Chapter 12: Energy Security for the Baltic Region[1]

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Introduction

Since the events of January 2006, in which natural gas supplies to Ukraine and Georgia were interrupted, energy security for Europe has become a "hot issue," with many national leaders calling for changes in policies and actions (see Appendix 1).

Achieving energy security for the Baltic region is particularly difficult because of the way this region has evolved with the end of the Cold War. The energy infrastructure was created when this region was part of the Soviet Union. Now Estonia, Latvia, and Lithuania are independent nations that have joined the European Union. As part of the process that led to its membership in the European Union, Lithuania has agreed to shut down the two nuclear power plants at Ignalina (3000 MW of installed capacity) that have been providing most of the electric generation for Lithuania and a large amount for export to neighboring countries. Unit #1 was shut down at the end of 2004, and the agreement specifies that Unit #2 will cease to operate by the end of 2009. While proposals have been made for expanded use of renewable energy supplies, it seems clear that most of the replacement for this nuclear generation will, in the near term, have to come from fossil fuel generation, such as use of natural gas from Russia, plus perhaps some limited use of heavy oil ("orimulsion") from Venezuela.

In January, representatives from "relevant ministries, energy industry, energy associations, regulators" from the three Baltic nations plus Finland, Poland, and Sweden met at a workshop in Vilnius, Lithuania and reached agreement supportive of building a new nuclear power plant in Lithuania. They agreed to work together to "prepare common energy strategy of

[1] The author's interest and involvement in energy security for the Baltic region began with a discussion with Dr. Christian Kirchsteiger of the European Commission staff in the fall of 2004 and a Stanford University class project during the winter of 2005. During the past year and a half the author has had extensive discussions with experts in Lithuania, in Moscow, and in Brussels. The effort became a case study for the IRGC following the Annual Meeting of the Society for Risk Analysis in December, 2005. The author recently gave a presentation on this case study at a meeting of the Organization for Security and Cooperation in Europe (OSCE). The technical program for this OSCE meeting, on April 18-19, 2006, was organized in large part through the work of Jean-Pierre Contzen and others from IRGC. At the meeting's end, a resolution was adopted by OSCE, that it would carry out activities aimed at achieving improved risk governance, with IRGC in support.

the Baltic during 2006." [1] A few days afterward, leaders of the Lithuanian Energy Institute (LEI), the author, and Dr. Kirchsteiger of the European Commission all attended a risk management meeting sponsored by Gazprom, Russia's large, state-controlled natural gas company and major supplier of natural gas to the Baltic and Europe, and its operating subsidiary, Vniigaz, in Moscow. The author presented an invited paper at a plenary session at this conference, on energy security for the Baltic region [2], which is attached as Appendix 2 and is a good background document on energy security issues and the technical tools for addressing them.[2] The following discussion presents case study of Baltic Energy security as seen from the perspective of the IRGC's Risk Governance Framework, particularly as an illustration of the framework's "pre-assessment phase." It represents the author's views on issues and opportunities for further work in this area.

Baltic Energy Security Viewed from the IRGC Framework: Uncertainty, Complexity, and Ambiguity

Energy policy in the Baltic and elsewhere is characterized by considerable uncertainty. The prices for oil and oil products, natural gas, and electric power production from these fossil fuels can vary considerably over time, as has been demonstrated in the past year and also in previous periods of "energy crisis" (e.g., as seen with the sharp rise of international oil price in the 1970s). Energy policy is also quite complex; a complex supply chain links the economics of extracting energy materials from the ground and transporting and transforming these materials into the forms and locations needed to meet demand for energy end uses, such as heat in a homes, propulsion of a vehicle such as an automobile, airplane, or electric train, or operation of a television set, hot water heater, or cooking appliance. Furthermore modern industrial societies rely on multiplicity of energy sources to meet this multiplicity of energy needs. As energy prices change, both consumers and energy companies adapt by changing their behavior in the purchase of energy equipment and materials as well as in end uses for energy demand. In the short term, measured in days, weeks, or months, demand for energy materials is highly inelastic – modern societies need energy to function, and people cannot maintain their life styles without it, so they pay the higher prices that usually result from a change that reduces supply. In the longer term, measured in periods of several years to several decades, purchases of energy equipment adapt to the altered patterns of energy price, and the response can be large increases in supply for some energy materials and large reductions in demand – especially for energy materials at a price that turns out to be significantly more expensive than the competing energy materials and technologies.

Understanding these uncertainties and the complexity of energy markets is a domain that has generated much specialized analysis, especially by companies that deal in energy materials, by government agencies with responsibilities in the energy sector, and by centers of scholarship that have focused on energy policy issues. Because of the importance of the energy sector, energy issues can become important issues of national policy. These issues may differ among nations and among regions. This case study of energy security in the Baltic region addresses the upcoming change from the closure of Ignalina Unit #2 in Lithuania, the implications of this action

[2] The reader unfamiliar with the energy security issues and the technical tools proposed for addressing them may wish to read Appendix 2 before going on. The author's paper from the European Commission meeting in Brussels, plus papers at this conference by former US Ambassador to Lithuania, Keith C. Smith [3], Dr. Juozas Augutis [4], and Dr. Arvydas Galinis and Dalius Tarvydas [5] provide additional details on the background of planning energy security for the Baltic regions.

in making the region more dependent on imported materials, particularly natural gas from Russia, the probability of interruption in the supply of such energy materials, and the economic and other impacts of supply interruption.

There are many complex value-laden issues associated with choices among energy technologies and policies. These issues represent the "ambiguous" dimension of this particular risk problem, as discussed in IRGC's Framework on Risk Governance. The acceptability of nuclear power generation, including management for safe operation without accidents leading to substantial release of radioactivity, and the management of high-level and long-lived radioactive waste materials resulting from nuclear power generation, have been the subject of discussion and debate for decades in Europe, the United States, and other countries. A second major issue is possible tradeoffs between the risks of nuclear power generation and the accumulation of greenhouse gases such as carbon dioxide from fossil fuel combustion, which may cause alteration in earth's climate.

The decision on replacement energy supply after the closure of Ignalina will affect Lithuania, its neighbors in the Baltic region, and the European Union as a whole. It is a *relatively simple* problem in international planning and governance for a region of Europe. The need is immediate, because Lithuania's agreement with the European Union specifies that Ignalina Unit #2 is to be closed in about three years – which gives very little time for the construction of new energy facilities. The need for analysis of risks to inform decisions on assuring energy security for the Baltic region should not depend on resolution of broader disagreements regarding the future use of nuclear power generation and measures to reduce emissions of carbon dioxide from fossil fuel combustion. These important issues may be dealt with on a longer time scale. The immediate risk facing Lithuania and its neighbors is an interruption in natural gas supply since these nations import natural gas from one supplier – the Russian Federation, via its state-controlled gas company, Gazprom.

The Baltic region obtains most of its natural gas from Russia. There are small domestic supplies in some countries, but far less than is needed to meet domestic demand. The Baltic countries are currently connected to the electricity grid for Russia, and not to the grid that serves Europe from Portugal to Poland, or to the one that serves the Scandinavian countries such as Sweden and Finland. While there are plans for such interconnection in the future, building high-capacity connections to the electrical grid to the north or to the west will be expensive. On the other hand, extensive excess capacity for electric generation now exists in the Baltic region, and new, more efficient gas-fired generation can be installed relatively quickly. The dilemma is that the available fuel supply is limited and the best candidate fuel is natural gas from Russia. Increased dependence on Russia for vital energy supply is of great concern to the three Baltic countries and to their southern neighbor, Poland. Sudden interruption of energy supplies is at a minimum an inconvenience. It can be highly disruptive to economic activity, and in cold weather it can be life-threatening.

There can be multiple contributors to disruptions of energy delivery, some foreseeable, other not. Energy companies plan for equipment failure, and for periods of extreme weather that can cause elevated levels of demand and also equipment failure. Acts of terrorism or civil unrest can disrupt energy supply. Deliberate interruption by a national authority can also cause sudden shortages.

Events in recent years provide a strong basis for these concerns about over-reliance on Russian gas supplies. In April of 2004, Gazprom cut gas supplies to Belarus and to Lithuania when Belarus failed to pay its gas bill on time. In early January 2006, Gazprom briefly curtailed gas supply to the Ukraine. In late January of 2006, two natural gas pipelines from Russia into Georgia and several electric power transmission towers were destroyed by acts of terrorism with the result that many areas of Georgia were without electricity or natural gas. People withstood the cold weather as best they could.

One alternative energy solution for Baltic countries might be to take advantage of existing pipeline projects. Construction of a natural gas pipeline under the Baltic Sea is already underway, after a decision last September by Germany and Russia. While the current plan is to build this pipeline from Russia (near Saint Petersburg) to Germany, the plan could be amended to create a spur line to the Baltic region, either to Latvia or to the Kaliningrad region of Russia, which is geographically cut off from the remainder of the Russian Federation by Poland and Lithuania. At the present time, natural gas to Kaliningrad comes from the rest of the Russian Federation through Belarus and then through Lithuania to Kaliningrad. A spur line from the Baltic Sea pipeline to Kaliningrad would enable gas to flow eastward to Lithuania, Latvia, and Belarus through existing pipelines, should there be an interruption in supply from the Yamal pipeline now bringing gas from Russia to Belarus, Lithuania, and Kaliningrad.

Establishment of extensive emergency supplies of natural gas is another approach. In the 1970's, when the United States faced possible interruptions in the oil supply from the Middle East, analysis showed that it was important to distinguish between alternatives that could provide a quickly accessible reserve of up to several months and those that relied on technologies that might provide liquid fuels, but which required large investments and many years for development and construction. The result was the conception, and then the implementation, of the Strategic Petroleum Reserve, the placement of large amounts of crude oil in underground salt dome structures. This crude oil could be quickly and easily retrieved to serve as an emergency supply in the event of a crude oil shortage.

A similar alternative for the Baltic Region would be the development of underground natural gas storage. Latvia has favorable geology for the construction of such facilities, which might hold amounts of gas that could meet the needs for up to several months if supplies through the existing pipelines from Russia were to be interrupted. Interruption for a much longer period would require an alternative source of supply – for example include a terminal facility for the importation of liquefied natural gas (LNG) from countries such as Qatar in the Middle East, which have very large supplies of natural gas and no nearby markets for it. Some international commerce in LNG is already occurring and worldwide commerce in LNG using large LNG tankers is expected to develop rapidly within the next decade. Liquefied natural gas delivered to the Baltic region would be expensive compared to historical prices for natural gas, but it might be economically competitive with other sources of natural gas and with fuels derived from petroleum.

For reasons set forth in the "Declaration" from the workshop held in Vilnius, Latvia in January 2006 [1], it may also be advantageous to proceed toward the construction of a new nuclear power plant in Lithuania, probably near the existing units at Ignalina, which has existing infrastructure, including cooling water and professional personnel trained in nuclear technology. But construction of a new nuclear unit that could operate by the end of 2009 seems highly unlikely. Construction of a new nuclear plant on the scale of one of the existing units (Unit #2 has been derated to 1350 MW) will require capital investment of many billions of dollars. It is unlikely that capital of this quantity can be obtained without financing from outside the Baltic region.

Even if it were possible to raise such capital, it would be necessary to renegotiate Lithuania's agreement with the EU so that Ignalina Unit #2 could remain in operation for a longer time. But such extension of the existing agreement between Lithuania and the rest of the European Union may be quite controversial. Discussions with one official of the European Commission suggest that Lithuania will be held to the existing agreement that Unit #2 will cease operation by the end of 2009.

In the short term, perhaps the best overall technical and economic solution might be increased cooperation between the Baltic nations and the Russian Federation and its state-owned gas company, Gazprom. Baltic natural gas infrastructure can be made more reliable through the addition of underground gas storage and redundancy in pipelines, and the threat of sudden price increases or curtailment of supply might be eliminated through new agreements between Gazprom and its customers. While Gazprom has potential access to very large known natural gas fields, its infrastructure is aging, many of its existing gas producing areas are depleting, and some of its own experts believe it may have trouble meeting its commitments for export and domestic supply during the next 15 years. Investment capital and technology from outside the Russian Federation may be very valuable to Gazprom (as well as to the Russian oil industry [6]) for expanding production from existing gas fields, for bringing new fields into production, and for upgrading its existing pipeline infrastructure, much of which was built in the 1970s.

Within the context of the IRGC's Risk Governance framework, the Baltic energy security problem requires initially that both uncertainty and complexity in the issue be addressed. The tools for dealing with uncertainty -- probabilistic risk analyses -- are available and routinely applied in the assessment and management of risks from equipment failure and/or from occurrence of extreme climatic events. It could also be applied to the risk of terrorist attacks. The use of decision trees and influence diagrams to characterize uncertainty in sequences of political events leading to war, civil unrest, or disruption of energy supply was pioneered by the author and colleagues during the energy crisis period of the 1970s [7]. An application of decision analysis carried out for the US government in the 1970s demonstrated how uncertainty in future energy prices might be assessed for analysis of a major energy policy decision (see Appendix 2 and its references).

The tools for dealing with the complexity of energy systems are also well-developed and available from leading centers of scholarship and energy planning. The recent work of the Lithuanian Energy Institute demonstrates a high level of sophistication in analyzing alternative energy supply and equipment configurations. The Stanford University Energy Modeling Forum was established in the 1970s as a center of scholarship for the evaluation and comparison of energy models and modeling methodologies. There appears to be relatively little planning capability to assist decision making by the European Commission and the leadership of the European Union in dealing with near-term energy supply planning.

Consideration of the future role of nuclear power in Lithuania introduces ambiguity into the evaluation of energy solutions for the Baltic region. Furthermore, additional nuclear generation is a longer term solution rather than one that will meet the short-term need for energy in the event of disruption of natural gas supplies. The best approach would be to carry out a risk analysis in two stages: a first stage aimed primarily at providing assured gas supply, and a second stage that addresses the addition of new nuclear capacity. The first stage might best be characterized as "complexity induced" and thus require the kind of analysis and stakeholder involvement suggested in the IRGC's risk management escalator (See Figure 4 in Chapter 1). The second stage might correspond more closely to an "ambiguity" induced problem and thus require the more extensive approach envisioned by IRGC's framework.

For the first stage, the shut-down of Ignalina by the end of 2009 is taken as given. The replacement of electric generation will come primarily from existing and new thermal power plants fueled by natural gas (with perhaps a substantial contribution from orimulsion, other heavy oil, and/or biomass). The analysis should examine ways to make the supply system for natural gas into the Baltic region appropriately secure. Participants in the discussion for this analysis should include Gazprom, representatives of the St. Petersburg region of the Russian Federation, as well as Kaliningrad and neighboring nations such as Belarus, Lithuania, Latvia, and Poland. The evaluation would focus on the probability of failure to have adequate energy supply because of interruption caused by equipment failure, weather, terrorist attack, or deliberate acts to cut off or restrict supply. The time period for this analysis would be 2010 to 2020 or slightly beyond.

A second stage of analysis could address a longer time scale – perhaps to 2050 or even further - and address a broader set of issues associated with new nuclear power generation and with steps beyond those in the Kyoto Treaty for management of greenhouse gases emitted in the combustion process. Expanding the use of renewable energy sources such as biomass, phasing out relatively carbon-rich fossil fuels such as coal and orimulsion, and the creation and management of additional nuclear waste materials all should be part of the agenda for this expanded analysis. There are strong value judgments – issues of ambiguity in the terminology of IRGC's framework - held by many individuals and nations on the acceptability of nuclear power, that have been a great source of controversy within Europe. Germany and some other countries have policies in place specifying that nuclear generation must be phased out, whereas France is highly dependent on nuclear and plans to continue to develop and deploy advanced nuclear technology. In the US, some who have been skeptical and opposed to further expansion of nuclear power generation are shifting to favor it. [8,9]

Every reasonable effort should be made to have the first stage of analysis precede the consideration of issues for the second. The primary issue for the first stage involves cooperation with Russia. It is not at all unusual in controversial international risk governance situations to have national leaders trading strong conflicting statements and questioning each other's credibility and intentions (Appendix 1). Within Russia and within Gazprom, there are many technical experts who would like to work out a set of arrangements that will assist Russia in developing its extensive gas resources and selling natural gas for a fair and reasonable price to export markets in European countries. Underground storage would provide resiliency, and multiple gas pipelines or an LNG terminal might alleviate the current limitation, that Lithuania and other Baltic countries are dependent on gas from a single supplier through a single natural gas pipeline.

Baltic Energy Security; IRGC's Four Phases of Risk Analysis and Management

The IRGC framework describes four phases for its process of risk analysis and management: pre-assessment, risk appraisal, tolerability/acceptability assessment, and risk management. This case study is essentially at the pre-assessment phase. We have described above the "framing" of the problem, and the "early warning" on the importance of increasing dependence of the Baltic Region on gas supplies from Russia. An understanding of the importance of the problem is clearly set forth in EC Green Papers (see Appendix 1) and in the writings of political leaders and widely read columnists (see Appendix 1). But as yet there has been little integrated analysis, especially in a form that includes knowledge and perspectives from the Baltic countries, their western European neighbors, and from the Russian Federation.

This case study has attempted to carry out a pre-screening and a preliminary selection of assumptions, conventions, and methodologies and procedures for progressing forward into risk appraisal and risk management. It represents essentially a reconnaissance by one United-States-based academic who has had the opportunity to travel in Lithuania, in other Baltic countries, and in the Russian Federation, to attend conferences in Brussels and Moscow, and to discuss the problem with a small number of leading experts. What is needed to go forward is both adequate funding and a charter from the national governments and international organizations to support a risk appraisal effort on a much larger scale than what has been done to date. A reasonable analogy for this effort exists in the planning and analysis done for the US government on synthetic fuels in the mid-1970s, involving about a dozen agencies of the US government and an analysis staff of tens of people working for a period of six months or more, supported by energy analysis models and risk methodology that took years for development (see Appendix 2 for details).

The need for greatly improved communications to support "Risk Management" and "Tolerability and Acceptability Judgements" also seems clear. The IRGC's framework sets forth many ideas for how to accomplish effective dialogue among the parties. IRGC recently released a white paper on critical infrastructures [10] that presents the results of a preliminary investigation of coupled infrastructures, of which natural gas transport is one of five kinds of infrastructure considered. An overarching concern expressed in that analysis is that privatization and internationalization of such infrastructures may have increased the risk of catastrophic service interruption, that is, failure to meet demand. The paper concludes that "Security of service supply and the impacts of extensive service interruption should be made a high-level priority for further legislation, planning, and evaluation." The text goes on to note: "A framework needs to be created aiming to achieve a better balance between conflicting social objectives, such as, for example, in the trade-off between economic objectives and the provision of sufficient redundancy in systems or of redundant back-up systems and reserve supplies. The IRGC Framework on Risk Governance provides one starting place for such analysis." (page 12) [11].

This case study of Baltic energy security, even in combination with IRGC's white paper on critical infrastructures, has not yet been developed to the point where it can be taken as validation of the IRGC's risk governance framework (11). However, the IRGC framework still seems highly applicable to the need to address uncertainty, complexity, and ambiguity with modern analytical and risk analysis tools in support of improving risk governance. The importance of the problem of assuring reliable energy supply to the Baltic Region, and more generally, to Europe and other areas of the world is very high, and at this time, much more analysis and international dialogue are needed. The approach described in IRGC's framework seems promising for meeting this great need. Implementation of the approach, however, requires both ample funding for analysis and political leadership in support of risk management decision making.

Summary

The author views that a pre-assessment reconnaissance for Baltic Energy Security is far along, perhaps essentially completed, with respect to a first stage of analysis. The technical tools needed, energy modeling capability and probabilistic risk analysis methods, are readily available– but there appears to be little experience in using such analysis tools to support risk governance on this problem in the European Commission, or in Gazprom and the Russian Federation. As such, this first stage of risk analysis would be a challenging and pioneering effort in international dialogue and cooperation as well as in technical analysis.

The author concluded his presentation to the Organization for Security and Cooperation in Europe (OSCE) in April 2006 with the following statement:

> "We need proactive national and international leadership in pursuit of economic growth, environmental protection, and social well-being, as well as energy security. Scientists and analysts like me can help. Our community has excellent tools for planning in the face of large uncertainty and great complexity. But enlightened, **proactive national and international political leadership is crucial** for enabling progress. **I hope OSCE can help in providing such leadership.**"

The author believes Baltic energy security provides an excellent case study for IRGC and for international organizations, such as the European Union and the OSCE. A fully developed case study on this subject could demonstrate what can be done with available technical tools to develop a risk analysis that can lead to improved risk governance, and thereby, to improved energy security to those in the Baltic region.

References:

[1]. "Declaration" of the Workshop "Development of the electricity markets and security of supply in the Baltic Sea region," 26-27 January 2006, Vilnius, Lithuania, 1 page. http://www.president.It/en/news.full/7510.

[2]. D. Warner North, "Analysis of Risk of Supply Interruption to Lithuania from Disruption of Natural Gas Supply from Russia," presented at the SEIF-IV Conference
Brussels, Belgium, November 14-16, 2005. http://www.northworks.net/w_pub_seif-iv.htm

[3]. Keith C. Smith, "Political Issues Arising from Central European Dependency on Russia," paper presented at the SEIF-IV Conference, Brussels, November 2005.

[4]. Juozas Augutis, Lithuanian Power Network Reliability Analysis," paper presented at the SEIF-IV Conference, Brussels, November 2005.

[5]. Arvydas Galinis and Dalius Tarvydas, "Power Systems Planning for Lithuania and the Baltic Region," paper presented at the SEIF-IV Conference, Brussels, November 2005.

[6]. Andrew E. Kramer, "Russia Decides It's Time to Try Modern Oil Drilling," New York Times, May 13, 2006, page B9. http://www.nytimes.com/2006/05/13/business/worldbusiness/13russogas.html.

[7]. Ronald A. Howard, James E. Matheson, Miley W. Merkhofer, Allen C. Miller, and D. Warner North, "Comment on Influence Diagram Retrospective," *Decision Analysis*, 3(2): 117-119, 2006.

[8] Donald Kennedy, "Risks and Risks," editorial, *Science* 309:2137, 30 Sept 2005. http://www.sciencemag.org/cgi/reprint/309/5744/2137.pdf (access required)

[9] New York Times editorial, "The Greening of Nuclear Power," May 13, 2006, page A28. (http://nytimes.com/2006/05/13/opinion/13sat1.html)

[10]. *Managing and Reducing Social Vulnerabilities from Coupled Critical Infrastructures*, International Risk Governance Council, Geneva, Switzerland, October 2006.

[11]. Risk Governance: Toward an Integrative Approach, International Risk Governance Council, Geneva, Switzerland, September 2005.

Appendix 1

Quotations from Leaders and Leading News Media Writers on Energy Security with Respect to the Use of Russian Natural Gas in Europe, 2006

1. Commissioner Andris Piebalgs' Speech to EU Parliament, January 17, 2006:

> "… this dispute has underlined not only the importance but also the necessity of a clearer, more cohesive and pro-active EU-wide energy security policy. While it is true that the Commission and Parliament have argued for this for many years, the time is now right to make real progress on this."

http://europa.eu.int/comm/commission_barroso/piebalgs/doc/media/2006_01_17_gas_crisis_speakings_plenary.pdf

2. The new European Commission Green Paper, "A European Strategy for Sustainable, Competitive, and Secure Energy, released March 8, 2006:

- … the Baltic States, which remain an "energy island," largely cut off from the rest of the Community. (p. 6)
- The EU needs to complete the internal gas and electricity markets. (Rec. #1, p. 18) …Review "could propose clearly identified priorities for the upgrading and construction of new infrastructure" (p. 15).
- A common external energy policy (Rec. 6, p. 19) As part of it, "a new energy partnership with Russia" (p. 20). "A new initiative is particularly opportune with regard to Russia" (p. 15).

http://ec.europa.eu/energy/green-paper-energy/doc/2006_03_08_gp_document_en.pdf :

3. President Putin's Opinion/editorial article, which appeared in the *Wall Street Journal* and in the *Moscow Times*, March 1, 2006, page 10:

> "The new policy of the leading countries should be based on the understanding that the globalization of the energy sector makes energy security indivisible. Our common future in the area of energy means common responsibilities, risks, and benefits. … Generally speaking, all of us should recognize and admit that "energy egoism" in a modern and highly interdependent world is a road to nowhere. … We [Russia] will strive to create an energy security system sensitive to the needs of the whole international community … international cooperation opens all avenues for that."

4. Reaction, via a letter about March 9 to the *Wall Street Journal*, from former Estonian Prime Minister Mart Lahr:

> "Somehow Mr. Putin's article reminded me of speeches of former Soviet leaders, when peace was praised but in reality preparations for war were made. Russia's recent actions against Ukriane, Moldova, and Georgia have made absolutely clear that Moscow has decided to use energy deliveries as a political weapon. … His intentions became obvious when Russia unilaterally withheld Ukraine's gas supply following their price

dispute, and in Moscow's actions against Moldova and Georgia. As long as Mr. Putin is inclined to use oil and gas as a foreign policy weapon, a rules-based energy system will be impossible – regardless of how many articles Mr. Putin chooses to pen in the international media."

Estonian Review, http://www.vm.ee/eng/kat_137/7390.html

5. Valdus Adamkus, President of Lithuania, interviewed by reporter Stefan Wagstyl, *Financial Times*, London, UK, May 4:

"President Valdus Adamkus has called for a common European Union front in response to Russia's willingness to use its energy supplies to secure political influence over its neighbors. Speaking to the *Financial Times* on the eve of an international pro-democracy meeting in Vilnius, Mr. Adamkus condemned Germany for backing Russia's controversial planned Baltic Sea gas pipeline, which will circumvent transit countries including the Baltic states, Ukraine, and Poland. He said, "I can understand the Russian position but I can't understand Germany's position. As a member of the EU, they acted without even extending the courtesy of advising the Baltic states [about their plans]." ….

"I don't want to use the word blackmail," said Mr. Adamkus in referring to Moscow's efforts to extend its influence through energy policy, but he made it clear he was very concerned about Russia's economic and political pressure."

6. Vice President Richard Chaney's speech in Vilnius, May 4, 2006) included the following characterization of Russia:

"America and all of Europe also want to see Russia in the category of healthy, vibrant democracies. Yet in Russia today, opponents of reform are seeking to reverse the gains of the last decade. In many areas of civil society -- from religion and the news media, to advocacy groups and political parties -- the government has unfairly and improperly restricted the rights of her people. Other actions by the Russian government have been counterproductive, and could begin to affect relations with other countries. No legitimate interest is served when oil and gas become tools of intimidation or blackmail, either by supply manipulation or attempts to monopolize transportation. And no one can justify actions that undermine the territorial integrity of a neighbor, or interfere with democratic movements.

Russia has a choice to make. And there is no question that a return to democratic reform in Russia will generate further success for its people and greater respect among fellow nations. Democratization in Russia helped to end the Cold War, and the Russian people have made heroic progress in overcoming the miseries of the 20th century. They deserve now to live out their peaceful aspirations under a government that upholds freedom at home, and builds good relations abroad.

None of us believes that Russia is fated to become an enemy. A Russia that increasingly shares the values of this community can be a strategic partner and a trusted friend as we work toward common goals"

http://www.whitehouse.gov/news/releases/2006/05/20060504-1.html

7. Keith Smith, former US Ambassador to Lithuania, in a speech April 24, 2006 at the European Policy Exchange, London:

> "European dependency on Russian gas and oil has become a hot topic of discussion in Brussels and Washington following January's Ukrainian-Russian "gas war." Nevertheless, there are few signs that leaders in either capital are prepared to develop a coordinated strategy to deal with the mix of opportunities and threats stemming from our greater energy dependency on an ever more aggressive and authoritarian Russia.
>
> Europe has a new Green Paper, filled with recommendations, but no enforcement power on the vital issues of energy diversity. EC President Barroso has traveled to and from Moscow with little to show for his appeal to President Putin for more business transparency, energy market reciprocity and pipeline competition."

8. Author and columnist Thomas L. Friedman, in the *New York Times*, May 10, 2006, in a response to Vice President Cheney's May 4 Vilnius speech, wrote:

> "In the post-cold war world, European integration and economic reform seemed irreversible and certain. But in the post-post-cold war, Europe can't unite on anything – even on an energy policy – and so it is being pushed around by Russia."

9 Simon Zekaria, in AFX Europe, Brussels, Belgium, Wednesday May 10, 2006 wrote:

> "Former prime minister of Russia Mikhail Kasyanov said that Moscow's standoff in January over gas prices that cut off supplies to Ukraine by state-owned Gazprom, which also cut off gas supplies to western Europe, was a "big mistake."
>
> Speaking in Brussels, Kasyanov – prime minister between 200-2004 and tipped to be a candidate in Russia's 2008 presidential election – said: "That was a big political mistake. It must never happen again." He said the dispute raised questions over the "reliability of supplies" and added that it was wrong that gas was used as a "political weapon" over the issue.
>
> Late last month, the European Commission called on Gazprom to stick to its contractual commitments and warned it against threatening crucial European energy supplies. The commission reacted after Gazprom warned the EU not to "politicize" terms for Russian gas supplies, implicitly threatening to sell its product elsewhere. …
>
> Kasyanov said that it is unlikely a full energy deal on the issues could be struck in the "near future". "I don't think that during this year or next year something revolutionary in energy relations will happen."

10. Author and columnist Thomas Friedman, in the *The New York Times*, October 25, 2006, in a column entitled "The Really Cold War," wrote:

> When Europeans tell you that they fear a new "cold war," this time they really are talking about the temperature -- and the fear that Russia, if it wanted to turn off the gas, could make Europeans very cold. About 40 percent of Europe's natural gas imports come from Russia, and that is expected to grow to 70 percent by 2030.

11. *Der Spiegel* International, online edition in English, October 30, 2006, wrote about the meeting in Berlin of Polish Prime Minister Kaczynski with German Chancellor Angela Merkel:

> "Germany's neighbor [Poland] is especially unhappy about the Baltic Sea pipeline which bypasses Poland on its way from Russia to Germany -- a pipeline which the Polish Defense Minister Radek Sikorski compared to the 1939 Molotov-Ribbentrop pact that divided Poland up between Nazi Germany and the Stalinist Soviet Union.
>
> Kaczynski says his country is concerned about being overly reliant on Russia for its energy supplies and wants to be able to pipe in energy from Western Europe too if necessary. However, Merkel did not budge from her support for the pipeline, saying it is important to establish a Europe-wide energy market. She promised she would make Poland's access to European gas markets a priority during the German EU presidency during the first half of 2007."

Appendix 2

Available on the web:
http://www.northworks.net/w_pub_vniigaz.htm

Assessing Risks in Long-Term Planning: Probabilistic Scenario Analysis with Generalized Equilibrium Energy Models

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ABSTRACT

This paper provides a brief introductory summary of methodologies that have been used in the United States for long-term planning of large energy investments that require extensive capital investment and development of technology. It is expected that such methods may be useful to GAZPROM and to its export customers in connection with planning and financing development of additional gas fields in the high arctic area of Russia and pipeline construction to bring such gas to export markets, such as the Baltic countries and other portions of Western Europe. There are two methodologies involved: (1) the use of probabilistic scenario analysis to examine changes in market conditions, including political events that may limit or disrupt energy supply to customers; (2) the use of large-scale energy models that project how market conditions including energy prices and the mix of energy materials may evolve under specific scenarios. The example presented will be the analysis prepared for the US Presidential Task Force in 1975, when the US Government was considering a massive investment in new facilities to make liquid and gaseous fuels from coal and oil shale. This program was subsequently implemented, proved to be a market failure, and was therefore discontinued. The reasons for the market failure were clearly evident in the 1975 analysis. The author will present a retrospective review of this 1975 analysis, in which he was a participant, and an update on the energy modeling and probabilistic scenario methodologies as these have evolved in thirty years of subsequent use by US energy and risk specialists.

I. HISTORY AND BACKGROUND

At the midpoint of the first decade of the 21st century, oil and gas resources are depleting. Western Europe will need increasing amounts of imported oil and gas to meet its energy needs. There are also special situations. For example, the government of Lithuania has agreed as a condition for its membership in the European Union to shut down the Ignalina Nuclear Power Plant (NPP) [1]. This plant has two 1500 MW nuclear generating units of the graphite channel (RBMK-2) type, the same design as for the Chernobyl NPP in the Ukraine. Ignalina NPP was built during the time of the Soviet Union to provide electricity for the Baltic region, and it became a part of Lithuania when Lithuania became an independent country. Its 3000 MW generation capacity has allowed Lithuania to meet most of its own needs for electricity from this NPP and also to export large amounts of electricity to Latvia, Estonia, Belarus, and the Russian Federation. Unit one was shut down at the end of 2004. The second unit is scheduled to be shut down in 2009. Shutting down these two nuclear units will require that this electric generation be replaced by other energy sources, such as natural gas from Russia or a heavy oil/water mixture called orimulsion from Venezuela.

Increased reliance by European countries on natural gas from Russia has positive features for these countries and also for Russia. Russia has extremely large natural gas resources that can be developed and transported to European countries for costs that should be competitive with other energy sources. Natural gas does not contain sulfur, nitrogen, metals, or complex hydrocarbons, so control of air pollutants such as sulfur oxides, nitrogen oxides, and particulate matter is inherently much more easily accomplished; pollution control equipment is needed only for management of oxides of nitrogen formed from atmospheric nitrogen in the combustion process. The low carbon content of natural gas compared to oil and coal implies lower levels of carbon dioxide emissions into the atmosphere, compared to burning coal or oil. More use of natural gas, instead of coal or oil, therefore reduces global climate alteration. For these reasons natural gas will increasingly be viewed as a premium fuel, for which customers are willing to pay a higher price. Production areas of natural gas in Western Europe such as in the North Sea are depleting, and large new gas resources are unlikely to be discovered. Russia is known to have very large gas resources that are only now beginning to be developed, such as the Shtokman field. These resources could provide ample supplies for European consumers for much of the 21st century, and may permit export of liquefied natural gas (LNG) to North America as well. [2]

Development of Russian natural gas for export to European countries will require considerable capital expenditure, including the construction of new pipelines and development of gas fields in the arctic region. While agreement was reached between GAZPROM and German companies last year to construct a new gas pipeline to provide Russian gas to Germany, the Baltic countries and Poland expressed concern that this pipeline would bypass them and leave them dependent on single pipelines from Russia. The countries would have preferred an alternative overland route. The 2004 interruption of gas supply to Belarus and the New Year's Day interruption of gas supply to the Ukraine, and the recent terrorist attacks on the pipelines to Georgia have increased concerns among Europeans that the supply of gas from Russia may not be reliable. Events such as equipment breakdowns and extreme weather can lead to supply interruptions. The planning of the multibillion dollar investments in gas field development and pipeline construction will depend on perceptions that (1) the price of the natural gas to customers will be competitive with other energy sources, and (2) that supplies will be reliable. There must be assurances that neither politically motivated shutdowns, equipment failures, extreme weather, or acts of terrorism or war will disrupt the transport of gas essential for heating and continued function of the economy in countries depending on natural gas imports. Alternative supplies energy are available to Europe through North Africa, the Middle East, and possibly from Central Asia, especially as new pipelines or LNG facilities are constructed.

What is needed for planning is methodology to deal with two issues: (1) a way of assessing the competition in price between gas from Russia and other energy materials for meeting the needs of European Countries, looking forward for decades (2) a way to assess the uncertainties arising from weather, equipment failures, and political events to plan adequate redundancy in the energy supply system to that the probability of significant supply interruption can be made acceptably low. Multiple natural gas pipelines connecting gas fields to customers, underground gas storage located in customer countries, and provision to obtain and use other supplies under upset conditions may be needed to assure adequate supply reliability. The cost of these facilities needed for adequate supply reliability should be included in calculating what it will cost to provide gas from Russia to serve export markets in Europe. Therefore, the two issues must be linked.

II. METHODLOGY NEEDED

How can these planning needs be met? In this paper the author shares experience from applications within the United States of risk and decision analysis, in the belief that such experience may be useful for those in Russia and in Europe responsible for planning GAZPROM's future and a reliable supply of energy to meet European energy needs. In the 1970s the author was involved in a number of energy planning studies in the United States, including the analysis of a major Presidential initiative to create a one million barrels-per-day synthetic fuel capability within ten years [3,4], and a comparison of the economic and social costs of coal and nuclear generation [5]. The author was also involved in a pioneering application of decision analysis to political events in the Persian Gulf area that might impact on the reliability of energy supply from that region [6]. The influence diagram methods developed in that project are described in a recently published pair of journal articles [7.8]. The author also chaired the review of the first set of reports to the US Congress on global climate change, for the Science Advisory Board of the US Environmental Protection Agency [9]. In October of 2004 the author substituted on short notice for his Stanford University colleague, Professor Stephen Schneider, in giving a presentation on global climate alteration in Stuttgart, at a meeting organized by the Minister of Transport and Energy of the State of Baden-Württemberg [10]. Especially in the roundtable discussion that followed the presentations, which included leaders of German industry and representatives from the German Bundestag, the author became persuaded that formal analysis of the kind done in the United States in the 1970s would be very helpful in Europe.

Analytical Tools Area #1 – Probabilistic Risk Analysis: A shortfall or failure in a complex system often can be described as a scenario, a set of events leading to this failure. Probabilistic models of such event sequences have a long history in statistics and reliability theory. Such approaches were developed in the aerospace and nuclear power industries and then widely applied in these industries and elsewhere. Decision analysis evolved out of statistical decision theory in the aftermath of World War II. In decision analysis, sequences are examined of decisions and uncertain events. A decision tree is often used as a visual display and as a computing device for computing the probability distributions corresponding to different decision alternatives, and then evaluating these to find the best decision. [11].

Influence diagrams [6,7,8] evolved from decision trees to deal with situations in the sequence of decisions and events has a complex structure of conditionality. For example, a series of ten to twenty uncertain events precedes the system failure of interest, and the probabilities assigned to one of these events may depend on some (say, 2 to 6), but not all of the preceding events and decisions in the sequence. With binary (two possible outcomes) events, a sequence of ten events leads to a thousand end points or scenarios, and 20 leads to a million. An illustration of such a tree showing all the possible outcomes becomes impractical except in a generic form. The influence diagram is a schematic form that shows by means of arrows connecting decisions and events (collectively referred to as “nodes”) the conditionality structure. Influence diagrams have achieved widespread use in decision analysis, operations research [12] reliability [13] and also in computer science applications, sometimes under the term, Bayesian nets. A recent application to protection against terrorism by the author’s department chairman at Stanford and one of her students is found in [14]. Software packages for influence diagram computations are available from several sources. For the illustrative example below, the author has used *Decision Advisor*, a propriety software package for R&D management marketed by SmartOrg of Menlo Park, CA.

Failure of the natural gas supply system to meet gas demand might result from four types of events:

1. high peak demand and/or reduced supply resulting from extreme weather
2. equipment failure for reasons other than extreme weather
3. terrorist attacks
4. deliberate interruption by the supplying country or by the operator of a pipeline, for political reasons.

An influence diagram is shown in Figure 1.

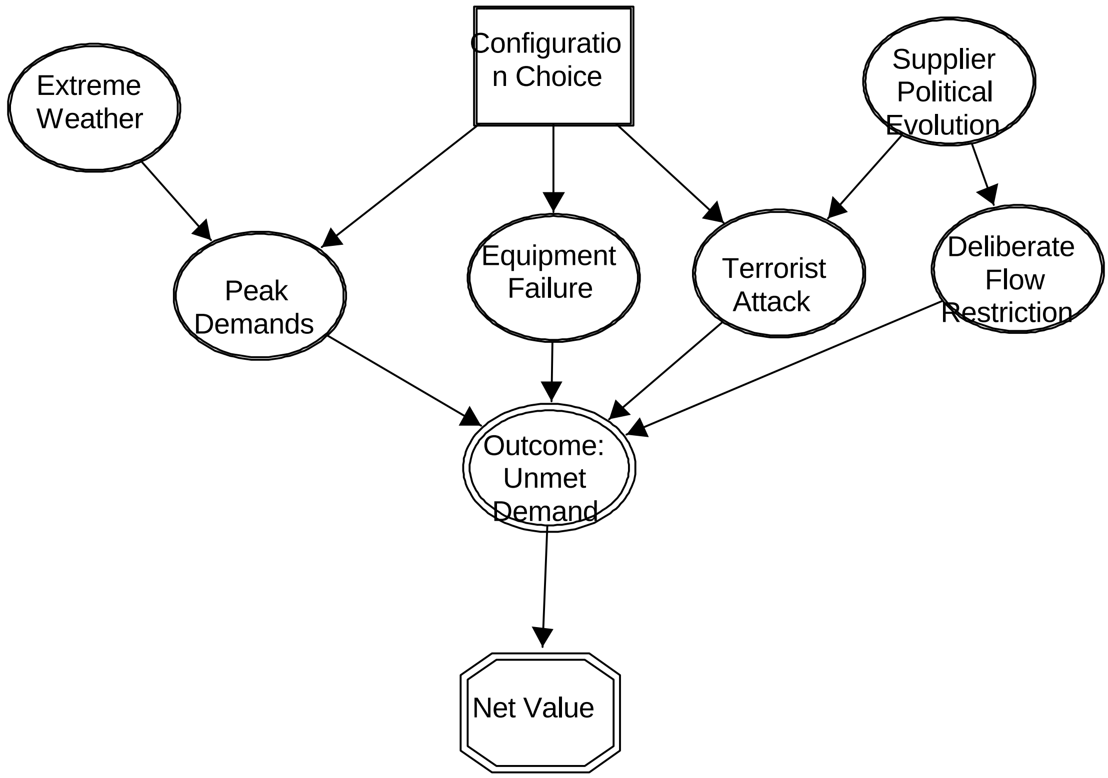

Figure 1. Influence Diagram for Gas Supply – Simple Illustration. Diagram produced by *Decision Advisor* software.

The arrows show conditionality for dependence of the uncertain events on preceding events. For example, we assume that a failure of the system to meet peak demands as the result of extreme weather depends on whether the extreme weather occurs (and perhaps to what extent) and on the configuration of the pipeline and storage system. An analysis might consider a base case and several alternatives in which additional investment has been made to have storage facilities and one or more additional pipelines from the supplier country. For each system configuration and each of the weather outcomes, a probability is assigned to the outcome of a supply shortfall. We show below in Figure 2 a decision tree representation for a portion of the influence diagram: two outcomes for extreme weather (yes and no), three systems configurations (base and two alternatives) and two possibilities for shortfall (shortage and none).

Moving from left to right and then down the influence diagram in Fig 1, probabilities are assigned to "terrorist attack," conditional on which of these outcomes occurs and the system configuration alterative. "Deliberate flow restriction" is shown conditioned only on 'supplier political evolution." Once probabilities are assigned to all the possible outcomes for each event and decision, a composite probability can be computed for each possible path or scenario. Figure 3 shows the probability distribution computed for illustrative numbers in this highly simplified influence diagram.

The approach is capable of using a much more complex structure of decisions and uncertain events conditionally dependent on preceding decisions and events (nodes) in the influence diagram. For the other three terms, we have conditioned equipment failure only on the configuration decision, and we condition "terrorist attack" on "supplier political evolution." "Deliberate flow restriction" is also conditioned on what happens in "supplier political evolution." This node is intended to describe what might happen politically in eastern European countries during the next 5-15 years. A very simple characterization of three mutually exclusive, collectively exhaustive outcomes for one or more countries might be: continued steady progress in democracy, protracted civil unrest, and reversion to authoritarian imperialism. Probabilities may be assigned to each of these outcomes, based on the judgment of experts in the politics of the area. Disagreement among such experts can be expected. Which judgments are most important? Sensitivity analysis can help determine which judgments are most important in influencing the overall probability of supply interruption and its economic and social consequences.

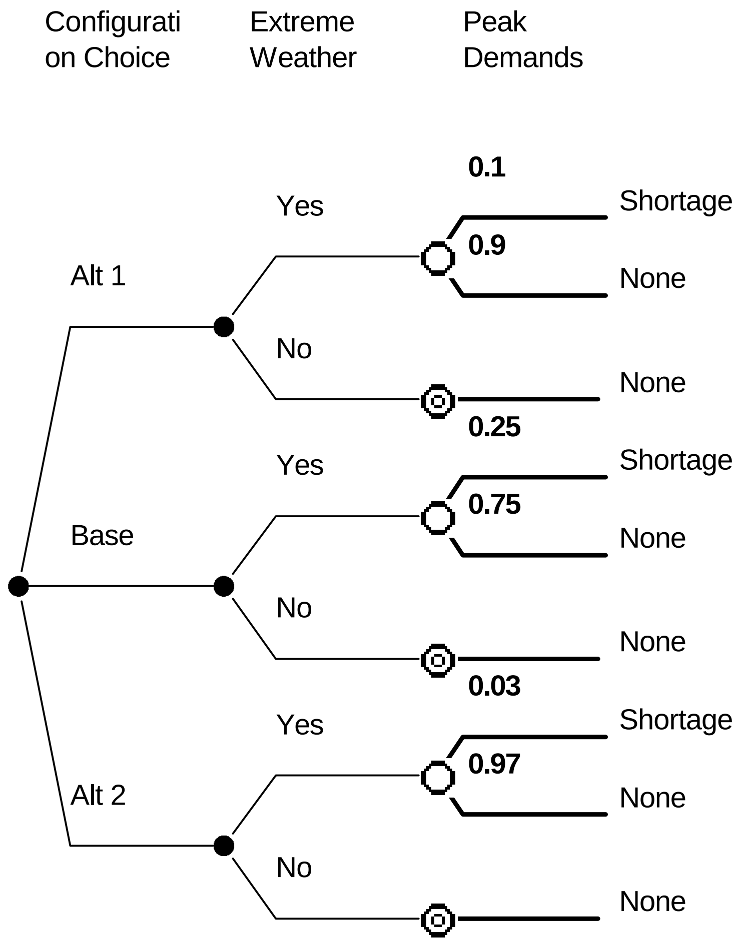

Figure 2. Tree representation showing probability assignments for "peak demand" node in the Influence Diagram. Tree as shown is a display produced by *Decision Advisor*.

Once the set of conditional probability assignments are complete and outcomes for "unmet demand" resulting from the four sets of causes are described, then the software can compute probability distributions for each configuration, so that costs and risks of supply interruptions over different time periods and impact magnitudes can be compared. An illustrative cumulative distribution is shown below in Figure 3. It shows a moderate probability (about 7%) of a limited shortfall judged to be worth about € 1 billion, and a much smaller probability (0.7 %) of a much larger shortfall, valued at € 60 billion. Such a large disaster would be comparable to the impacts the US experienced in 2005 from the Gulf Coast hurricanes. It might plausibly result from a major, extended interruption, perhaps from a series of successful terrorist attacks, civil unrest, or an extreme action or series of actions to reduce supply from the gas sources and deliberate shutdown of pipelines.

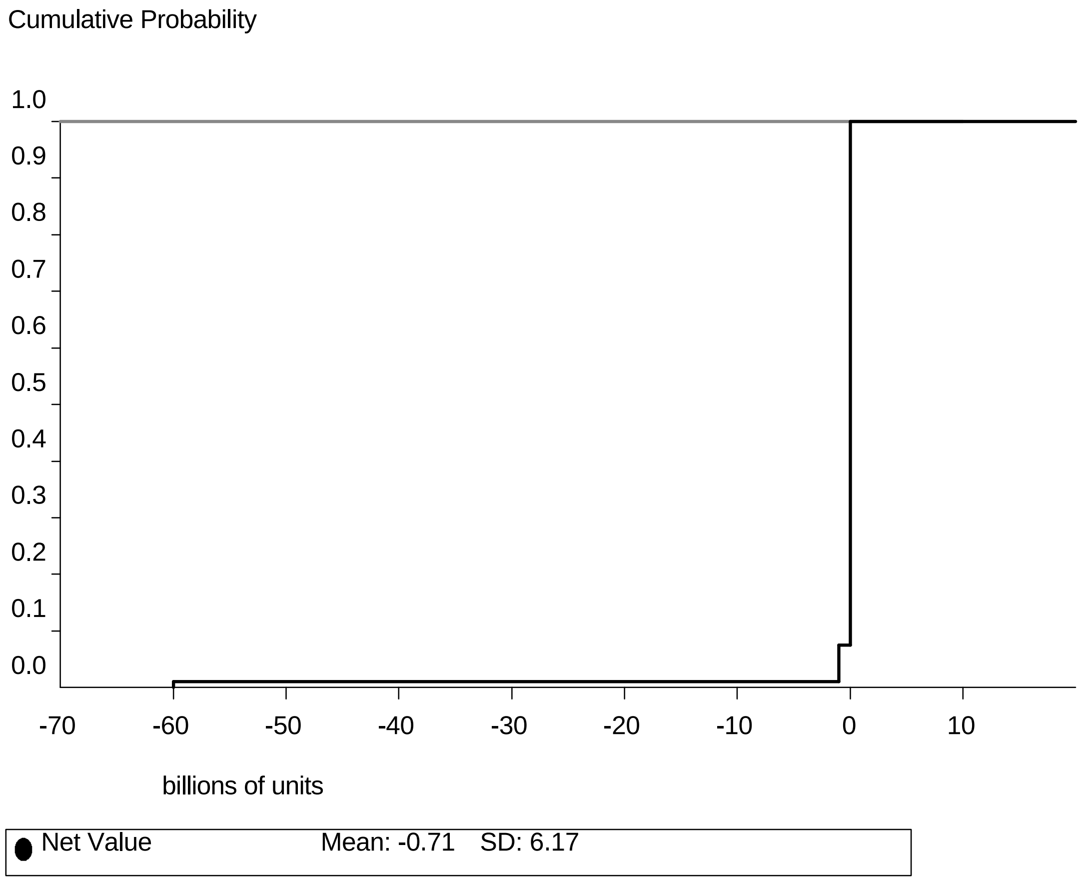

Figure 3. Illustrative calculation of probability distribution of loss, with supply interruption scenarios valued in monetary units, such as Euros. SD = standard deviation. Distribution shown is output from *Decision Advisor*.

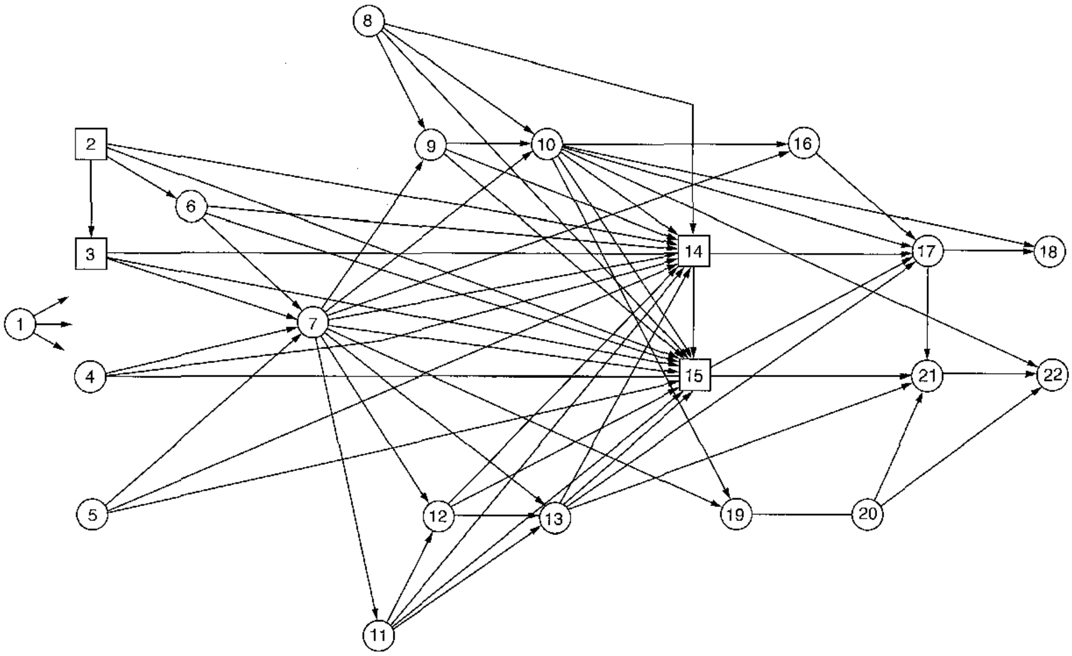

Figure 4. Influence Diagram for Persian Gulf Political Events (from [7], page 145. The original version was produced by Allen Miller and colleagues in 1973-74.)

Table 1 Sequence of Decisions and Events in the Influence Diagram Example

I. Information received from the intelligence activity
  1. The activity reports that an event will occur.

II. Initial U.S. policy decisions
  2. The United States continues its strong diplomatic support for Israel and continues to supply significant amounts of military equipment to Israel.
  3. The United States moves the naval force it currently has in the Persian Gulf to a base in the Indian Ocean.

III. Soviet Influence
  4. The Soviets substantially increase the amount of military equipment they supply to revolutionary organizations in the Persian Gulf.
  5. The Soviets increase their own military presence in the Persian Gulf.

IV. Arab-Israeli conflict and revolutionary activity
  6. The Arabs and Israel reach a political settlement that is acceptable to most Arabs in the Persian Gulf states.
  7. There is a significant increase in the level of revolutionary organization and activity in the Persian Gulf states.

V. Instability and revolution in Saudi Arabia
  8. King Faisal dies.
  9. Considerable internal instability develops in Saudi Arabia

VI. Instability and "revolution" in Iran
  11. The Shah of Iran dies.
  12. Considerable internal instability develops in Iran.
  13. A revolutionary regime takes power in Iran.

VII. U.S. policy decisions to support Persian Gulf states
  14. The United States gives diplomatic support and large amounts of military equipment to Saudi Arabia.
  15. The United States gives diplomatic support and large amounts of military equipment to Iran.

VIII. Conflict between Saudi Arabia and Iran
  16. A revolutionary regime takes power in Qatar, Bahrain, or the U.A.E.
  17. Saudi Arabia and Iran engage in a serious military conflict.
  18. Iraq enters the conflict between Saudi Arabia and Iran.

IX. Conflict between Iraq and Kuwait or Iran
  19. A revolutionary regime takes power in Kuwait.
  20. Iraq engages in military conflict with Kuwait—possibly in an attempt to annex Kuwait.
  21. Iraq and Iran enter a serious military conflict.
  22. Saudi Arabia enters the conflict between Iran and Iraq.

Table 1, Reproduced from [7], page 146

The structure shown in Figure 1 here is intended only as a highly simplistic description of the methodology, for those not familiar with influence diagrams and probabilistic risk analysis. Applications of probabilistic risk analysis to weather and equipment failure are widely carried out by gas and electric utilities. Application to the threat posed by terrorism and political decisions to interrupt supply are not widely practiced. It may be useful to carry out such an analysis as the basis for dialogue among the concerned parties. For example, some parties in Russia may assert that the threat of terrorist attack in Lithuania and other Baltic countries led to a preference for the Baltic undersea pipeline route over the cheaper overland route. Figure 4 and influence diagrams of similar complexity in [14] illustrate how complex sequences of events may be represented suing influence diagrams as a means of assessment expert judgment for probabilistic risk analysis.

Analytical Tools Area #2: Energy Models for Long-range Planning: Planning the future of a complex energy system on a time scale of many decades is a daunting challenge. Dating back at least to period in the 1970s when the United States was considering large investments in new energy systems, such computer planning models are increasingly being used by businesses and government agencies.

Stanford University has since the 1970s had an activity called the Energy Modeling Forum, in which leaders in the field of energy modeling bring their models (often proprietary computer software, developed at considerable investment expense) and come together to analyze case exercises, from regional planning to global response in the context of global climate change. Reference [15] is a report on dealing with natural gas supply in North America. One of the models used in the exercise described in [15], the North American Gas Model (NARG), is a direct descendent of the SRI-Gulf model used for the synthetic fuel commercialization analysis described in [3] and [4]. In [15] this model was being used on behalf of the California Energy Commission; it has also been used for many leading US and international oil and gas companies. The lead modeler, Dale Nesbitt, worked with the author on the 1975 synthetic fuel analysis ([3] and [4]). The generalized equilibrium methodology involves an extension from mathematical programming to finding the fixed point solution x to an equation $f(x) = x$, where x is a vector of very high dimensionality describing flow quantities and prices of energy materials at different locations in a network connecting energy resources in the ground to energy end use demands, and at different time points from the beginning to the end of the planning horizon [16,17]. The NARG model and its European counterpart, the European Gas Model, are not unique to one vendor. Argonne National Laboratory (ANL) and Rice University have developed similar models based on the generalized equilibrium approach. Other modeling and simulation approaches can be used to forecast how the competition may evolve between natural gas from Russia, natural gas from other sources, and competing fuels and technologies for meeting Europe's needs.

Understanding how the European energy system may evolve over a period from now to the middle of the twenty-first century can be greatly aided by the use of advanced energy modeling tools. Energy models are particularly useful for projecting changes as energy prices and the availability of energy technologies change over time. The models can also be used to analyze upset conditions, such as those that occurred in the US during the last half of 2005 because of hurricane damage.

III. Combining Both Analytical Tool Areas: the 1975 Synthetic Fuels Analysis

The 1975 analysis [3,4] of the US decision on investing billions of dollars to create a million-barrel-per-day industry to make gas and liquid fuels from coal and oil shale showed that this investment was a poor idea. The program proposed in the President's State of the Union was first scaled down to a smaller program of one commercial scale plant of each technology, a total capacity of 1/3 of a million barrels per day. This smaller program was proposed by President Gerald Ford but voted down by the US Congress. Under the next President, Jimmy Carter, a small synthetic fuels program was established. The program failed badly, for reasons that were foreseen in the analysis: The increased prices of oil and other energy materials that occurred in the mid-1970s led to reduction in demand, and also to expansion of conventional oil and gas supplies, with the result that there was no market for high-cost synthetic fuel made from shale and coal. The Great Plains Coal Gasification plant was built, but it was not able to sell its gas product, because the price of gas was below the operating cost to produce gas from this plant. There was no return of profit to offset the high capital cost of the plant. The plant was therefore abandoned, with the loss of the capital cost of its construction at the expense of the US government.

The analytic tools used for the analysis ([3] and [4]) included the decision tree shown in Figure 5 describing important uncertainties and how future decisions to expand capacity would depend on the immediate decisions to be taken in the mid-1970s. Many thousands of scenarios were represented in the decision tree, and across this large number of scenarios (with some approximations via curve fitting) an energy model was used to assess how prices, technology choices, and energy quantities might evolve for that scenario.

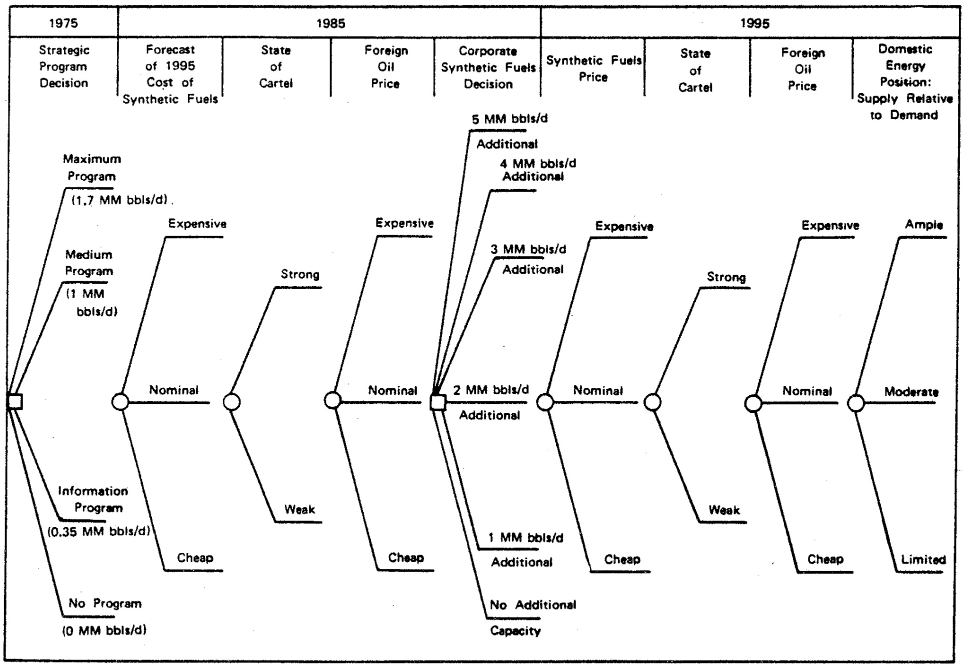

Figure 4: Synthetic Fuels Decision Tree

A number of other analyses were carried out in the US in the late 1970s using multiple scenarios and energy models. A review of some of these analyses appears in [18]. The synthetic fuels analysis was one of the most elaborate, and it was tightly focused toward one specific government policy decision. It should be a useful example to Russian and European Union experts in analysis of specific alternatives, such as new pipelines and LNG transport facilities, for supplying reliable natural gas and other energy materials to Europe in the coming decades.

IV. Needs for Future Planning and Decision Making

In planning Europe's energy future, the leadership in energy companies and governments need to work effectively together, and to overcome legacies of mistrust and misunderstanding that come from many historical events and from differences in institutions and cultures. Effective planning and decision making require not only the mastery of analytical methods for dealing with the complexity and uncertainty of energy markets and technological development, but also learning how effective governance can be achieved among a multiplicity of stakeholders – national governments, the European Union and the G-8, energy companies, and concerned citizens in many countries. It is not just a technical problem - it is also an extreme social and political challenge! Several recent reports have suggested how decision analysis methods can support improvements in risk governance in order to improve the transparency and effectiveness of national and international dialogue [19, 20, 21].

In the Preface to the National Energy Strategy for Lithuania ([1], page 5), Dr. Jurgis Vilemas[3] writes, "Decision-making will hopefully, in the end, be based on economic reasoning, realistic demand forecasts and the latest achievements in development of energy generation technology." This is an excellent place for planning to start, and the author looks forward to working with Dr. Vilemas and his colleagues on a study of how to meet the energy needs of the Baltic Region. This analysis will be broadened from a focus on purely economic reasoning to include the four types of risk issues that have been listed in this paper and illustrated in the simple influence diagram: extreme weather, equipment failure, terrorism and sabotage, and political interference in energy trade. The author hopes that the RIMS-2006 participants, the management of VNIIGAZ and GAZPROM, and the leadership of energy planning for Europe share this expanded view on what needs to be done to support good decision making for the energy future of Russia and Europe.

REFERENCES

[1]. J. Vilemas, V. Miškinis, and A. Galinis, *National Energy Strategy*, Prepared for, and approved by, the Seimas (Lithuanian Parliament) on 10 October 2002, Lithuanian Energy Institute, 2003.

[2]. Tristana Moore, "Gazprom's Global Ambitions," BBC News, Tuesday 20 December 2005. Available at http://news.bbc.co.uk/1/hi/business/4531578.stm

[3]. Synfuels Interagency Task Force, *Recommendations for a Synthetic Fuels Commercialization Program,* report prepared for the President's Energy Resources Council, November 1975, Washington, DC: US Government Printing Office.

[4]. S. N. Tani, "Decision Analysis of the Synthetic Fuels Commercialization Program," *The Principles and Applications of Decision Analysis*, R. A. Howard and J. E. Matheson, editors, Menlo Park, CA: Strategic Decisions Group, 1989.

[5]. Stephen M. Barrager, Bruce R. Judd, and D. Warner North, *The Economic and Social Costs of Coal and Nuclear Generation*, Report prepared for the National Science Foundation by Stanford Research Institute, Menlo Park, CA, March 1976.

[6]. Allen C. Miller, III, James. E. Matheson, Miley W. Merkhofer, Thomas R. Rice, and Ronald A. Howard, *Development of Automated Aids for Decision Analysis*, Final technical report prepared for the Defense Advanced Research Projects Agency (DARPA) by Stanford Research Institute, Menlo Park CA, May 1976.

[7]. Ronald A. Howard and James E. Matheson, "Influence Diagram Retrospective," *Decision Analysis* **2**:144-147 (2005).

[3]Dr. Jurgis Vilemas was Director for 23 years of the Lithuanian Energy Institute. Dr. Eugenijus Uspuras is now the LEI Director, and Dr. Vilemas remains active at LEI as Chairman of its Council. Dr. Vilemas, Dr. Uspuras, and Dr. Juozas Augutis from LEI attended the RIMS 2006 Conference February 1-2, 2006.

[8]. Ronald A. Howard and James E. Matheson, “Influence Diagrams,” *Decision Analysis* **2**: 127-143 (2005).

[9]. D. Warner North, “EPA’s Draft Reports to Congress on Global Warming: An Overview from 1990,” available at http://www.northworks.net/w_epasab1990.htm.

[10]. D. Warner North and Stephen H. Schneider, “Global Climate Change: A Survey of the Science and Policy Implications,” in press for conference report publication; available at http://www.northworks.net/w_pub_stuttgart.htm.

[11]. Robert T. Clemen, *Making Hard Decisions: An Introduction to Decision Analysis*, Belmont, CA: Duxbury Press, 1991.

[12]. Ross Shachter, “Evaluating Influence Diagrams,” *Operations Research*, **34**:871-882, 1986.

[13]. *Reliability and Decision Making*, Richard E. Barlow, Carlo A. Clarotti, and Fabio Spizzichino, editors, London: Chapman and Hall, 1993.

[14]. Elisabeth Paté-Cornell and Seth Guikema, “Probabilistic Modeling of Terrorist Threats: A Systems Analysis Approach to Setting Priorities Among Countermeasures,” *Military Operations Research* **7**(4): 5-23, 2002.

[15]. Stanford Energy Modeling Forum, *Natural Gas, Energy Diversity, and North American Energy Markets*, report on EMF 20, Stanford University, September 2003. Available at: http://www.stanford.edu/group/EMF/publications/doc/emf20summary.pdf. A list of other EMF reports is available at: http://www.stanford.edu/group/EMF/publications/order.htm.

[16]. Edward G. Cazalet, *Generalized Equilibrium Modeling: The Methodology of the SRI-Gulf Energy Model*, report prepared by Stanford Research Institute for the Federal Energy Administration, May 1977.

[17]. Horace W, Brock and Dale M. Nesbitt*, Large Scale Energy Models: A Methodological Analysis*, report prepared by Stanford Research Institute for the National Science Foundation, May 1977.

[18]. James Just and Lester Lave, “Review of Scenarios of Future US Energy Use,” *Annual Review of Energy*, **4**:501-36 (1979). http://arjournals.annualreviews.org/doi/pdf/10.1146/annurev.eg.04.110179.002441

[19]. National Research Council, *Understanding Risk: Informing Decisions in a Democratic Society*, Washington DC: National Academy Press, 1996. Available at: http://books.nap.edu/catalog/5138.html.

[20]. D. Warner North and Ortwin Renn, “Decision Analytic Tools and Participatory Decision Processes,” “State of the Science” paper prepared for the National Research Council Panel on Public Participation in Environmental Assessment and Decision Making, March 2005. Available on the web through: http://www7.nationalacademies.org/hdgc/Public_Participation.html. A final report from this Panel of the National Research Council is expected in late 2006.

[21]. Ortwin Renn, *Risk Governance: Towards an Integrative Approach*, White Paper #1, International Risk Governance Council, Geneva, Switzerland, September 2005. Available at: http://www.irgc.org/spip/IMG/pdf/IRGC_WP_No_1_Risk_Governance_(reprinted_version).pdf