-65,216	-90,925	-110,479	-132,075	-151,303
Current-account balance (US$ m)	-8,036	-15,601	-22,603	-31,764	-35,545

Domestic Politics and Geopolitical Situation

Even with occasional flair-ups, such as the selection of current President Abdullah Gul in August 2007, Turkey has been blessed with relative political stability. Turkey's Prime Minister, who functions as the true head of state, is Recep Tayyip Erdogan, who has been leading the government since March 14, 2003. Erdogan along with Energy Minister Hilmi Guler, have been strong advocates for Turkey's continual advancement toward the development of a Turkish nuclear power program.

Rationale for a Nuclear Energy Program

- **Why Turkey?**

Turkey has long sought to develop a nuclear energy program. The years 1960, 1968, 1974, 1998 and 2000 all marked failed attempts by the Turkish government to jump-start the construction of a nuclear power plant.[99] Turkey does, however, operate a number of nuclear research centers and has one operating, U.S. supplied, research reactor. In November 2007, the Turkish parliament passed legislation which created an outline by which the Turkish Public Electricity Wholesale Co. (TETAS) could oversee the licensing, building and operation of nuclear power reactors in Turkey. The legislation stipulated that after a bidding process, the winning bidder sign a contract with TETAS to supply the government 100% of the output from the nuclear plant for the first fifteen years after its commissioning. The Turkish Atomic Energy Authority (TEAK) was designated as the regulatory body which would specify the selection criteria for participation in the tender.

Initially the tender was to be issued by February 21, 2008, but this date was not met and on March 24, TEAK announced the formal launch of the tender with all bids due by September 24, 2008.[100] This gives any interested company or consortium of com-

[97] CIA world fact book.
[98] TheEconomist.com, *Turkey's Economic Structure.*
[99] Hibbs, Mark, *Clock Begins Ticking on Turkey's Complex Power Reactor Plan*, Nuclear Watch, Vol. 48, No. 48, pg. 7.
[100] *Turkey Tender Formally Launched*, World Nuclear News, March 25, 2008.

panies six months to assemble a proposal. To date, the specifications of the tender remain unclear, although it is known that TEAK willing to accept bids for Pressurized Water Reactors (PWR), Boiling Water Reactors (BWR) or Pressurized Heavy Water Reactors (PHWR). The reactors must produce at least 600 MWe and have a forty year service life. TEAK officials have said they will not establish set guidelines on "what suite of technologies, infrastructure, and financial arrangements can best fulfill the terms of the winning bid."[101] The law does not require a Turkish company be a part of the winning bid, but many small Turkish firms are looking to participate.

According to the legislation, firms will own the plant and will, as part of their proposal, form a consortium with banks to demonstrate the ability to finance the project.[102] Originally the legislation established price ceilings at which TETAS would purchase the nuclear electricity. This requirement was removed, however, over fears it would limit the pool of companies willing to bid.

The law stipulates that the winning bidder be granted a power generation license to build a nuclear power plant to house up to three reactors, each having a minimum capacity of 600 megawatts.[103] They will be given public property free of charge so as to ensure the plant is built at a government approved site. The reactor will remain privately owned.[104]

It is clear that even though much has moved forward, there remain significant hurdles to the plan. Procedural details remain to be ironed out. The details of the tender remain murky.[105] While the Turkish Supreme Court recently upheld the constitutionality of the November 2007 legislation, it did overturn one provision in the law, which would have allowed foreign staff to be employed by the Turkish Atomic Institute. This has led to some uncertainties regarding how foreign workers would be able to interact with the Turkish government in planning, developing, constructing, operating and maintaining the reactors.[106]

- **Turkey's Energy Dilemma**

There has been a significant growth in demand for power in Turkey. Nearly half of Turkey's electricity output comes from power plants which run on Russian and Iran supplied natural gas.[107] Some are predicting Turkey's electricity resources will fall short by 2014.[108] Even if this does not prove true, it is predicted that by 2020, 82% of Turkey's natural gas will come from Russia and Iran, making the economy more vulnerable to price increase and supply disruptions.[109] As Figure 11 below demonstrates, Turkey's current energy portfolio puts the nation in a weak position as it is very dependent on foreign imports of oil and natural gas.

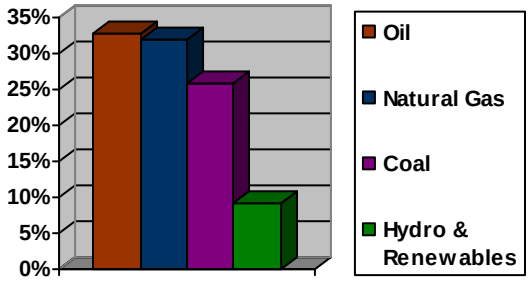
[101] Hibbs, Mark; *Clock Begins Ticking on Turkey's Complex Power Reactor Plan*, Nuclear Watch, Vol. 28, No. 48, pg. 6.
[102] *Ibid.*, pg. 5.
[103] *Turkey Could Announce Tender for its First Nuclear Power Plant on February* 21, Ux Weekly, December 3, 2008, Vol. 21, Issue 49.
[104] Hibbs, Mark; *Clock Begins Ticking on Turkey's Complex Power Reactor Plan*, Nuclear Watch, Vol. 28, No. 48, pg. 8.
[105] At the time of writing this report, the exact details of the tender remained unclear.
[106] *Turkish Court paves Way for Nuclear Power Tender*, Reuters UK, March 6, 2008.
[107] *Turkey Delays Inauguration of First Nuclear Plant Tender*, The International Herald Tribune, February 21, 2008.
[108] *High Growth in Electricity Generation Necessitates Nuclear Plants in Turkey, Say Electricity Generators*, Anatolia, July 31, 2007.
[109] Cevik, Serhan, *Diversifying Turkey's Energy Portfolio will Help Reducing Vulnerability to Supply Disruptions*, Morgan Stanley: Global Economic Forum, April 19, 2006.

In addition to concerns over price concerns, many Turkish leaders are uncomfortable with their dependence on Russia and Iran, which have occasionally failed to provide Turkey with adequate supplies. Energy Minister Guler has expressed optimism that nuclear power could meet twenty percent of Turkey's total electricity needs.[110]

Turkey is dependent on Russia for nearly 63% of its natural gas supply and therefore is very dependent on its northern neighbor. For this reason, Turkey is working with Russia to build a liquefied gas terminal in the port of Ceyhan, located on the Mediterranean Coast to complement the LNG plant already in place on Turkey's Black Sea coast.[111] It should come as no surprise then that Turkey is eager to be more independent by developing its own nuclear power program.

Some believe the natural gas problem might be addressed by the Nabucco pipeline, which is to run from the Caspian Sea, via Turkey and up into Europe. However, Russia has expressed concern with this project and sought to undermine it by recently signing deals with Turkmenistan and Kazakhstan which were to supply Nabucco. Under the agreement, the two nations would run their natural gas supplies through Russia, thereby limiting the ability of the Nabucco pipelines to attract sufficient natural gas supplies.[112]

Figure 11. Turkey's Energy Portfolio



Nuclear Fuel Supply

Many questions remain as to how the tender will address fuel requirements. In January, Energy Minister Guler stated that at first the fuel for the nuclear power plant will be imported, "but we are also going to process our own uranium reserves . . . [and] establish our fuel producing facility and have the opportunity to use our national potential."[113] Turkish professor Dr. Ahmet Bayulken, an expert in Turkey's nuclear field, has also made similar claims. In March 2008, he stated his preference that Turkey builds reactors that use nuclear technologies which used natural uranium which Turkey posses in its own soil. This, he argued, would allow Turkey not to depend on

[110] *Turkey Delays Inauguration of First Nuclear Plant Tender*, The International Herald Tribune, February 21, 2008.
[111] *Russia Interested in Turkey LNG Terminal*, Reutgers, February 21, 2008.
[112] Ozerkan, Fulya, *Turkey Warm to Russian Involvement in Nabucco*, Turkish Daily News, February, 23, 2008.
[113] *Government Set to go Nuclear*, The New Anatolian, January 21, 2008.

enriched uranium from the U.S., Russia or France.[114] These questions must be resolved before 2014, when the government hopes to have the plant fully operational.

Environmental Issues

Many of the details regarding the handling of spent fuel were addressed in the November 2007 legislation which stipulated that TETAS would be responsible for waste management and disposal. The law further required that a fee be placed on the eventual bid winner to pay 0.15 cents/kWh to cover TETAS' costs. The builder, however, would be responsible for the transportation of fuel and radioactive material to the plant.

Location of Nuclear Plants

Turkey has already designated the site for the first nuclear power plant. It will be built on the Mediterranean coast at Akkuyu (see Figure 12 below). Energy Minister Guler made this clear in an announcement on national television on March 18, 2008.[115] The site was preferred as it had been licensed by the government in 1979 as a suitable place to build a nuclear reactor.[116] Not all are happy with this selection, however. Greenpeace has called on the Turkish government to abandon the project.[117] Environmentalist argue Akkuyu is unsafe and not fit for housing a nuclear power plant as it is only 15 miles from a seismic fault line.[118]

The government, however, is quickly moving ahead with the Akkuyu site, and already has plans for the location of a second plant which it would like to see officially approved and licensed by early 2009. The second plant would be at Sinop which is located on the coast of the Black Sea. As soon as the first tender is completed, the government hopes to launch a second tender for the Sinop location.[119] A possible third tender, for a nuclear power plant is also under discussion. A third site has yet to be identified, however.

Figure 12. Turkey's Nuclear Plant Sites: Sinop and Akkuyu

[114] *I.T.U.'s Nuclear Reactor to Resume Activities,* Turkish Press.com, March 18, 2008.
[115] *Turkey to Build First Nuclear Plant on Mediterranean Coast: Minister*, " Turkish Daily News, March 19, 2008.
[116] *I.T.U.'s Nuclear Reactor to Resume Activity*, Turkish Press.com, March 18, 2008.
[117] *Nuclear Companies Gamble on Future of Turkey*, Turkish Daily News, February 20, 2008.
[118] *Turkey to Build First Nuclear Plant on Mediterranean Coast: Minister*, Turkish Daily News, March 19, 2008.
[119] Yackley, Ayla Jean. *Turkey Seeks Bids to Build First Nuclear Power Plant*, Bloomberg.com, March 24, 2008.

International Support

Given the recent trend of market liberalization, Turkey has attracted many foreign investors, who see Turkey as a growth market. Foreign nations are also eager to partner with Turkey in its nuclear ambitions. With the launch of the tender, vendors from around the world have expressed an interest in bidding. In the United States, General Electric Co. is rumored to be exploring a partnership with Turkey's Haci Omer Sabanci Holding AS to submit a joint bid.[120] But the United States is far from the only country with industries looking to Turkey. In early April Japan's Itochu, along with Atomic Energy Canada Ltd, France's Vinci and Suez all submitted tender documents, hoping to win the bid.[121] A coalition of German companies, including E.ON, Siemens, BASF, Knauf, Ekosolar, ISKEN, Babcock, Hitachi Power Europe, GmbH and EnBW, are weighing the possibility of also making a play. On March 13, 2008, a large group of German businessmen and the German Ambassador to Ankara met with Guler to discuss the Turkish energy market and the possible role of German firms in meeting Turkey's future power needs. Guler claimed the nuclear tender was not discussed.[122] Germany's neighbor, the Czech Republic, is also pushing its nuclear energy firm, CEZ which is actively looking for new opportunities to build nuclear power station abroad. It is likely CEZ would need to partner with a larger firm to be a viable player in the bidding war.[123] TETAS has announced that it also expects bids from companies in Russia and South Korea.[124]

Of all the company's eager to place a bid, none is in worse condition then France's AREVA. This has nothing to do with AREVA's ability, but rather with the tense political situation between the two nations. In 2001, the French parliament recognized as genocide the World War I killings of Armenians by the Ottoman Empire. In 2006 France's lower house of parliament further infuriated Turkey by passing a bill which criminalized any denial of the alleged genocide.[125] The fact that France's President Nicolas Sarkozy continues to oppose Turkey's bid to join the European Union, further complicates matters.

All this has not stopped AREVA from declaring its intentions to bid on the Turkish tender. Gabriel Saltarelli, head of AREVA's commercial affairs in Central and Eastern Europe stated that AREVA is "going to give it all [they] have and hang on to demonstrate that it is possible to work in Turkey despite difficult political conditions."[126] In order to help AREVA's prospects, France's junior Trade Minister, Herve Norelli took a three day visit to Turkey in February 2008 to meet with Turkish energy officials.[127]

[120] Yackley, Ayla Jean, *Turkey Seeks Bids to Build First Nuclear Power Plant*, Bloomberg, March 24, 2008.
[121] *Four Foreign Firms Eye Turk Nuclear Tender*, Reuters, April 8, 2008.
[122] Ozerkan, Fulya, *Germans Eye Turkey's Booming Energy Sector*, Turkish Daily News, March 14, 2008.
[123] *Czech CEZ Says to Look for Nuclear Projects Abroad*, Reuters, March 19, 2008.
[124] *Four Foreign Firms Eye Turk Nuclear Tender*, Reuters, April 8, 2008.
[125] Ozerkan, Fulya, *France Seeks Economic Thaw against Political Chill*, Turkish Daily News, February 20, 2008.
[126] *Areva Declares Interest in Turkey Nuclear Plant Project*, Interactive Investor, February 18, 2008.
[127] *Areva Declares Interest in Turkey Nuclear Plant Project*, Interactive Investor, February 18, 2008.

Existing Treaties

Turkey has done much work to ensure it has the proper treaties in place to facilitate its nuclear aspirations. Turkey is currently bound by many international agreements including the IAEA's Nuclear Nonproliferation Treaty. In addition President Bush sent the *Agreement for Cooperation between the United States of American and the Republic of Turkey Concerning the Peaceful Uses of Nuclear Energy* to Congress for approval. Also known as a "123 Agreement,"[128] the trade pact was initially negotiated by the Clinton administration in early 2000 but was not submitted to Congress for approval until now due to proliferation concerns and the presence of the A.Q. Khan network in Turkey.[129]

In arguing for the agreement, President Bush wrote Congress assuring the concerns have been resolved and arguing that "entry into force of the Agreement will serve as a strong incentive for Turkey to continue its support for nonproliferation objectives and . . . provide the necessary legal framework for U.S. industry to make nuclear exports to Turkey's planned civil nuclear sector."[130] The Turkish parliament has already approved the agreement. Congress is expected to pass the agreement this year. In addition to the 123 Agreement, Turkey has expressed a desire to join U.S. Department of Energy-led Global Nuclear Energy Partnership this year.[131]

Conclusion for Turkey

It is highly likely Turkey will have one or two nuclear power reactors in operation by 2020. The government has made clear it would like to see the first reactor operational by 2014 – an ambitious timeline. It is possible a third reactor could be online by 2030. Despite a history of failed attempts to jumpstart a nuclear power program, Turkey seems well positioned, at this time, to begin construction of a plant at Akkuyu within the next year or two. Much will rely on the ability of the Turkish government to stick with the current schedule for the completion of the tender. Further delays could shake the confidence of foreign investors. The complexity and relative speed at which the government is moving is sure to produce bumps in the road as companies and the regulatory bodies seek to hammer out the details. Also, uncertainty regarding fuel supply remains an unresolved issue. Overall, however, Turkey can be categorized as a very strong contender for becoming a nuclear power plant operator in the near future.

[128] Named for Section 123 of the Atomic Energy Act of 1954 which addresses cooperation with foreign nations.
[129] *Turkey Prepares to Prosecute Nuclear Smugglers*, International Export Control Observer, February.
[130] White House Press Release, January 23, 2008.
[131] Hibbs, Mark, David O'Byrne, *Turkey to Pick Reactor Vendor by End of 2008*, Nucleonics Week, January 31, 2008.

5 – Vietnam

Author: This chapter was written by Michael Lowe.

Geography

The Socialist Republic of Vietnam is located in Southeast Asia and is bordered by the Gulf of Tonkin and the South China Sea to the east, China to the north, Laos and Cambodia to the west, and the Gulf of Thailand. With an area of 330,363 square kilometers, Vietnam is equivalent in size to Ohio, Kentucky, and Tennessee combined. Its estimated population at the end of 2007 was 85.2 million.[132] Vietnam's location is strategically significant in that it occupies the Greater Mekong Sub-region (GMS), which provides the People's Republic of China's (PRC) with a gateway to members of the Association of Southeast Asian Nations (ASEAN). Vietnam's long shoreline, deep-water ports, and road links with neighboring countries are similarly advantageous, as they facilitate increased economic interaction at both the regional and global level.

Figure 13. Map of Vietnam

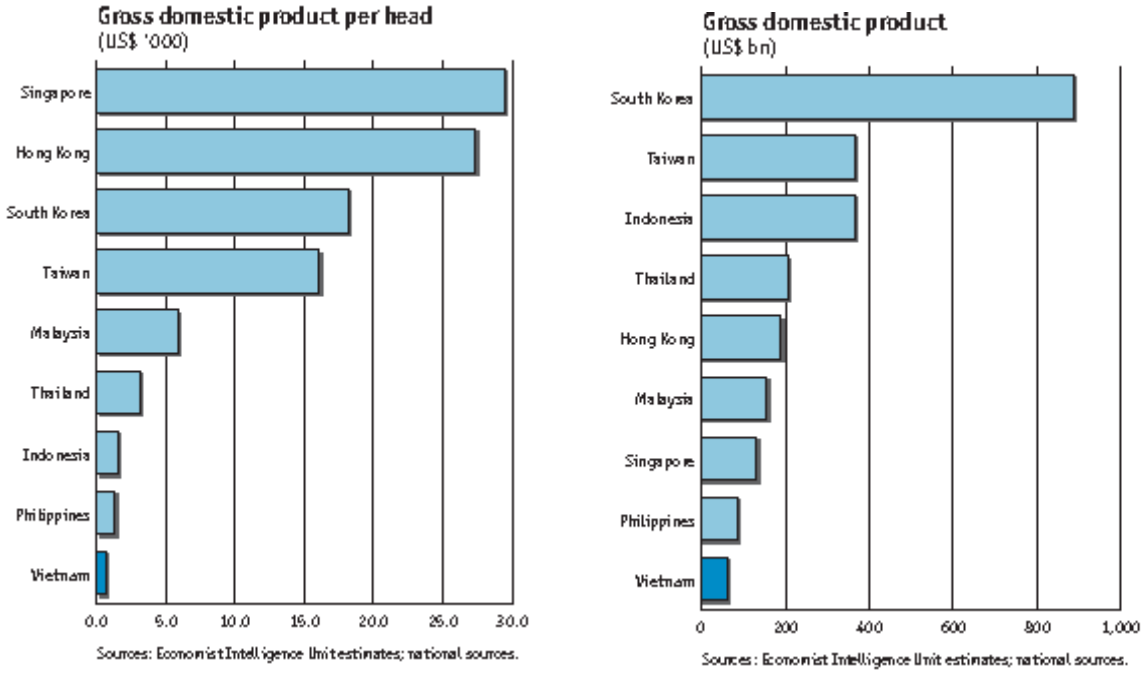
Source: CIA World Factbook

Economy

In 1986 a commitment was made to pursue a policy of *doi moi* (economic renovation) that would open Vietnam to the world economy and to limit some of the constraints on private enterprise. This transition from a centrally-planned economy to a market-oriented one has delivered significant benefits in terms of economic growth and social development. As a testament to this fact, Vietnam's average annual economic growth of 7.8% since 2001 has exceeded that of all other countries in the Asian and Pacific region except for the PRC. While Vietnam's economic growth experience over the past decade has been impressive, it is still a small economy with a GDP of US$61bn in 2006 and has low levels of per capita GDP (US$726 in 2006) relative to its Asian peers (see Figure 14 below).

[132] "Vietnam—Background Notes." U.S. Department of State. http://www.state.gov/r/pa/ei/bgn/4130.htm

Figure 14. Vietnam's Economy in Comparison to Other Asian Countries



Source: Economist Intelligence Unit

The sector breakdown of the Vietnamese economy is: Industry and construction (41.5% of GDP, 2006), services (38.1%) agriculture and forestry (20.4%).[133] Growth in the industrial sector has been particularly strong, with annual growth surpassing 10%, mostly as a result of expansion in the production of steel products, garments, footwear, cement, and car and motorcycle assembly.[134] Services growth has also been stellar at 7% annual growth, with retail sales and tourism being the main drivers. Agricultural growth, however, has lagged at 3.9% annually since 2002.[135] The compositional breakdown of Vietnam's economy is reflective of the country's steady transition from an agriculturally-based economy to an industrialized economy.

The Vietnamese government is also in engaged (though somewhat reluctantly) in the process of selling shares in state-owned enterprises (SOEs) to private investors. That being said, the government continues to maintain full control of enterprises in strategic sectors (e.g. energy). Additionally, the SOEs share of GDP has remained relatively constant since 2000, at 38-39%.[136]

Vietnam's impressive economic growth is due in large part to a rapid rise in exports and the aforementioned growth in industrial production. In an effort to build on recent success the Vietnamese Government has outlined the following targets for economic development for the period 2000-2020:[137]

[133] Background Note—Vietnam. U.S. Department of State. http://www.state.gov/r/pa/ei/bgn/4130.htm.
[134] Ibid.
[135] Vietnam Country Profile. Economist Intelligence Unit. October 1, 2007.
[136] Background Note—Vietnam. U.S. Department of State. http://www.state.gov/r/pa/ei/bgn/4130.htm
[137] Socio-Economic Development Plan 2006–2010 (SEDP). Government of Vietnam. http://siteresources.worldbank.org/INTVIETNAM/Overview/20270134/cprgs_finalreport_Nov03.pdf

- A doubling of GDP by 2015 to be attained through economic growth of over 7% per annum;
- Investment to be increased to 40% of GDP (already achieved);
- Exports to grow more than twice the rate of GDP;
- The share of agriculture in GDP to decline to 16-17%; industry to increase from to 40-41%; and services to increase from 40% to 42-43%;
- The share of rural employment to decline from about two-thirds to half;
- The share of urban population to increase from a quarter to a third.

Please refer to the table below for the Vietnam government's projections of economic growth rates for three scenarios (low, base, high). Importantly, these growth rates were used in the estimation of future electricity demand to 2020 (see section on Energy Demand below).

Figure 15. Vietnam's GDP Growth Rates for the Period 2000-2020 (Government Estimates)

GDP annual growth rate	2000-2005	2006-2010	2011-2020
Low, %	6.5	6.5	6.3
Base, %	7.2	7.2	7.1
High, %	8.0	8.0	7.5

Source: Vietnam Atomic Energy Commission (VEAC)

In order to achieve the aforementioned targets, the Vietnamese government is actively pursuing a series of reforms seeking to: "develop infrastructure; remove remaining policy and structural barriers to business development; complete further administrative reforms; develop market institutions, including financial institutions and land and labor markets; and develop human resources."[138]

While Vietnam's recent economic performance has been striking, its economy does face risks that could negatively affect the economic growth outlook in the near- to medium-term. The economy remains at risk due to inflationary pressures arising from excessive domestic credit growth. The State Bank of Vietnam (SBV), Vietnam's central bank, has responded by taking steps to tighten monetary policy, but pressure from the central government to keep interest rates unchanged (so as to promote economic growth) has raised concerns about inflation. These fears have been borne out, as Vietnam's annual inflation rate soared to 19.4% in March 2008. Additionally, the cost of food and foodstuffs surged by 30.6% year over year. These developments are significant in that, in addition to weakening Vietnam's economic

[138] Vietnam Country Strategy and Program, 2007-2010. Asian Development Bank. http://www.adb.org/Documents/CSPs/VIE/2006/CPS-VIE-2006-02.pdf

competitiveness, continued increases in food prices will create significant social unrest and could negatively affect governability (i.e. political stability).

Domestic Finances

With regard to domestic finances, the government's budget deficit reached an equivalent of 1.8% of GDP in 2007, up from 0.3% of GDP in 2006.[139] With the expected drop-off in tariff revenue as a result of WTO accession, growth in budget revenue is expected to decline from 17.0% per year (2001–2005), to 12.9% per year (2008–2010).[140] Given the strong likelihood that the government runs a budget deficit in the coming years, there is a high probability that debt financing will be needed to finance a significant portion of the eventual construction costs for the nation's first nuclear power plant (NPP). According to media reports, government-owned Electricity of Vietnam (EVN) will have an equity interest in the project of US$1bn, with plans to borrow an additional $2.4bn, comprised of $602mil in local commercial loans and $1.74bn overseas.[141] Acquiring such financing will likely require a combination of political risk insurance, export credit and other commercial financing guarantees to make financing terms more viable.

Electricity Supply and Demand

Electricity of Vietnam (EVN) is the state-owned electricity utility in Vietnam operating under the management of the government. The electricity supply regime is divided according to the regions: northern, central, and southern. The electric demand/supply conditions differ substantially between the various regions. In Vietnam, there are substantial regional differences in energy endowments and in the patterns of energy consumption. The North has an excess of hydro and coal-fired power resources, and power surplus is now being transported to the Center and the South over a high-voltage transmission line at 500 kV with a length of about 1,500 km.[142] This transmission line effectively interconnects the electric systems of the three regions of the country.

Total electricity production reached 53.5 bn kWh in 2006, up from 30.7 bn kWh in 2001. The state-owned Electricity of Vietnam (EVN) had installed capacity of 12,270 MWe at the end of 2006, up from 8,860 MWe at end-2002. Of this total, 6,586 MWe (60%) was thermal power, mainly based on natural gas, but also some coal and oil; the remaining 40% of capacity was based on hydropower, including 1,920 MWe at the Hoa Binh plant on the Da River in the north of the country.[143] Vietnam imports small amounts of electricity from China in the north during the dry season, and the country has the option to import electricity from Laos if needed in 2008.

[139] Ibid.
[140] Vietnam Country Strategy and Program, 2007-2010. Asian Development Bank. http://www.adb.org/Documents/CSPs/VIE/2006/CPS-VIE-2006-02.pdf
[141] "Bond Issue to Fund First Nuclear Power Plant." VietNamNet Bridge. May 15, 2006.
[142] Vietnam Country Strategy and Program, 2007-2010. Asian Development Bank. http://www.adb.org/Documents/CSPs/VIE/2006/CPS-VIE-2006-02.pdf
[143] "Electricity/Heat Data for Vietnam." International Energy Agency, http://www.iea.org/Textbase/stats/electricitydata.asp?COUNTRY_CODE=VN.

According to government projections of domestic electricity supply and demand, electricity production is expected to meet demand up to 2015 in the low and base case scenarios. A shortage of supply could occur as early as 2015 in the high demand growth scenario. There is expected to be an electricity shortage by the year 2020 in all three scenarios[144] (see table below).

Figure 16. Vietnam's Electricity Balance for the Years 2015-and 2020

Year	2015	2020
Total domestic production, TWh	149.0	165.0
Total demand for low/base/high scenarios, TWh	131/142/158	176/201/230
Shortage, TWh	-18/-7/9	11/36/65

Source: Vietnam Atomic Energy Commission (VAEC)

These estimates of future energy demand seem somewhat dubious as recent data suggest that demand for electricity will rise by about 12% annually[145] (the high growth scenario in the above table assumes roughly 8% annual growth). Even if the country increases its installed hydropower and thermal power capacity, it is still likely that the country will face an energy shortfall in as early as 2010.[146]

Given the above scenarios and based on national energy resources and energy demand/supply balance, the priority in electricity expansion development plan as delineated by the central government is as follows:[147]

- Hydro power plants;
- Gas-fired plants in the North;
- Import electricity from neighboring countries;
- Import coal-fired plants in the North;
- The introduction of nuclear power after 2015.

Political Structure and Domestic Politics

Vietnam is a one-party state, run by a collective leadership comprising the Vietnamese Communist Party (VCP) general secretary, Nong Duc Manh, the prime minister, Nguyen Tan Dung, and the president, Nguyen Minh Triet. There is a 493-member National Assembly (91% of the deputies are members of the VCP). As such, the dis-

[144] "Preparation Studies for Introduction of Nuclear Power to Vietnam." Vietnam Atomic Energy Commission. http://www.vaec.gov.vn/Userfiles/file/NP-Vietnam.pdf
[145] Vietnam Country Profile. Economist Intelligence Unit (EIU). October 1, 2007.
[146] "Market Economy Spurs Energy Crunch." The Asahi Shimbun. March 28, 2005.
[147] Preparation Studies for Introduction of Nuclear Power to Vietnam." Vietnam Atomic Energy Commission. http://www.vaec.gov.vn/Userfiles/file/NP-Vietnam.pdf

tribution (or lack thereof) of political power within Vietnam affords the VCP a virtual monopoly in policymaking. The VCP's dominance in the domestic political arena is not necessarily a bad thing, as it has created the political stability and continuity necessary to encourage the country's continued economic progress. The centralization of decision-making authority within the VCP combined with government's stated intention of expanding and diversifying the country's electricity mix bodes well for the implementation of nuclear power as scheduled by 2020.

Geopolitical Situation

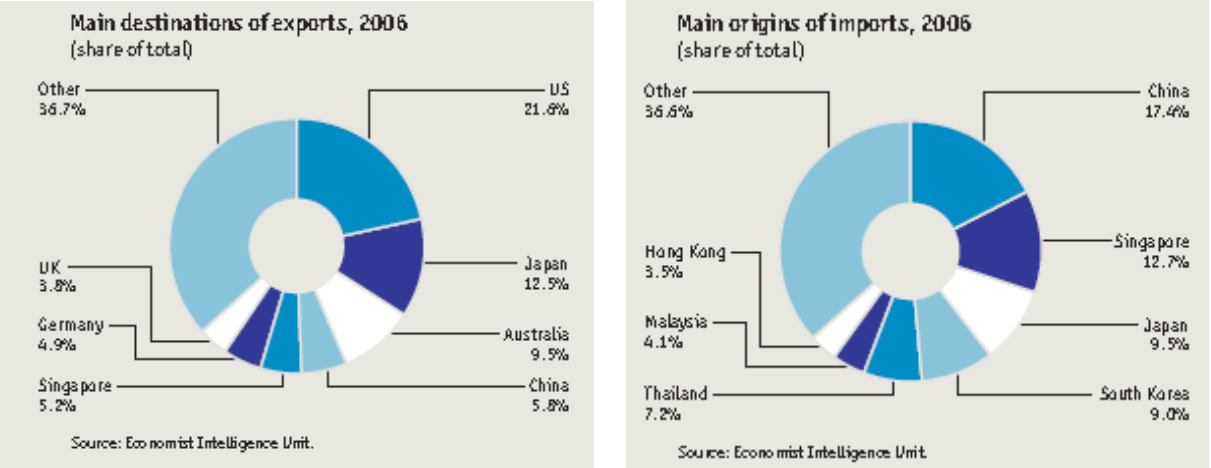
Achieving energy independence is clearly one of the primary motives of policymakers in Vietnam as they formulate their country's energy strategy, as a secure supply of electricity is a necessary precondition to achieving the government's targets for economic growth. The prospect of having to depend on neighboring countries such as China for imports of electricity is a cause for concern, particularly in light of the fact that the two countries have a long-standing conflict over rights to the resource-rich islands in the South China Sea.[148] Any future escalation of bilateral tensions with China could be highly damaging to Vietnam if it is dependent on China for imports of electricity.

International Trade and Investment

Vietnam's integration into the regional and global economy has been formalized through its membership with several international organizations. The most important of these is the Association of South-East Asian Nations (ASEAN), which Vietnam joined in July 1995, the Asia-Pacific Economic Co-operation (APEC) forum, which Vietnam joined in November 1998, and the World Trade Organization, of which Vietnam became a member in January 2007.[149] Please refer to the graphs and table below for a snapshot of Vietnam's principal trade partners and the composition of its exports and imports.

[148] Vietnam Country Analysis Brief. U.S. Energy Information Administration (EIA). July 2007. http://www.eia.doe.gov/emeu/cabs/Vietnam/pdf.pdf
[149] Vietnam Country Profile 2007. Economist Intelligence Unit.

Figure 17. Vietnam's Exports and Imports in 2006



Source: Economist Intelligence Unit

Table 3. Vietnam's Main Composition of Trade[150]

(US$ million, fob-cif)	2002	2003	2004	2005	2006
Exports fob					
Crude oil	3,226	3,777	5,671	7,387	8,323
Textiles & garments	2,710	3,630	4,386	4,806	5,802
Footwear	1,828	2,225	2,692	3,005	3,555
Fisheries products	2,024	2,217	2,401	2,741	3,364
Total exports incl others	16,704	20,142	25,984	32,233	39,605
Imports cif					
Machinery, equipment & parts	3,700	5,350	5,504	5,254	6,555
Refined petroleum	2,017	2,410	3,624	4,969	5,848
Steel	1,317	1,642	2,609	2,984	2,905
Material for textile industry	1,781	2,039	2,284	2,308	1,959
Total imports incl others	19,734	25,194	31,470	36,881	44,410

Vietnam's economic success has been due in large part to growth in exports. In 2006, exports reached US$39.6 bn, up from only US$15.1 bn in 2001. Crude oil has been the leading export earner in recent years, buoyed by a rising world price but restrained by a declining volume of shipments as Vietnam's offshore reserves continue to be depleted. In 2006 the value of crude oil exports reached US$8.3bn (21% of total export revenue).[151] Foreign sales of textiles, garments and footwear, as well as commodities such as rubber, coffee and seafood have also been robust.

Vietnam's accession to the WTO in January 2007 has also helped to increase foreign investor interest in Vietnam – in 2007 foreign direct investment (FDI) commitments for new and existing projects reached US$20.3bn, up from US$12bn in 2006, and the UN recently ranked Vietnam among the ten most attractive destinations for FDI.[152]

[150] Source: Economist Intelligence Unit
[151] Vietnam Country Report. Economist Intelligence Unit. March 2008.
[152] Vietnam Country Profile. Economist Intelligence Unit. March 2008.

WTO accession will help to support export growth, but falling tariff barriers will also make imports increasingly affordable relative to domestic products, so net exports will likely make a negative contribution to GDP growth going forward.

International Nuclear Cooperation Agreements

Vietnam has bilateral nuclear cooperation agreements with several countries including the United States, Russia, India, France, South Korea, Japan, and Canada. These bilateral agreements have contributed to the ongoing plans for the implementation of nuclear power in Vietnam through technology transfer, human resource training, research and development of legal framework for nuclear power, as well as regulations on the nuclear power industry's environmental impact.

At the multilateral level, Vietnam is part of the IAEA Regional Cooperation Agreement (RCA) and South Asian Frameworks for Environmental Data-Sharing, a structure to increase nuclear transparency in South Asia, as well as the Asian Network for Education in Nuclear Technology (ANENT), a partnership of government, academia and industry for cooperation in education, training and research in nuclear technology and nuclear applications. ANENT currently includes 28 participating institutions from 12 countries.[153]

Where and How to Build a Nuclear Power Plant

An exploratory committee appointed by the government in 2001 has completed a feasibility study for nuclear power development. After studying nuclear power plants abroad and 20 locations in Vietnam, the committee selected Phuoc Dinh and Vinh Hai in the southern central Ninh Thuan Province and Hoa Tam in the neighboring Phu Yen Province as the ideal sites for a nuclear power plant. With the most ideal position, Phuoc Dinh was chosen as the first priority.[154] The nuclear power plant is scheduled to include two 1,000 MWe reactors in the first phase (2017-2019).[155] Formal approval of the Atomic Energy Law by the National Assembly will be required to open the bidding process with a view to begin construction in 2011 and commissioning in 2017. The vote is scheduled to take place in May 2008. The Prime Minister has already endorsed the setting up of three nuclear power plants which would add 8,000 MWe to the national power grid by 2025, at a projected cost of US$16 billion.[156]

[153] "Asian Network for Education in Nuclear Technology (ANENT): An initiative to promote education and training in nuclear technology." IAEA.
http://www.iaea.org/OurWork/ST/NE/inisnkm/nkm/documents/trieste2005/39_W_Kossilov_2226Aug05.pdf
[154] "Nuclear Energy Prospects Grow." The Saigon Times Daily. April 1, 2004.
[155] Ibid.
[156] "Vietnam nuclear establishment meets to chart plans" Thanh Nien News. August 30, 2007. http://www.thanhniennews.com/society/?catid=3&newsid=31554

Potential Reactor Designs and Vendors

In the process of preparing for the planned nuclear project, the Vietnam Atomic Energy Commission (VAEC) has held consultations with the following vendors concerning the appropriateness of their reactor designs for Vietnam's circumstances:[157]

- Boiling Water Reactor (Toshiba and JCI, Japan)
- Pressurized Water Reactor (Mitsubishi, Japan)
- CANDU (AECL, Canada)
- KSNP (KEPCO, South Korea)

It remains to be seen which reactor design will be chosen. Though a specific date for the issuing of a tender offer has yet to be released, it is expected that the EVN will begin accepting proposals as early as 2009.

Nuclear Fuel Supply

Though Vietnam has an estimated 210 thousand tons of uranium ore deposits, it does not currently have the operational or technological capability to extract or process it into nuclear fuel. As such, Vietnam will need to either import the nuclear fuel rods from abroad or include a provision in the tender offer that requires the eventual winning bidder to supply the nuclear fuel necessary to run the reactors. If the country decides to import the nuclear fuel rods on its own, the potential foreign suppliers, according to the Director of VAEC, would be France, the US, Russia, Japan and Canada.[158] Given that the first NPP is projected to come on-line in 2020, it will be necessary for the government to make arrangements for nuclear fuel procurement several years prior to the start-up date.

International Nonproliferation Agreements

On August 10, 2007, Vietnam became the 114th country to sign the Additional Protocol with the IAEA, thus granting the IAEA oversight over the country's nuclear activities and "in particular to verify the absence of undeclared nuclear material or activities."[159] Shortly thereafter, Vietnam's Ministry of Science and Technology (MOST) signed an agreement with the U.S. Department of Energy's National Nuclear Security Administration (NNSA). Under the arrangement with the NNSA, scientists from the Lawrence Livermore and Oak Ridge national laboratories will collaborate with Vietnamese technical personnel on specific measures that promote nonproliferation and security objectives.[160]

[157] "Preparation Studies for Introduction of Nuclear Power to Vietnam." Vietnam Atomic Energy Commission. http://www.vaec.gov.vn/Userfiles/file/NP-Vietnam.pdf
[158] "Vietnam aims to build nuclear power plant within 10 years." The Straits Times (Singapore). September 7, 2006.
[159] "Vietnam Hosts Seminar on Nuclear Safeguards." IAEA. August 17, 2007. http://www.iaea.org/NewsCenter/News/2007/vietnam_sgseminar.html
[160] "United States and Vietnam Agree to Cooperate in Peaceful Uses of Nuclear Energy." U.S. Department of Energy. September 12, 2007. http://nnsa.energy.gov/news/909.htm

In addition to the above agreements, Vietnam is also a signatory to the following nonproliferation treaties:

- Biological Weapons Convention, 20 June 1980
- Certain Conventional Weapons Convention, signed 10 April 1981
- Comprehensive Nuclear Test Ban Treaty, signed 24 September 1996
- Chemical Weapons Convention, 30 September 1998
- Nuclear Non-Proliferation Treaty, 14 June 1982
- Outer Space Treaty, signed 20 June 1980
- Sea Bed Treaty, signed 20 June 1980
- Treaty of Bangkok, 26 November 1996

Judging from the government's aforementioned international agreements, and specifically its signing of the Additional Protocol, it is highly likely that Vietnam will honor its commitments to abide by IAEA safeguards and inspections. Vietnam should thus not be considered a nuclear security risk.

Conclusion for Vietnam

Vietnam still has significant work to do in preparation for the introduction of a nuclear power plant including the creation of a standard system of building and operating nuclear power plants, developing human resource training sites on nuclear power that meet international standards, and drawing up effective plans to deal with nuclear power plant breakdowns. These tasks, while achievable, will require continued collaboration with the IAEA and international partner countries.

That being said, after weighing the various factors outlined in this report, it is highly probable that Vietnam will achieve its goal of having 2,000 MWe of installed nuclear capacity by 2020. This determination was made under the assumptions that Vietnam will: 1) continue to exhibit political stability; 2) maintain baseline rates of economic growth; and 3) not provoke China.

The government's goal of having 8,000 MWe of installed capacity by 2025 seems improbable given that the sheer amount of financing required for such a project. A more realistic projection would be 6,000 MWe of installed capacity by 2030 – I would assign a *medium* probability to this being achieved.

6 – Comparative Matrix & Conclusions

Table 4 on the following page presents a comparative matrix of some of the key economic and energy data for each of the four countries analyzed. In the last column, of this matrix are our projections for future nuclear power capacities in each of the countries by the year 2030.

Following this matrix, we provide an overall summary and conclusion to this four country nuclear energy assessment.

Table 4. Four Country Comparative Matrix

		Economic Factors	Domestic Energy Portfolio Characteristics		Current Nuclear Plans			Roadblocks to Implementation of Nuclear Power Program		Projections for Nuclear Power Implementation	
		Projected Annual GDP Growth (2007-2017)	Projected Annual Growth in Domestic Electricity Demand	Current Energy Portfolio Composition	Existing Feasibility Study	Existing Nuclear Technology or Technical Assistance Agreements	Domestic Government Agencies with Equity	Domestic Constraints	International Constraints	Probability of Nuclear Program Being Realized	Projection for Installed Nuclear Capacity by 2030
Country	**Chile**	5%	4.6 - 5.6%	61% Thermal; 39% Hydro	Yes	2 Research reactors, one still in operation	National Energy Commission and Nuclear Energy Commission.	Political will, public opposition, legal framework, environmental	None	Medium	**1,000 MW**
	Belarus	4%	1.9-2.9%	92% Natural Gas; 8% Oil	Yes	2 retired research reactors; Joint Institute for Power and Nuclear Research "Sosny"	Ministry of Energy; Ministry of Emergencies; Directorate of Construction of a Nuclear Power Plant	Constraints on obtaining funding	None	High	**2,000 MW**
	Vietnam	7%	12%	60% Thermal; 40% Hydro	Yes	1 Research reactor	Ministry of Science, Technology & Environment (MOSTE); Vietnam Atomic Energy Commission (VEAC)	Financial resources; Legal and regulatory framework; Lack of nuclear engineers	None	Medium-High	**6000 MW**
	Turkey	8%	8%	33% Oil,; 32% Natural Gas; 26% Coal; 9% hydro and renewables	Yes	Multiple research centers and one operating research reactor	Turkish Atomic Energy Authority (TEAK), Turkish Public Electricity Wholesale Co. (TETAS)	Very few. Ambitious schedule and lack of transparency regarding the tender	None	Very High	**5000 MW**

Summary and Conclusions

The world economy and population experience continuous growth. In 2007, global economic growth amounted to 5.2 percent. What is remarkable about this growth is that it has been driven by the developing nations. Inevitably, economic success is accompanied by increased energy demand in general and, specifically, demand for electricity. Such a rise in demand puts pressure on energy prices, especially oil and gas, which together serve as the main inputs into the production of electricity. Thus, nuclear energy has received a new impetus in the last few years with a number of countries looking at the possibility of creating their domestic civilian nuclear programs. We assessed the likelihood of realization of nuclear programs in four such countries in our study: Belarus, Chile, Turkey and Vietnam.

All four countries are experiencing high growth rates and have very favorable projections as to the annual GDP growth rates for the next decade (2007-2017), ranging from 4 percent to 8 percent. Indeed, small expected economic growth would not justify the high capital expenditures required for construction of a NPP.

The countries differ in their energy portfolios. Belarus is the most dependent on a single source of electricity as 92% of total electricity is produced from natural gas. Turkey, on the other hand, has the most diversified energy portfolio, relying not only on oil and natural gas, but also on coal, hydro- and renewable energy. However, all the countries share the problem of a lack of domestic energy resources, which forces them to rely on foreign suppliers.

Interestingly, all four states presently have, or had in the past, research reactors as well as nuclear research facilities. Such an investment is not only costly, but requires a legal framework and cooperation with the IAEA, serving as a precursor to a full-scale nuclear program.

A necessary first step to construct a nuclear power plant, according to the IAEA handbook, is to carry out a feasibility study. This step has already been completed by all the countries and in all but Chile concluded with recommendation to commence a nuclear program. A feasibility study does not only assess energy needs and the economic realities of a state, but also reflects political will and public opinion. The negative conclusion of a study in Chile reflects precisely such a lack of political will while emphasizing desirability of a NPP in the future. Such duality in the finding of the study, in fact, allows for the decision to be reconsidered during a different administration. Thus, we consider it to be a medium probability of construction of one 1,000 MWe reactor by 2030.

Assessing the likelihood of a nuclear program being realized, two countries – Belarus and Turkey and Vietnam – are deemed to have a high probability. These three states have already begun preparatory processes. Turkey has already announced an open tender in 2008, while Belarus is planning to do so by the end of the year. Vietnam, though not as far along as Belarus and Turkey, is expected to pass an Atomic Energy Law in May 2008, thus setting the stage for a tender offer in as early as 2009. The

likelihood is assessed to be medium-high in Vietnam, where the government has been taking measured steps towards the nuclear power program. Overall, we project 13,000 MWe of nuclear capacity to be added in these four states by 2030.

Appendix – UxC Nuclear Power Outlook Excerpts

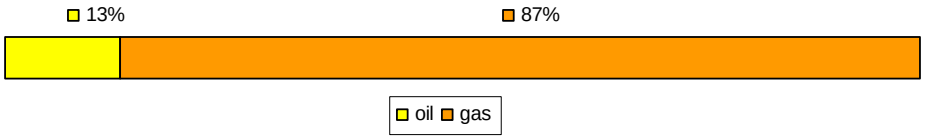
To provide additional context and information on Belarus, Chile, Turkey and Vietnam, we hereby include UxC's Nuclear Power Outlook (NPO) discussions on these four countries. This excerpt is taken from the January 2008 edition of the NPO report. It should be noted that the above report by our four GWU Capstone Project students will help to augment and improve our NPO offering in future editions. In addition, we will work to resolve any contradictory information that may be found between the students' reporting and our NPO coverage.

Belarus

Table 5. Belarus Nuclear & Electric Power Data

	Units	MWe (net)	Total Power Generation
Operating	0	0	28.0 TWh
Under Construction	0	0	
Planned/Anticipated	2	~2,000	
Total in 2020	1	~1,000	
Total in 2030	2	~2,000	

Electric Power Generation Mix



- **Country Overview**

Although Belarus does not currently have any nuclear plants, the government is actively pursuing plans to build the country's first new reactor in the next decade in order to reduce its large natural gas import dependency from Russia. Still, it is expected that Belarus will receive significant support from Russia for its reactor project, and the technology will likely be VVER-1000 PWRs. In early 2007, Belarus' government announced that construction on a two-unit plant in the Mogilev region would begin in 2008.

- **Latest Developments**

On November 12, 2007, the President of Belarus, Alexander Lukashenko, signed a decree to begin activities to prepare for building the nation's first nuclear power plant, which is to have two reactors. The preparations include the creation of a Directorate on Nuclear Power Station Construction within the Ministry of Energy and the

establishment of a Department of Nuclear and Radiation Safety within the Ministry of Emergency Situations. Belarus plans to select a site for the plant in mid-2008, and the first reactor could begin operation in 2016, with the second unit coming online in 2018. In related news, Russia's Atomstroyexport is reportedly in talks with Belarus regarding the possibility of becoming the primary vendor for the country's planned two-reactor plant, but Belarus could also consider reactor designs from AREVA and Westinghouse.

- **Reactor Forecast**

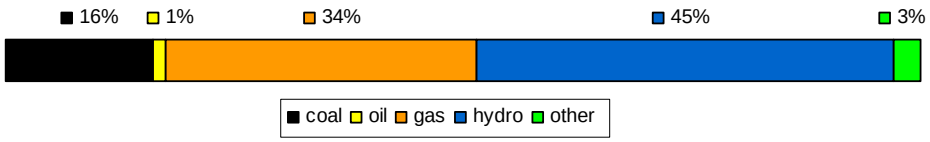
Although start-up for Belarus' two new reactors will be later than current plans, we expect the first 1,000 MWe reactor will be online in the next decade, and the second after 2020. Both units will be online by 2030 with 2,000 MWe of capacity.

Chile

Table 6. Chile Nuclear & Electric Power Data

	Units	MWe (net)	Total Power Generation
Operating	0	0	55.1 TWh
Under Construction	0	0	
Planned/Anticipated	~1	~1,500	
Total in 2020	0	0	
Total in 2030	~1	~1,500	

Electric Power Generation Mix



- **Country Overview**

Chile has begun serious discussions which could eventually lead to the development of a nuclear power program. Many politicians in Chile have called for the consideration of nuclear power as a means of diversifying the nation's energy supply away from fossil fuels. At the present time, Chile's total electric generating capacity is around 7,500 MWe, and within ten years, the nation could require an additional 5,000 MWe of capacity to meet rising demand.

- **Latest Developments**

In November 2007, a government-sponsored commission completed a study that determined that nuclear power is a viable option for Chile to consider and would improve the nation's energy security despite the nation's high level of seismic activity. The report recommended that additional studies be carried out. Michelle Bachelet, Chile's President, has promised not to build nuclear reactors during her term in of-

fice, which ends in 2010. However, Bachelet has asked the Energy Minister to conduct the recommended additional studies so that the next administration will have the option of developing a nuclear power plant.

- **Reactor Forecast**

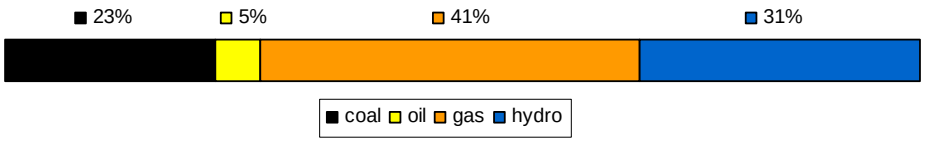
Currently, one large reactor in Chile with around 1,500 MWe in capacity operating by 2030 is a realistic forecast, although this is unlikely by 2020.

Turkey

Table 7. Turkey Nuclear & Electric Power Data

	Units	MWe (net)	Total Power Generation
Operating	0	0	176.0 TWh
Under Construction	0	0	
Planned/Anticipated	~5	~5,000	
Total in 2020	~1	~1,000	
Total in 2030	~3	~3,000	

Electric Power Generation Mix



- **Country Overview**

Turkey is one of the countries in this region that is most likely to see nuclear reactors built in the near term. Although plans have been underway for numerous decades, it is only more recently that economic growth has allowed the government to seriously conceive of building a nuclear plant. The latest plans now call for the nation to have up to five reactors with a total of 5,000 MWe operating by 2020. This is an ambitious target, and although the schedule may be delayed, serious planning has already commenced with two sites chosen and an international bidding process starting.

- **Latest Developments**

In November 2007, Turkey's President signed a law establishing a framework for nuclear power development. An article from Turkish newspaper *Today's Zaman* said that the main qualification the government will use to select a company to operate the plant is management experience. The plan calls for at least 60% of the investment in the project to be from the domestic sources. If private companies do not express enough interest in the project, the law allows the government to move forward on its own or to make use of public-private joint ventures.

On January 22, 2008, U.S. President Bush sent a proposed Agreement Concerning the Peaceful Uses of Nuclear Energy with Turkey to the U.S. Congress. Congress

has 90 days to consider the 123 Agreement. Unless Congress votes against the agreement within the 90 day period, it will automatically become law.

The Turkish Electricity Trade & Contract Corporation (TETAS) had planned to issue a tender for companies interested in investing in the construction of the nation's first nuclear power plant on February 21. However, Turkey announced that it would postpone the launch of a tender because the government is waiting on comments from its audit agency before it can begin the tender process. TETAS will purchase all of the electricity generated by the nuclear power plant, and the law guarantees that the government will continue to purchase electricity for a 15-year period. Final conditions of a nuclear plant tender will be determined by Turkey's Energy Ministry.

Turkey is considering the use of PHWR, PWR, and BWR technologies, with minimum reactor capacities of 600 MWe and up to three reactors for the first plant. Turkey wants to make use of reactors with up-to-date designs that are based on units already licensed and in operation.

The site of Akkuyu on the Mediterranean coast has been selected for Turkey's first nuclear power plant. Sinop on the Black Sea was previously seen as the most likely site for the first nuclear plant, and Sinop has now been selected as the site for the nation's second nuclear plant. Companies that invest in the nuclear projects have the right to suggest new locations, but if a company wants to build the plant at a location other than that recommended by the government, it would then be responsible for getting a site license. Turkey hopes to begin construction of its first nuclear plant in 2008, and sees the facility becoming operational by 2013 or 2014. In January 2008, *Reuters* reported that Turkish construction company Enka Insaat ENKAI.IS would work jointly with Korea Electric Power Corp. (KEPCO) on nuclear energy development in Turkey. Other foreign vendors are also vying for the project.

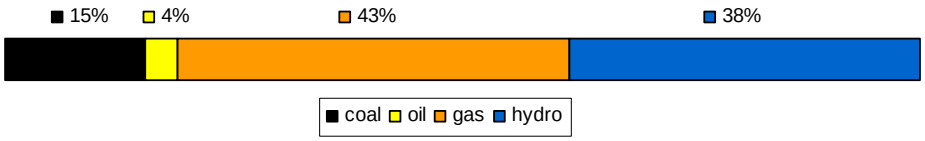
- **Reactor Forecast**

  Turkey's nuclear power plans are becoming very concrete. Therefore, UxC's base case estimate puts Turkey's nuclear capacity at 2,000 MWe from two reactors by 2020. By 2030, we forecast at least 3 reactors with a total of at least 3,000 MWe.

Vietnam

Table 8. Vietnam Nuclear & Electric Power Data			
	Units	**MWe (net)**	**Total Power Generation**
Operating	0	0	39.5 TWh
Under Construction	0	0	
Planned/Anticipated	~8	~8,000	
Total in 2020	~2	~2,000	
Total in 2030	~4	~4,000	

Electric Power Generation Mix



- **Country Overview**

Vietnam does not currently have any reactors, but the government has repeatedly shown interest in developing nuclear power to help its growing economy. The most recent reports call for eight reactors with around 8,000 MWe to be built in the next twenty years. A feasibility study for this project is expected to be completed in 2008 followed by a formal bidding process. Japanese, French, Russian, U.S., and South Korean vendors have shown interest.

- **Latest Developments**

In September 2007, Vietnam's government announced that it wants to complete up to eight reactors with a combined capacity of around 8,000 MWe by 2025. The cost for building all eight units has been estimated at approximately $16 billion, according to Vuong Huu Tan, the director of the Nuclear Energy Institute of Vietnam. The nation, which plans to complete its first nuclear power plant by 2017, has not yet decided on what reactor technology it will use.

Also in September 2007, Vietnam signed an agreement with the U.S. DOE for peaceful nuclear cooperation. The agreement calls for U.S. scientists to assist Vietnamese technical specialists with various issues related to nonproliferation, safety, and reactor operations.

- **Reactor Forecast**

Although completion of 8,000 MWe is unlikely in the next two decades, it is highly probable that up to 4,000 MWe from four reactors will be operational by 2030. As for our 2020 forecast, we anticipate 2 reactors online with around 2,000 MWe.