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# The Decision to Reactivate a First-Generation Soviet Nuclear Power Plant: Conceptual and Decision-Analytic Frameworks

John M. Gleason\*

## Introduction

In March 1994, Armenia and Russia signed a bilateral nuclear cooperation treaty in which the countries agreed to reactivate the Metsamor Nuclear Power Plant (MNPP), a first-generation Soviet facility near Yerevan, Armenia. The facility was closed for safety reasons in 1989, following an earthquake in Armenia. This would be the first time a nuclear plant would be reactivated after so long a period of disuse. The decision to reactivate the plant was opposed by countries in the region, by the Group of Seven (G-7) countries and by countries of the European Union.<sup>1</sup> Opposition is based on safety concerns, specifically, about seismic risks and, more importantly, risks related to facility design characteristics (the plant has no containment facilities to prevent the spread of radioactive material in the event of an accident).

A variety of factors influenced the controversial decision to reopen. The decision was prompted by a complex interaction of political, social, economic and environmental factors that combined to create conditions overriding technological considerations that caused reactivation to be so overwhelmingly opposed by other countries. Specifically, ethnic conflict, turmoil and warfare in the region have resulted in social and economic paralysis in Armenia. Those conditions, with associated environmental problems, have prompted a decision that virtually everyone agrees is not warranted by technological considerations.

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<sup>1</sup> *Armenia Determined to Reopen Controversial Reactor*, Reuters, May 8, 1994, available in SK News Digest.

In light of significant safety concerns, and worldwide opposition to reactivation of the MNPP, why would the Armenian government do so? This paper examines a variety of factors which combined to yield the chaotic conditions that prompted the 1994 MNPP reactivation agreement between Armenia and Russia. Several conceptual/theoretical frameworks regarding industrial crises, organizational disasters, and stakeholder behavior are discussed. These qualitative frameworks provide a basis for understanding the evolution of the reactivation decision. A quantitative decision-analytic model which provides insights regarding the reactivation decision process is also examined.

The qualitative frameworks are shown to have implications regarding the real-world operationalization of the decision-analytic model; the implications suggest the need for a reappraisal of our understanding of how the quantitative model is applied in a decision process. *Because the terms "risk" and "uncertainty" are defined differently in various academic fields, it should be noted that the terms are used synonymously in much of this discussion.*

### Conditions In Armenia

The former Soviet republic of Armenia is a small landlocked country bounded by Turkey, Georgia, Azerbaijan and Iran. Approximately one-third of the population of 3.7 million lived in Yerevan, the capital city.<sup>2</sup>

Ethnic rivalries, separatist movements, rebellion and even Georgian/Armenian mafia activities have created turmoil in the region. The most significant problem is the war between Armenia and Azerbaijan, over the disputed region of Nagorno-Karabakh. This undeclared war, which began in 1988, had resulted in 20,000 deaths and one million refugees by 1994.<sup>3</sup> It has created significant social and economic hardships in both Armenia and Azerbaijan.

Georgia, which borders Armenia to the north, is a nation in chaos. Separatist movements spawned rebellion and internal warfare causing governmental instability and collapse. Georgia's current government is

<sup>2</sup> Armenia National Institute of Health, Armenian Public Health Report (1994)

<sup>3</sup> Jon Auerbach, *In a Corner of Former USSR an Ethnic Conflict Rages on*, Boston Globe, April 21, 1994, at 14; Lawrence Sheets, *Azerbaijan says Armenians Blocking Refugee Return*, Reuters, May 23, 1994, available in, SK News Digest.

skeptical of Russian efforts in the region. These conditions are exacerbated by Azerbaijani activities directed against Armenia on Georgian territory, including continued pipeline sabotage and railroad bombings. For example, during January and February 1994, the gas pipeline to Armenia from Georgia was blown up twice, and the railway was blown up five times.<sup>4</sup> The Mafia, which is heavily involved in gasoline sales, is the suspected instigator of much of the sabotage that results in reduced flows of gasoline from Georgia to Armenia.<sup>5</sup>

Long-standing enmity exists between Armenia and Turkey, as a result of activities (described by the Armenians as “the genocide”) directed against Armenians by the Ottoman Empire. During 1915–16, an estimated one million Armenians died or were killed during forced deportation by the Turks. Presently, Turkey is engaged in continuing attempts to quell rebellion by Kurdish rebels. Turkey also supports Turkic-speaking Azerbaijan in its war with Armenia. Turkish support has included an embargo on Armenia.

Finally, Iran, to the south of Armenia, has a myriad of problems. Despite the fact Armenia is a Christian country, Iran and Armenia have a relatively good relationship.

While the general chaos in the region has had a negative effect on social and economic conditions in Armenia, the most significant impact on those conditions derives from the war between Armenia and Azerbaijan over Nagorno-Karabakh. Armenia has always been dependent upon imports for a significant amount of its food and for all of its oil and natural gas.<sup>6</sup> Armenia is heavily dependent upon natural gas; gas is the primary source of energy for residential and industrial needs and for the generation of electricity. Before the disintegration of the Soviet Union, two pipelines from Turkmenistan that pass through Azerbaijan were the primary sources (providing 80%) of natural gas for Armenia.<sup>7</sup> Because of the war, Azerbaijan imposed an embargo on

<sup>4</sup> Armenian Assembly of America, *Department of Emergency Situations Report*, Daily News Report From Armenia, April 4, 1994.

<sup>5</sup> *Armenian Nuclear Power: Better than Cold*, *The Economist*, April 15, 1994, at 54.

<sup>6</sup> Raymond Bonner, *War, Blockade and Poverty “Strangling” Armenia*, *The New York Times*, April 16, 1994, at 3.

<sup>7</sup> Richard Giragossian, *The Economic Effects of Azerbaijan’s Blockade of Armenia*, *The Noyan Tapan Highlights*, May 14, 1994; see also *The Economist*,

Armenia.<sup>8</sup> The embargo has limited fuel supplies reaching Armenia. The source of the minimal supply of fuel (only 20% of Armenia's needs) is a gas pipeline through Georgia from Turkmenistan.<sup>9</sup> The supply of fuel from Georgia is erratic at best, due to pipeline sabotage.

The shortage of fuel has been devastating to Armenia. As a result of energy shortages, industry operated at 30% capacity in early 1994.<sup>10</sup> A limited number of shops were operating, and severe shortages of goods existed.<sup>11</sup> During the first four months of 1994, consumer prices increased 450%.<sup>12</sup> In April 1994, when the Central Bank removed month-long controls from the Armenian currency (the dram), the value of the dram dropped 22% in one week, suggesting an annualized inflation rate of 1200-1300%.<sup>13</sup>

The harsh conditions have resulted in severe problems of emigration. Emigration estimates range from 500,000 during the three years preceding the Metsamor reactivation agreement<sup>14</sup> to 750,000 in the year preceding the agreement.<sup>15</sup> Emigration, whatever the true numbers, is partially offset by an influx of 305,000 refugees.<sup>16</sup>

Finally, the lack of energy sources exacerbates conditions in a country that still has not recovered from the 1988 earthquake in northern Armenia. That earthquake killed more than 25,000 people, left 503,000 people homeless and destroyed seven major cities.<sup>17</sup> Serious, unrepaired damage from the earthquake is still evident.

The winters following the imposition of the Azerbaijan energy embargo were devastating. The severe winter conditions have resulted

*supra* note 5.

<sup>8</sup> Richard Balmforth, *Armenia Determined to Reopen Controversial Reactor*, Reuters, May 8, 1994, available in SK News Digest.

<sup>9</sup> Giragossian, *supra* note 7; see also The Economist, *supra* note 5.

<sup>10</sup> Bonner, *supra* note 6.

<sup>11</sup> Armenia Assembly of America, *305,000 Refugees in Armenia*, Daily News Report From Armenia, March 25, 1994.

<sup>12</sup> Suren Karapetian, *Economic Survey*, The Noyan Tapan Highlights, May 14, 1994.

<sup>13</sup> Anahit Khachatryan, *Economic Situation in Armenia*, The Noyan Tapan Highlights, April 22, 1994.

<sup>14</sup> Bonner, *supra* note 6.

<sup>15</sup> The Economist, *supra* note 5.

<sup>16</sup> Armenian Assembly of America, *supra* note 11.

<sup>17</sup> *Russia, Armenia Sign Accord to Restart Nuclear Plant*, UPI, March 21, 1994, available in SK News Digest.

in massive cutting of forests for firewood (1.5 million trees were cut during the winter of 1992–93), to the extent that the future of Armenian forests, which cover 13% of its land, is threatened.<sup>18</sup>

In addition, Lake Sevan, the pride of Armenia, has been significantly drained to provide hydroelectric power. The Ministry of Nature and Environmental Protection reports 957 million cubic meters of water were drained in 1992, and another 1,517 million cubic meters in 1993.<sup>19</sup> During the first quarter of 1994, nearly 400 million cubic meters of water were drained from Sevan. Experts have suggested that the lake soon will become a marsh if draining continues.<sup>20</sup>

In light of regional turmoil, degenerating social and economic conditions in Armenia and continuing damage to the country's environment, the Armenian government made a decision to embark on the reactivation of a first-generation Soviet nuclear power plant.

### The Metsamor Nuclear Power Plant

The Metsamor (or Medzamor) Nuclear Power Plant (MNPP), also known as the Armenian Nuclear Power Plant (ANPP), is approximately 40 kilometers from Yerevan. The MNPP is a first-generation Soviet plant capable of producing 880 megawatts of electricity.<sup>21</sup> The twin reactors were commissioned in 1976 and 1980.<sup>22</sup> The VVER-440 pressurized light water-cooled reactors were built in the early 1970's and are among the oldest of their design.<sup>23</sup>

Consequently, the reactors present risks related to design characteristics. They were constructed according to long-outdated

<sup>18</sup> Rem Ananikyan, *Tourist Attractions in Armenia* (1989); see also, Balmforth, *supra* note 6; *Desperate Nation Wants To Revive Reactor Older than Chernobyl*, Omaha World-Herald, Nov. 23, 1993, at 3; Regula Heusser-Markun, *Survival in Armenia*, Swiss Review of World Affairs, Feb. 1994, at 16; The Economist, *supra* note 5.

<sup>19</sup> *Sevan Suffers from Electricity Production*, Aragil Electronic News Bulletin, May 27, 1994.

<sup>20</sup> Omaha World-Herald, *supra* note 18; see also, *This Year 400 Million Cubic Meters of Water Drained From Lake Sevan*, Noyon Tapan Highlights, April 22, 1994.

<sup>21</sup> Omaha World-Herald, *supra* note 18; see also, *Armenia to Restart Nuclear Plant*, UPI, April 22, 1994, available in SK News Digest.

<sup>22</sup> UPI, *supra* note 21.

<sup>23</sup> The Economist, *supra* note 5.

Soviet safety standards, and they have no containment facilities — that is, no concrete containment domes to prevent the escape of radioactive material in the event of an accident.<sup>24</sup> These risks are exacerbated by seismic-related risks.

The MNPP was closed following an earthquake near Yerevan.<sup>25</sup> It was the first operating nuclear plant to be decommissioned in the Soviet Union.<sup>26</sup> The MNPP is thought to be located on an earthquake fault, and it was the concern about potential earthquake damage that resulted in the decision to close the facility in early 1989.

The Armenian government claims the seismic characteristics of the facility have been upgraded in recent years and the facility could withstand any earthquake.<sup>27</sup> Specifically, the head of the Armenian nuclear energy authority has claimed that the facility was designed to withstand earthquakes measuring 9.0 on the Richter scale.<sup>28</sup> More recently, the director of the MNPP, also indicated that the plant could withstand a 9.0 earthquake.<sup>29</sup>

The cost of reactivation was estimated to be \$70 million, approximately half of which would pay for the uranium.<sup>30</sup> As part of the reactivation efforts, Russia would provide nuclear fuel, equipment and 560 specialists to reactivate the facility. However, the reactivation of the MNPP presents still other risks related to the handling and disposal of nuclear waste. Azerbaijan, for example, has expressed concern that nuclear waste would be buried on occupied territory.

### Opposition to the Rectivation: Safety Risks

All countries in the region, the G-7 countries and the countries of the European Union have expressed opposition to the reactivation of the plant.<sup>31</sup> Major concerns about the facility have been expressed by

<sup>24</sup> Omaha World-Herald, *supra* note 18; *see also* UPI, *supra* note 21.

<sup>25</sup> The Economist, *supra* note 5.

<sup>26</sup> UPI, *supra* note 17.

<sup>27</sup> *Nuclear Power Plant Will be Started Up*, Aragil Electronic News Bulletin, March 5, 1994.

<sup>28</sup> UPI, *supra* note 21.

<sup>29</sup> *Medzamor Can Endure a 9 Point Quake*, Asabarez-On-Line, June 18, 1996.

<sup>30</sup> The Economist, *supra* note 5.

<sup>31</sup> Balmforth, *supra* note 8; *see also*, *Armenia Determined to Reopen Controversial Nuclear Reactor*, SK News Digest, May 6, 1994.

Azerbaijan. Azerbaijan has called on the International Atomic Energy Agency to investigate the ecological, military and political consequences of the reactivation.<sup>32</sup>

The G-7 countries and the European Union countries have cited safety concerns in their continuing opposition. For example, a spokesperson for the U.S. embassy in Yerevan has stated that the U.S. believes the design of the Metsamor plant is inherently unsafe.<sup>33</sup> Even the Armenian Deputy Prime Minister for Energy admitted the plant “will never be brought into line with Western safety standards.”<sup>34</sup>

Certainly, issues related to safety risks may be the subject of disagreement. For example, although various nations have expressed concern regarding seismic safety, Armenia claims that seismic-safety risks are inconsequential. However, perception is reality, and the perceptions of seismic safety risks by various countries cannot be significantly modified by the assertions of Armenia that the MNPP poses no such risks.

Concerns about risks related to design characteristics and operational safety may be less subject to disagreement. However, challenges to those concerns could be raised, by comparing the reactivation decision to the Soviet decision to continue to operate the undamaged reactors at Chernobyl. Thus, an important question may be: Are there factors related to the reactivation that may present more risk than the continued operation of the Chernobyl reactors? As noted earlier, the MNPP reactivation is the first time in history that a nuclear reactor has been reactivated after so long a period of disuse. The continued operation of Chernobyl reactors is a distinctly different undertaking. Society has no experience with such an undertaking; consequently, those involved cannot be expected to consider all the possible consequences of the reactivation. Perrow, for example, argues safety procedures cannot possibly deal appropriately with the plethora

<sup>32</sup> *Bakou is Worried by Re-Opening of ANPP*, Aragil Electronic New Bulletin, April 4, 1994; see also, *Azerbaijan Protests Reopening of Armenian Power Plant*, Armenian Information Service Daily News Summary, March 28, 1994; *Azerbaijan on Prepared Launch of Armenian Nuclear Power Plant*, SK News Digest, March 25, 1994.

<sup>33</sup> *Epigraph: When Your Feet Hurt, Remember the Old Shoes*, AP News Wire, March 17, 1994; see also, Balmforth, *supra* note 8.

<sup>34</sup> *Id.*

of possible interactions that lead to system failures in high-risk technologies.<sup>35</sup> In fact, Perrow raises a number of issues related to safety risks with nuclear power.

*Risks Related to Nuclear Power*

A premise of the concern over safety risks is the greater risk of a catastrophic incident than would: (1) the activation of a nuclear power plant constructed in compliance with state-of-the-art knowledge and technology in an industrialized country, or (2) the continued operation of undamaged reactors at Chernobyl. The premise is based on several facts, including: (1) the MNPP was closed for safety reasons following a devastating earthquake in the area; (2) this is the first time in history that a plant has been reactivated after such a lengthy period of disuse; and (3) the MNPP is a first generation facility which was originally constructed according to long-outdated Soviet safety standards. Thus, our discussion has assumed heightened danger in the specific case of the MNPP, and there has been no discussion of general risks related to nuclear power. While a detailed examination of the MNPP in the broader context of these general risks is well beyond the scope of this paper, it may be useful to briefly discuss a few of these issues.

In considering the potential for accidents arising from the use of high-risk technologies, Perrow groups the technologies into three categories. Nuclear power and nuclear weapons comprise the category of systems "that are hopeless and should be abandoned because the inevitable risks outweigh any reasonable benefits."<sup>36</sup> Perrow bases his discussion primarily on experience with nuclear facilities in industrialized nations, but the issues he raises are perhaps more worrisome when considered from the MNPP perspective.

Perrow argues that the limited operating experience we have with nuclear facilities is insufficient as a basis for claims of safety.<sup>37</sup> In the case of the MNPP, we have no experience with reactivation of a facility after so long a period of disuse.<sup>38</sup> The MNPP reactors incorporate a first-generation design even older than the Chernobyl RBMK reactors (the other basic reactor design produced in the former Soviet Union).

<sup>35</sup> Charles Perrow, *Accidents in High Risk Systems Technology* 9 (1994).

<sup>36</sup> Charles Perrow, *Normal Accidents* 304 (1984).

<sup>37</sup> *Id.*

<sup>38</sup> *Id.*

Moreover, the MNPP was constructed according to out-dated safety standards. The VVER-440 reactors at the MNPP are pressurized water reactors (PWRs) that differ from Western models in several respects, including lower ratings and higher heat intensities in the cores. There are only eight such reactors in the former Soviet Union, and they have been described as a "largely obsolete model".<sup>39</sup> More specifically, Kalinin observes:<sup>40</sup>

The VVERs fall far short of Western PWRs. In general, they are inferior in safety, life span, thermal intensity in the reactor core, and the efficiency with which fuel is used. In addition, VVER fuel must be enriched to a higher level...The greater safety of Western PWRs comes mainly from their doubled concrete containments and much more sophisticated and reliable control systems.

...The safety of (newer Soviet design) reactors has been much improved. The last version of Soviet safety regulations was quite close to the international rules. Unfortunately, only one in four nuclear power units in the former USSR, meet these standards.

Serious construction problems with various nuclear plants are detailed by Perrow.<sup>41</sup> Construction involved in the MNPP reactivation also has the potential to yield serious problems. These derive from two major sources: the Soviet work ethic and the growing level of corruption in Armenia. Under the Soviet system, everyone was guaranteed employment. The legacy of that system is the failure to recognize that a job has an objective. Workers believe simply going through the motions associated with a job is satisfactory; they are indifferent to the achievement of a purpose. Clearly, this work ethic could be detrimental to the quality of construction activities associated with the reactivation. Moreover, the growing level of corruption, Mafia influence and bribery has the potential to seriously impact construction activities related to the reactivation.

Perrow<sup>42</sup> also discusses the potentially serious impact of trivial events in high-risk systems. Despite detailed rules and procedures

<sup>39</sup> Alexander V. Kalinin, *Secrets of The Soviet Nuclear Complex*, 31 *IEEE Spectrum* 32 (1994).

<sup>40</sup> *Id.* at 36-7.

<sup>41</sup> Perrow, *supra* note 36.

<sup>42</sup> *Id.*

related to the operation of a nuclear facility, it is unrealistic to assume procedures will be developed for all potential problems. The potential for unrecognized problems in the reactivation of early-generation technology, such as the MNPP, is troublesome, especially in light of the work-ethic. If the objectives related to the development of safety procedures are not fully appreciated, then the resultant safety procedures might be more limited than they should be.

Finally, Perrow examines a factor that has received little attention with respect to the MNPP: the fuel cycle, which includes the entire cycle from mining of uranium to waste disposal. The potential for problems within this cycle is sobering.<sup>43</sup> Sources of potential problems range from Mafia influence and corruption to transportation safety. The last is exacerbated in an environment characterized by deteriorating infrastructure and war-related terrorist activities.

### Decision Alternatives

Efforts to deal with the worsening economic conditions could take many forms. However, beyond the fact that the set of alternatives considered in a given decision process is often too limited,<sup>44</sup> there are other reasons to believe the set of alternatives considered in this case was not particularly large.

Armenia considers itself isolated, its borders shared by malefactors. That mentality can severely limit alternatives that might have been considered in attempting to deal with its energy-related problems.

Moreover, the legacy of the Soviet Union influenced the decision process. For example, the Soviet system produced highly educated scientists with strong theoretical training. However, it virtually ignored fields such as management science and industrial engineering. Consequently, the body of decision-making knowledge is virtually unknown in former Soviet states. This lack of decision-making knowledge can affect the development and analysis of alternatives.

Accordingly, the decision process was more heuristically than analytically based. Heuristic processes considerably reduce the time and effort needed to analyze and rank-order a large number of alternatives.

<sup>43</sup> *Id.*

<sup>44</sup> Ralph Keeney, *Using Values in Operations Research*, 42 *Operations Res.* 793 (1994).

Moreover, heuristic processes eliminate the need to devote considerable effort to the analysis of contingencies.<sup>45</sup> For example, the *satisficing* approach is a heuristic approach in which the goal is to make a satisfactory decision (a “good enough” decision) in a reasonable time, rather than an optimal decision.<sup>46</sup> Satisficing, therefore, may be considered to be an effort to optimize the decision process, rather than an effort to determine an optimal solution.<sup>47</sup> Consequently, the reliance on heuristic processes may have resulted in considering a limited number of alternatives.

Obvious alternatives span the spectrum of those that might have been considered, ranging from do-nothing to reactivating the MNPP. Others would have been between these. We will focus on three in attempting to develop an understanding of why the reactivation decision was taken.

The first, **do-nothing**, is to continue as in the past and accept the economic and social strife caused by the energy blockade. Citizens will continue to destroy forests to survive winters. The short-term result of is to virtually destroy the country’s forests. In the long term, the country would then have to deal with the host of known environmental effects of forest depletion and the potentially unknown effects of such depletion in Armenia. Furthermore, because of the limited amount of forest land, this alternative could be expected to provide only short-term, inefficient relief. Moreover, after the forests are destroyed, Armenia will again be facing the same decision, but with one less alternative. This first alternative, therefore, may be viewed as a “slow death” alternative.

The second alternative would require government action: rely more on hydroelectric power generated by draining Lake Sevan (the Sevan alternative). However, there has been significant ecological damage caused by earlier draining. Even under optimistic conditions, continued draining of the lake could exacerbate already-significant ecological and environmental damage. Moreover, with continued draining, the lake is

<sup>45</sup> Perrow, *supra* note 36.

<sup>46</sup> James March & Herbert Simon, *Organizations* (1958); *see also*, Herbert Simon, *Economics, Bounded Rationality and the Cognitive Revolution* (1992); Herbert Simon, *Models of Man* (1957).

<sup>47</sup> Frederick Hillier & Gerald Lieberman, *Introduction to Operations Research* (1986).

expected to be a marshland in the near future, so this alternative, like the first alternative, provides only short-term benefits with significant long-term costs. Thus, this second alternative may also be viewed as a slow-death alternative.

Finally, a third alternative also requires government action: reactivation of the MNPP (the reactivation alternative). This alternative has the greatest potential for severe environmental damage to the entire region. The deputy environmental minister has stated: "Only crazy people would think of reopening a nuclear plant that was closed because it was dangerous."<sup>48</sup> However, under optimistic conditions, there will be no catastrophic "incident." Consequently, after years of Soviet rule, followed by the major economic and social devastation of the post-Soviet era, this alternative offers the hope of avoiding the slow death of the previous two alternatives.

In light of the major safety concerns, and the overwhelming worldwide opposition to the reactivation of the MNPP, what would cause the Armenian government to choose the reactivation alternative? To answer that question, several qualitative conceptual/theoretical frameworks regarding industrial crises, organizational disasters and stakeholder behavior are discussed. A quantitative decision-analytic framework which provides insights regarding the reactivation decision process is also examined, and relationships between the qualitative and quantitative frameworks are explored.

### Conceptual/Theoretical Frameworks

If the concerns of those opposed to the reactivation of the MNPP were to be realized in the context of a major accident, such an accident could be expected to cause significant damage to human life, the environment and the social structure. These effects are consistent with *industrial crises* as discussed by Shrivastava, Mitroff, Miller and Miglani, who note that such crises often occur in "environments of economic crisis characterized by insufficient growth, unemployment, fiscal deficits, budgetary and competitive pressures on individual organization and an inadequate industrial infrastructure."<sup>49</sup> Since all of

<sup>48</sup> Omaha World-Herald, *supra* note 18.

<sup>49</sup> Paul Shrivastava et al., *Understanding Industrial Crises*, 25 J. Mgmt. Stud. 285, 287 (1988).

these characteristics are evident in Armenia, the Shrivastava et al. conceptual framework for industrial crises may provide a useful basis for developing an understanding of the evolution decision process, particularly from the perspective of the Armenian government.

### *Industrial Crises*

In societies which are involved in rapid industrialization, such as Armenia, the legitimacy of the government is based on its ability to properly administer and control the economy. A rationality crisis occurs when the state is unable to properly manage economic growth, and extended rationality crisis may lead to a legitimacy crisis in which the government loses the support of the population. A legitimacy crisis can then lead to a motivational crisis which is evidenced by a decline in moral values and a lessened commitment to accepted societal order.<sup>50</sup> All of these types of crises are evident, in Armenia; consequently, the activities of the current government are a source of controversy and dissatisfaction. Under these conditions, it is understandable that the government would be attracted to a "quick fix" which would be expected to provide for the energy needs of the citizens and the needs of the economic base which is involved in fledgling efforts to survive in a competitive environment.

Shrivastava et al. identify a number of defining characteristics of industrial crises: (1) triggering event, (2) significant damage to the populace and the environment, (3) significant economic losses, (4) significant social costs, (5) causes of crises, (6) involvement and conflict between multiple stakeholders, (7) crisis response and (8) crisis resolution and the impact on the extension of crises.<sup>51</sup> A detailed discussion of the relationship between these characteristics and a potential accident pursuant to the MNPP reactivation is beyond the scope of this paper. Yet, many will be evident from earlier discussion.

Several characteristics, deserve more discussion (including the issue of multiple stakeholders which is discussed in more detail below). The last two characteristics, crisis response and crisis resolution, also may be considered from the perspective of precursors to the reactivation

<sup>50</sup> Jurgen Habermas, *Legitimation Crisis* (1975); *see also*, Shrivastava et al., *supra* note 49, at 286.

<sup>51</sup> *Id.*

decision. That is, the reactivation decision may be considered to be an attempt to respond to, and resolve, another crisis — the social, economic and environmental crisis caused by a lack of energy. Crisis response is an attempt to reduce the severity of destruction and social disruption, and to obviate future crises of a similar nature. Moreover, attempts to resolve a crisis typically focus on mitigating its effects.<sup>52</sup> Accordingly, the government's reactivation decision may be considered to be an attempt to respond to the current crisis resulting from a lack of energy. The *do-nothing* and *Sevan* alternatives will not be as effective as the *reactivation* alternative in terms of mitigating the effects of the current crisis. Moreover, they will not obviate future crises of a similar nature.

However, Shrivastava et al. note that crisis response typically focuses on symptoms and seldom deals with the original causes.<sup>53</sup> This is certainly true in the Armenian case. Accordingly, the response to and the resolution of a crisis can exacerbate the original problem. Unfortunately, the reactivation decision could eventually lead to problems of *significantly* greater severity than the current problems.

#### *Stakeholders*

The various stakeholders affected by the MNPP decision differ in terms of their cosmological perspectives; that is, they differ in terms of their social organization, cultural biases and risk interpretations.<sup>54</sup> Douglas and Wildavsky consider cultures along two dimensions (group and grid) and use *group/grid analysis* to explore the relationship between group culture and group attitudes regarding risk.<sup>55</sup> Based on high and low group, and high and low grid categories, four cultures are identified, each with distinct cosmologies and rationalities; three of these cultural rationality groups (hierarchical, market and sectarian) are of interest in the Armenian case. Gephart et al.<sup>56</sup> note that “each

<sup>52</sup> Paul Shrivastava, *Bophal: Anatomy of a Crisis* (1987); *see also*, Shrivastava et al., *supra* note 49, at 293.

<sup>53</sup> *Id.*

<sup>54</sup> Robert P. Gephart, Jr., *The Textual Approach: Risk and Blame in Disaster Sensemaking*, 36 *Acad. of Mgmt. J.* 1465 (1993); *see also*, Robert P. Gephart, Jr., et al., *Cultural Rationalities in Crisis Sensemaking: A Study of Public Inquiry into a Major Industrial Accident*, 4 *Indus. Crisis Q.* 27 (1990).

<sup>55</sup> Mary Douglas & Aaron Wildavsky, *Risk Culture* (1982); *see also*, Mary Douglas, *Natural Symbols* (1970).

cosmology and associated rationality leads to unique interpretations of events, to particular actions and to selection of certain risks." In trying to make sense of accidents, disasters and crises, the various groups often have divergent interpretations of events.<sup>57</sup>

A brief examination of the cultural rationalities of three broad stakeholder groups (the Armenian government, the Russian interests and the Armenian population) provides further insights into the evolution of the decision. The culture of government typically exhibits hierarchical rationality. There are multiple goals to satisfy a variety of stakeholders. Decision-making often occurs in response to problems; that is, it is reactive rather than proactive. Rules, procedures and sanctions are used to control social behavior. Risks threaten the hierarchy, and the origins of the risks are typically external to the group. Hierarchies are willing to accept large future risks in their efforts to resolve a current problem.<sup>58</sup> Accordingly, given the political threat to the government which is inherent in the energy crisis in Armenia, it is not surprising that the government would decide to reactivate the MNPP. The large future risk is acceptable to resolve the current energy problems. Moreover, from the perspective of a government, the reactivation alternative is better subject to control by rules, procedures and sanctions than are the other alternatives. That is, threats to the hierarchy can be best managed by reactivating the MNPP and establishing and enforcing rules, procedures and sanctions related to the operation of the facility. It should be noted, Perrow argues safety procedures cannot deal appropriately with the plethora of possible interactions that lead to system failures and accidents related to high-risk technologies.<sup>59</sup> Yet, Perrow notes that "since catastrophes are rare, elites feel free to populate the earth with these kinds of risky systems."

*Market rationality* focuses on profit-seeking. Tradeoffs are unavoidable, and tradeoffs between safety and profits often result in a willingness to accept higher safety risks to obtain greater profits. Market stakeholders expect the hierarchy stakeholders to limit unnecessary

<sup>56</sup> Gephart et al., *supra* note 54, at 33.

<sup>57</sup> Robert P. Gephart, Jr., *Managing the Meaning of a Sour Gas Well Blowout: The Public Culture of Organizational Disasters*, 2 *Indus. Crisis Q.* 17 (1988)

<sup>58</sup> Gephart et al., *supra* note 54.

<sup>59</sup> Perrow, *supra* note 35.

regulation of market activities.<sup>60</sup> Accordingly, Russian trade interests, which are advanced by the decision to reactivate the MNPP, may be viewed from the perspective of market rationality. The inherent safety risks are acceptable to Russia in attempting to achieve market-oriented goals. Moreover, the bilateral agreement between Russia and Armenia ensures that Russia will have considerable input regarding evolving Armenian safety regulations that might tend to reduce Russian profits.

*Sectarian rationality* is exhibited by the populace. Sectarian rationality is characterized by informal norms and difficulty in achieving decisions (because there is a need for concurrence of others regarding the nature of risks).<sup>61</sup> Accordingly, opposition of the populace to the reactivation decision, especially in a society that only recently emerged from communist control, would evolve slowly and would be fragmented in nature, due to the various sub-stakeholders in the population of stakeholders.

There is another factor, the *availability heuristic*,<sup>62</sup> that may explain the populace's acceptance of the reactivation decision; this factor can be expected to have an impact on the government's decision. The availability heuristic suggests that people tend to evaluate issues on the basis of the most available cases (that is, cases which occur more frequently, thereby making them easier to recall). Rather than basing a decision on the results of a complete analysis of all relevant cases (including low-probability cases), there is a tendency to rely on recent experiences or on more common experiences — the most available experiences. Accordingly, recent experiences would have greater impact on decisions than would the potential for a nuclear crisis (the probability of which, psychologists suggest, would be underestimated via the availability heuristic).

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<sup>60</sup> Gephart et al., *supra* note 54, at 39.

<sup>61</sup> *Id.*

<sup>62</sup> M. Granger Morgan, *Probing the Question of Technology Induced Risk*, 18 *IEEE Spectrum* 58 (1981); *see also*, Perrow, *supra* note 36; Paul Slovic et al., *Rating the Risks*, 21 *Env't* 14 (1979); Amos Tversky & Daniel Kahneman, *Availability: A Heuristic For Judging Frequency and Probability*, 5 *Cognitive Psychol.* 207 (1973).

### A Decision-Analytic Framework

Daft considers organizational environments along two dimensions: the simple-complex dimension and the stable-unstable dimension.<sup>63</sup> In simple environments, only a few external elements influence the organization; in complex environments, many external elements have impact on the organization. In a stable environment, there is little change over time; in an unstable environment, abrupt changes can occur. This two-by-two scheme results in a framework for identifying the level of environmental uncertainty.

#### *Uncertainty*

Uncertain environments are those in which insufficient information prevents the precise determination of future (or even current) conditions; that is, decision-makers are unable to determine, with certainty, what will occur. Complex-unstable environments exhibit high uncertainty, and the organization must be loose, adaptive and decentralized.<sup>64</sup> Burns & Stalker define such management systems as *organic*.<sup>65</sup> On the other hand, simple-stable environments exhibit low uncertainty, and the organization is characterized by rules, procedures and hierarchy, with centralized decision-making.<sup>66</sup> Burns & Stalker define such management systems as *mechanistic*.<sup>67</sup>

Note the inconsistency between the Armenian environment and the organization of the Armenian government. A mechanistic system (best suited for simple-stable environments characterized by low uncertainty) is attempting to respond to a complex-unstable environment (characterized by high uncertainty which is best managed by an organic system). Under such conditions, it would be unusual to find that formal, well-defined and well-accepted decision processes are used. Moreover, as noted previously, the Soviet educational system ignored fields such as management science. Accordingly, it is doubtful that the reactivation decision process was based on a formal decision analysis.

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<sup>63</sup> Richard L. Daft, *Organizational Theory and Design* 75(1992).

<sup>64</sup> *Id.*

<sup>65</sup> Tom Burns & George Stalker, *The Management of Innovation* (1961).

<sup>66</sup> Daft, *supra* note 63.

<sup>67</sup> Burns, *supra* note 65.

*Decision Analysis*

The decision process related to attempts to deal with the highly uncertain environment can be considered from a decision-analytic perspective. First, some fundamentals of decision theory relevant to cases of uncertainty will be reviewed.<sup>68</sup> For simplicity, a discrete alternative space and a discrete state-of-nature space will be considered (that is, there will be a distinct number of alternatives and a distinct number of *states of nature*). Since conditions are uncertain, the outcomes of the various alternatives relative to a number of potential states of nature (that is, the future events that might occur) must be considered. Furthermore, because of insufficient information in the case of uncertainty, the decision-maker is unable to obtain meaningful probabilities related to the occurrence of the various states of nature.

Suppose the payoff (more specifically, the consequences evaluated in terms of values)<sup>69</sup> associated with each alternative/state-of-nature combination has been determined. An *optimistic* approach to decision-making is one in which the best payoff for each alternative is identified, and then the alternative which yields the best of the set of best payoffs is chosen. This approach is optimistic because only the best payoff for each alternative is considered; other payoffs are ignored. The decision-maker assumes that, regardless of the alternative chosen, the state of nature that yields the best result will occur. The chosen alternative yields the overall best payoff, and the approach which yields that decision is referred to as the maximax payoff approach.

Conversely, a *pessimistic* approach to decision-making is the worst payoff for each alternative is identified, and the alternative that yields the best of the set of worst payoffs is chosen. This approach is pessimistic because only the worst payoff for each alternative is considered; other payoffs are ignored. The decision-maker assumes that, regardless of the alternative chosen, the state of nature that yields the worst result will occur. The chosen alternative is the one which yields the best of the set of worst payoffs, and the approach which yields that decision is referred to as a maximin payoff approach.

<sup>68</sup> David R. Anderson et al., *Introduction to Management Science* (7th ed. 1994); see also, Barry Render & Ralph Stair, Jr., *Quantitative Analysis for Management* (1994).

<sup>69</sup> Keeney, *supra* note 44.

The decision process followed by the Armenian authorities may be considered to be a dramatic example of an optimistic approach to decision-making — an approach in which the chosen alternative is the one that yields the best of the set of best results that potentially would occur under the various alternatives (note that the best result may, in fact, be reflective of the least evil). Specifically, government officials and citizens alike may view the reactivation of the nuclear plant as the alternative that, under optimistic conditions, will yield the best of the set of least evil results.

Moreover, if the decision process is viewed as an example of an optimistic approach, then results other than the best result for a given alternative are not considered in the decision process; that is, only the result associated with the most favorable state of nature for the given alternative are considered. Because only the best result is considered, it is assumed no accident will occur at the MNPP (that is, states of nature related to significant MNPP accidents will yield unfavorable payoffs which will not be considered because, under an optimistic approach, only the best payoff is considered for each alternative). If the reactivation of the nuclear plant is successful, living conditions in Armenia will improve significantly in both the short-term and the long-term. Furthermore, Lake Sevan and the nation's forests will be saved.

Of course, there is the risk that an accident at the MNPP could result in a disaster. For that reason, reactivation may be viewed as a "quick death" alternative. Unfortunately, after years of hardship, the average Armenian may believe the potential benefits to society outweigh the potential costs. More specifically, a "quick death" (in the case of an accident at the nuclear plant) may be preferred to the slow death offered by the other alternatives.

The willingness to accept reactivation is consistent with the availability heuristic discussed earlier. Recent experiences with horrendous winters may have had a greater impact on the decision than the potential for a nuclear disaster; the impact of the former is more available, whereas the impact of the latter is a low-probability event that is less available. This view appears to be reflected in the results of a public opinion survey conducted by the Armenian National Academy of Sciences and the U.S. Information Service. One of the survey

questions was: "Do you favor or oppose re-opening the Nuclear Power Station at Metsamor?" Of 1200 respondents, 71% favored the reactivation of the MNPP, 14% opposed it, and 15% indicated it was difficult to answer the question.<sup>70</sup>

This view, that the reactivation of the MNPP is the only true option, is reinforced by statements of a number of Armenian officials. For example, Armenia's Deputy Prime Minister for Energy stated: "At this point, Armenia has no option, just no option."<sup>71</sup> Even the Minister of Nature and Environmental Protection supported the reactivation. She said the important question is whether Armenia will be kept inhabitable only for plants and animals, or for humans as well.<sup>72</sup> The deputy environmental minister was most succinct: "our water is running out, and we can't keep cutting down trees. So we simply have to choose which catastrophe we want to risk."<sup>73</sup>

Consistent with the availability heuristic, a major factor driving the decision process is clearly identified by Moskovskie Novosti:<sup>74</sup> The residents of Armenia "seem to have reached the point at which the specter of a 'nuclear winter' frightens them less than a climatic winter."

### Discussion

The decision to reactivate appears to have been driven by a variety of considerations, among which technological ones played a minor role. The complex interaction of the myriad of political, social, economic and environmental factors to create conditions that overrode the technological considerations provides an interesting example of decision-making under desperation. However, the reactivation decision which has been the subject of worldwide opposition is not particularly surprising when viewed from the perspectives of several qualitative conceptual/theoretical frameworks regarding industrial crises, organizational disasters and stakeholder behavior. While it is doubtful that the reactivation decision resulted from a formal quantitative

<sup>70</sup> *Questionary: Public Opinion Survey*, Noyan Tapan Highlights, May 6, 1994.

<sup>71</sup> Bonner, *supra* note 6.

<sup>72</sup> Heusser-Markun, *supra* note 18.

<sup>73</sup> Omaha World-Herald, *supra* note 18.

<sup>74</sup> *Political Implications of Medzamor*, Armenia Information Service Daily News Summary, May 12, 1994.

decision analysis, the decision appears to be consistent with one that would result from an optimistic approach to decision-making under conditions of uncertainty. Thus, the MNPP reactivation serves as a case study that relates qualitative frameworks from various disciplines to the quantitative decision-analytic framework.

Most textbook discussions of quantitative decision-analytic models are based on presumptions that appropriate analyses have been conducted. Discussions of optimistic, pessimistic and other approaches to decision-making under uncertainty, permit one to choose between various decision approaches, while being aware of the potential drawbacks of a specific approach. Thus, the existence of a relatively complete payoff structure is presumed in most discussions of decision-analytic models.

Yet, the relationship between the qualitative frameworks and the decision-analytic model suggests the qualitative frameworks have implications regarding the real-world operationalization of the decision-analytic model. Specifically, the qualitative frameworks suggest the level of analysis required in real-world implementations of optimistic decision-analytic models may be significantly less than would be expected. That is, much of the analysis that would be expected to be devoted to the development of the payoff structure, based on textbook discussions of optimistic decision-analytic models, may not be conducted in a real-world implementation of such a model.

We have seen the decision process in the case of the MNPP result in a decision in which the chosen alternative yields the best of the set of best results that potentially would occur under the various alternatives; thus, it resulted in a decision which is consistent with an optimistic approach to decision-making. While it is doubtful a formal decision-analytic approach was used in support of the decision process, it is clear that optimistic approaches under such conditions may result in analysis processes that are significantly less rigorous than would be expected. Since results other than the best results are not considered in the optimistic decision process, only the result associated with the most favorable state of nature is considered. Thus, analyses related to various "bad" outcomes of the reactivation would not be conducted.

Although the MNPP decision is consistent with an optimistic approach, we have seen such an approach yield a questionable decision.

Accordingly, it is instructive to review the qualitative frameworks we examined in order to identify concepts which seem to support the adoption of an optimistic approach.

There are growing problems that may be viewed within the context of rationality, legitimacy and motivational crises.<sup>75</sup> In attempting to deal with a rationality crisis, it is understandable that a government would be attracted to “quick fixes.” Such “quick fixes” often can be expected to be of an optimistic nature. Thus, there may be a tendency to focus analytical efforts on favorable results and ignore the potential for unfavorable results.

The response to an industrial crisis typically focuses on mitigating the effects; that is, the focus is on symptoms, and the response seldom deals with the elimination of the causes.<sup>76</sup> The focus on the mitigation of effects encourages an optimistic approach, in which only the best results for each alternative are considered. This type of focus suggests too few alternatives may be analyzed, which is consistent with a concern expressed by Keeney.<sup>77</sup>

The various types of cultural rationalities also encourage optimistic approaches to decision-making.<sup>78</sup> Government culture typically exhibits hierarchical rationality, in which decision-making is reactive, and in which risks that threaten the hierarchy are external to the group. Since hierarchies are willing to accept large future risks in their efforts to resolve current problems,<sup>79</sup> there will be a tendency to adopt optimistic approaches to decision-making. Market rationalities, which result in a willingness to accept higher safety risks to obtain greater profits, reinforce this tendency to adopt optimistic approaches.

### The Future

Technological advances have contributed to a world in which traditional approaches to decision-making under risk/uncertainty are not robust enough to incorporate the growing number of complex

<sup>75</sup> Habermas, *supra* note 51; *see also*, Shrivastava et al., *supra* note 50, at 286.

<sup>76</sup> Shrivastava, *supra* note 53; *see also* Shrivastava et al., *supra* note 50.

<sup>77</sup> Keeney, *supra* note 45.

<sup>78</sup> Douglas, *supra* note 56.

<sup>79</sup> Gephart et al., *supra* note 55.

interactions. Thus, public-sector decisions will, in the future, require consideration of more global concerns. These decisions will require greater emphasis on tradeoffs between short-term and long-term results which incorporate a myriad of factors.

Following the disintegration of the Soviet Union, there has been increasing chaos within the former Soviet republics, besides a variety of other regional conflicts around the globe. The Metsamor reactivation is one of the first results of such a regional conflict, and the 21st century can be expected to yield a growing number of similarly complex decision-making situations. Consequently, the Metsamor decision may prove to be a harbinger of increasingly complex decision processes reflecting the growing interaction between technology and other societal concerns. It can be expected that the growing technology bases in countries whose infrastructures and societies are ill-equipped to appropriately manage the technologies will lead to an increased number and severity of crises and disasters related to the technologies.

Moreover, the dangers of nuclear technologies cannot be understated. The illicit flow of nuclear materials from the former Soviet nations, in conjunction with the flow of those materials resulting from trade agreements between various countries, can be expected to eventually lead to significant crises and disasters related to nuclear technology. In fact, the risk of a nuclear incident is probably greater at this time than during the Cold War. International agreements to prohibit the flow of such materials cannot be expected to be particularly useful in dealing with the problems related to access to nuclear technologies and materials. Perhaps the next stage in attempting to deal with such problems will be international agreements to provide technical assistance to nations that receive the technologies (whether legally or illegally) in an attempt to avoid potential problems arising from their use. Such an approach would be similar to those used in some countries for controlling problems related to drug use. Rather than trying to prevent access, the focus is on mitigating problems arising from those who have access.

### Epilogue

The reactivated MNPP began generating electricity in November 1995. On May 20, 1996, a spate of earthquakes began in Armenia — more than 55 in less than one month, and many were of magnitudes of 5 and 6. Such activity was expected to continue through mid-July, according to the Armenian Minister of Emergency Situations. Another earthquake occurred near Yerevan two days before this epilogue was written on July 8. In response to questions, the director of the MNPP assured journalist that the MNPP could withstand earthquakes of magnitude 9.<sup>80</sup>

In June 1996, the U.S. pledged up to \$6 million in aid to improve the safety of the MNPP. The facility is to be shut down for at least 60 days beginning July 15 for refueling. Unfortunately, Lake Sevan is still in serious ecological danger due to water drainage since 1991. A number of recommendations have been made to restore the lake's ecological system, including setting limits on water drainage for purposes of power generation.<sup>81</sup>




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<sup>80</sup> *Medzamor Can Endure 9 point Quake*, Asbarez-on-line, June 18, 1996.

<sup>81</sup> *Lake Sevan Water Level Cause for Ecological Concern*, Asbarez-on-line, June 26, 1996.