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THE WHITE HOUSE

Office of the Press Secretary

File
Energy

For Immediate Release January 27, 1981

STATEMENT BY THE PRESIDENT

I am ordering -- effective immediately -- the elimination of remaining Federal controls on U.S. oil production and marketing.

For more than nine years, restrictive price controls have held U.S. oil production below its potential, artifically boosted energy consumption, aggravated our balance of payments problems and stifled technological breakthroughs. Price controls have also made us more energy-dependent on the OPEC nations -- a development that has jeopardized our economic security and undermined price stability at home.

Fears that the planned phase-out of controls would not be carried out for political reasons have also hampered production. Ending these controls now will erase this uncertainty.

This step will also stimulate energy conservation. At the same time, the elimination of price controls will end the entitlements system, which has been, in reality, a subsidy for the importation of foreign oil.

This order also ends the gasoline allocation regulations which the De epartments of Energy and Justice cite as important causes of the gas lines and shortages which have plagued American consumers on and off since 1974.

Ending price controls is a positive first step towards a balanced energy program -- a program free of arbitrary and counterproductive constraints -- one designed to promote prudent conservation and vigorous domestic production.

# # #

THE WHITE HOUSE

WASHINGTON

January 27, 1981

Mr. George F. Combs, Jr.
Director, Economic Analysis
Nuclear Resources International
9310 Weathervane Place
Gaithersburg, Maryland 20760

Dear Mr. Combs:

Thank you for sending me a copy of your report on nuclear fuel inventory policies. I appreciate your thinking of me.

Please give my best regards to Mike Conner.

Sincerely,

Frank Hodsoll

F.S.M. Hodsoll
Deputy Assistant to the President

NUCLEAR RESOURCES INTERNATIONAL

January 23, 1981

Mr. Frank S. Hodsoll
Special Assistant to the President
Deputy Assistant to Chief of Staff
White House
1600 Pennsylvania Avenue, N.W.
Washington, D.C. 25000

Dear Mr. Hodsoll:

At the request of Mike Connor, I am sending you a copy of the report on the first phase of our study on nuclear fuel inventory policies. Although you are in a different capacity now, we thought that you should have a copy because of your interest in the subject while you were with the State Department. This report has been well received, and we are hoping to go ahead with the second phase of the study. Mike sends his congratulations on your new position, as it is a notable achievement in your career.

Best regards.

Sincerely,

George F. Combs, Jr.
Director, Economic Analsis

1800 Century Boulevard, N.E. Suite 890, Atlanta, Georgia 30345 404 • 321 • 3555 Cable • INTERNUKE
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THE WHITE HOUSE

Office of the Press Secretary

For Immediate Release January 27, 1981

FACT SHEET
on
Decontrol of U.S. Oil Production and Marketing

Summary: President Reagan announced today that he is eliminating the remaining controls on U.S. oil production and marketing effective immediately.

Background:

-- Controls on U.S. petroleum production date back to 1971, when domestic crude oil prices and profit margins on petroleum products were controlled under the wage price freeze. Controls were subsequently locked into law under the Emergency Petroleum Allocation Act (EPAA) of 1973.

-- In 1975, mandatory controls were extended by the Energy Policy and Conservation Act (EPCA) until 1979, when they became discretionary. The EPCA originally contemplated that controls would be phased out in 1979.

-- In April 1979, President Carter determined that controls should be extended but that they should be phased out through September 30, 1981, when all discretionary control authority expires.

THE PRESIDENT'S ACTIONS

The President signed today an Executive order which eliminates all controls on crude oil and on petroleum products still subject to controls (gasoline and propane). The Executive order is effective immediately.)

EFFECT OF THE PRESIDENT'S ACTIONS

Decontrol of U.S. oil production and marketing will have the following effects:

-- A longstanding, fundamental defect in U.S. energy pricing policy will be eliminated. For over eight years, Federal regulation of U.S. oil production has decreased incentives for domestic energy production, encouraged energy consumption, aggravated balance of payment problems and discouraged use of alternative fuels and needed technological change.

-- Immediate decontrol will further stimulate domestic energy production and conservation, compared to phasing out controls through September 30, 1981, by removing any uncertainty that decontrol will be completed successfully. The previous gradual decontrol schedule has spurred a large increase in drilling activity. Rigs in use exceeded 3,300 in recent weeks, compared to less than 2,000 in mid-1979. New oil well completions were up 40 percent in the first nine months of 1980, compared to the first nine months of 1979. On the conservation side, Department of Energy analyses predict some 50 to 100,000 barrels per day in reduced energy consumption as a result of accelerated decontrol.

MORE

-- Decontrol terminates a regulatory program which has burdened the private sector with reporting requirements which have been particularly onerous on the smaller members of the industry.

-- The crude oil entitlements program will be ended. This program, administered by the Department of Energy, required refineries using price controlled domestic crude oil to pay refiners using imported oil a subsidy, such that all domestic refiners, on average, paid below world market prices for crude oil. This was a clear cut oil import subsidy, in direct opposition to stated objectives of energy policy to reduce imports. Decontrol ends the subsidy of oil imports, consistent with our commitments to our allies.

-- Allocation controls remaining on gasoline and propane will be abolished. These controls helped cause the gasoline lines and shortages which have periodically plagued the country since 1974. Studies by the Department of Energy, the Justice Department and others support this conclusion. The product controls required suppliers, when markets got tight, to allocate controlled products on the basis of historic use. But the historic based system is likely to have no relationship to market demand at the time supplies grow tight. The predictable result, if product controls were left in place, is product shortages in some areas, while products are plentiful in others. Decontrol will allow suppliers to send products to where they are needed most, instead of sending them were DOE regulations require.

-- At present, only 15 percent of the crude oil processed by U.S. refineries is still subject to price controls. This 15 percent is equal to about 25 percent of the crude oil produced in the U.S. and was previously scheduled for decontrol through September 1981. Thus immediate decontrol is not expected to have a major effect on the prices faced by U.S. consumers. While immediate decontrol may change the timing of that effect, it should be emphasized that not all of the costs resulting from decontrol will necessarily be passed through to consumers. This is the case because price ceilings for gasoline are currently well above actual selling prices by more than might be added by decontrol. In addition, elimination of DOE regulations at the retail level is expected to increase competition in the industry.

-- In order to provide for the orderly termination of petroleum controls, certain provisions will not end until March 31, 1981. Thus State governments will be permitted to allocate small amounts of distillate through that date. Refiners benefiting from the "buy/sell program" (which assures their crude supplies) will continue to benefit from that program through that date. The President has directed the Secretary of Energy to eliminate or modify current reporting or record keeping requirements associated with controls as quickly as possible.

# # #

NUCLEAR FUEL INVENTORY POLICIES
PHASE 1: The Results Of Initial Research Among Consumers of Nuclear Fuel in Asia, Europe and North America

October 1980

PREPARED FOR U.S. DEPARTMENT OF ENERGY
Assistant Secretary for Resource Applications
Grand Junction Office, Colorado

This report is a result of work performed by Nuclear Resources International, through a Bendix Field Engineering Corporation Subcontract.

NUCLEAR FUEL INVENTORY POLICIES PHASE 1:
The Results of Initial Research Among Consumers of Nuclear Fuel in Asia, Europe and North America

NUCLEAR RESOURCES INTERNATIONAL
1800 Century Boulevard, N.E. • Atlanta, Georgia 30345

October 1980

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY
ASSISTANT SECRETARY FOR RESOURCE APPLICATIONS
GRAND JUNCTION OFFICE, COLORADO
UNDER CONTRACT NO DE-AC13-76GJ01664
AND BENDIX FIELD ENGINEERING CORPORATION
SUBCONTRACT NO. 78-084-L

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EXECUTIVE SUMMARY

This report examines the existence of corporate and governmental inventory policies for nuclear fuel, their bases and the perceived risks which they are designed to counter. Consumers began to develop inventory policies in the latter half of the 1970's as a result of such events as the Canadian "safequards" embargo, the introduction of the U.S. Nuclear Non-Proliferation Act of 1978 and the formulation of the Australian safeguards policy. Inventory policies resulted primarily from consumer perceptions of potential difficulties arising in the delivery of foreign uranium supply. Some policies, however, arose from purely operational concerns after actual problems had occurred with supplies from specific production facilities. For many others, particularly U.S. utilities, the introduction in 1978-1979 by USDOE of its new Adjustable, Fixed-Commitment enrichment contract triggered technical evaluations of likely future corporate inventory levels. This thinking, in turn, led to the eventual development of the current policies on desired inventory levels.

In the normal course of its business, Nuclear Resources International (NRI) has had to develop an understanding of electric utility inventory policies around the world in order to analyze world markets for uranium and enrichment. Over the years, NRI has developed some basic definitions, a standard five-page questionnaire, and a framework for analysis of the data collected. The study upon which this report is based represents a kind of feasibility test to see if sufficient homogeneous data amenable to quantitative analyses could, in fact, be collected simultaneously by various NRI personnel through the structured approach it had developed.

NRI personnel visited and interviewed a representative sample of twenty small, medium and large utilities in twelve countries in Asia, Europe and North America. Two of the most basic questions were: what is an organization's desired inventory level for each of the different forms of nuclear fuel? How does the actual 1980 level compare with the desired level? The answers to those two questions, presented in terms of weighted average months of inventory levels, are shown in Table Exec-1 following.

TABLE Exec-1

Comparison of Desired and Actual 1980 Inventory Levels

	1980 Inventory Levels Desired	Actual	Difference (Actual-Desired)
Eastern Asia			
Fabricated Fuel	13.8 mos.	10.8 mos.	(3.0)mos.
Enriched UF_6	12.0	17.8	+5.8
Natural UF_6	-0-	26.1	+26.1
U_3O_8	22.6	15.4	(7.2)
Months Equivalent U_3O_8	48.4 mos.	70.1 mos.	+21.7 mos. excess
Europe			
Fabricated Fuel	3.3 mos.	3.7 mos.	+0.4 mos.
Enriched UF_6	7.6	7.8	+0.2
Natural UF_6	-0-	8.6	+8.6
U_3O_8	16.3	11.5	(4.8)
Months Equivalent U_3O_8	27.2 mos.	31.6 mos.	+ 4.4 mos. excess
North America			
Fabricated Fuel	3.8 mos.	7.0 mos.	+ 3.2 mos.
Enriched UF_6	-0-	-0-	-0-
Natural UF_6	6.0	6.5	+0.5
U_3O_8	10.7	11.8	+1.1
Months Equivalent U_3O_8	20.5 mos.	25.3 mos.	+ 4.8 mos. excess

NRI queried respondents about their minimum and maximum inventory levels, what conditions would trigger disposition of excess inventories, and whether and how their policies would change in the future. All participants in the study could state desired levels for 1980, but not all had policies for all forms of fuel, nor for minima and maxima criteria. Also, not everyone had thought as deeply about appropriate inventory levels for 1985 and 1990 as they had for 1980.

To accomodate the variability of the data, NRI developed a statistical model to normalize and present the data in a meaningful manner. A summary table of the findings of the study is presented in the following Table Exec-2. Subsequent studies should disclose that more organizations will have defined minima and maxima and 1985/1990 criteria after they have had a chance to assimilate these concepts. Statistical inferences can be expected to be better in future studies with more data.

TABLE Exec-2

Aggregate Coverage of Nuclear Fuel Inventories

In Terms of Months of Equivalent U_3O_8

(based on NRI's statistical model)

Region	Form	Months of Coverage		
		Maximum	Desired	Minimum
		(1980/1985/1990)	(1980/1985/1990)	(1980/1985/1990)
Eastern Asia	Fabricated Fuel	16.1/15.1/15.7	13.8/13.4/12.6	5.8/ 4.3/ 4.4
	Enriched UF_6	17.3/17.9/17.1	12.0/12.0/12.0	6.7/ 5.1/ 5.0
	Natural UF_6/UO_2	-0-	-0-	-0-
	U_3O_8	24.1/22.8/22.3	22.6/21.3/18.4	6.2/ 3.9/ 3.4
TOTAL (months of equivalent U_3O_8)		57.5/55.8/55.1	48.4/46.7/43.0	18.7/13.3/12.8
Europe	Fabricated Fuel	3.5/ 3.3/ 3.3	3.3/ 3.2/ 3.2	0.9/ 0.9/ 0.9
	Enriched UF_6	7.6/ 7.6/ 7.6	7.6/ 7.6/ 7.6	1.9/ 1.7/ 1.6
	Natural UF_6/UO_2	-0-	-0-	-0-
	U_3O_8	20.1/18.4/16.8	18.0/17.3/16.2	7.3/ 6.3/ 6.6
TOTAL (months of equivalent U_3O_8)		31.2/29.3/27.7	28.9/28.1/27.0	10.1/ 8.9/ 9.1
North America	Fabricated Fuel	12.7/12.8/12.7	10.5/10.4/10.5	4.2/ 4.5/ 4.4
	Enriched UF_6	-0-	-0-	-0-
	Natural UF_6/UO_2	4.2/ 4.8/ 5.2	3.8/ 4.0/ 4.2	0.9/ 1.7/ 1.1
	U_3O_8	9.8/ 9.5/ 9.1	9.4/ 9.1/ 8.8	0.6/ 0.7/ 0.6
TOTAL (months of equivalent U_3O_8)		26.7/27.1/27.0	23.7/23.5/23.5	5.7/ 6.9/ 6.1

Consumers' concerns regarding supply assurance problems in some cases change with their perceptions of how the future may evolve. Some of the ways that supply assurance mechanisms may develop in concert with non-proliferation objectives were explored during the International Nuclear Fuel Cycle Evaluation (INFCE) in Working Group 3 "Assurances of Long-Term Supply of Technology, Fuel and Heavy Water and Services in the Interest of National Needs Consistent with Non-Proliferation". NRI explored the attitudes of the participants in its research on the question of how alternative inventory schemes would affect the organization's inventory policy, and in turn how that revised policy might precipitate the development of different actual inventories or create different market actions. The specific questions and answers are recorded in Section 7 of this report.

Two phases were defined for the study. Phase I involved collecting stockpile information from a representative sampling of nuclear utilities around the world. Phase II, scheduled for FY 1981, will complete collection of the survey data and update the data in this report. The two major purposes of Phase I were:

- to test the basic feasibility of collecting what might be considered potentially sensitive data;
- to canvass a major portion of the non-U.S. nuclear generating capacity and a representative sample of U.S. utilities to provide basic data for subsequent analyses.

As this report demonstrates, it is possible to collect information on the inventory management policies of electric utilities around the world (Sections 3, 4, 5) in sufficient detail to permit meaningful analysis. In our opinion, the feasibility test has been passed. Data of both a qualitative and quantitative nature can be collected. The quantitative data, particularly on minimum and maximum criteria (Section 6), should, after several annual repetitions, become an increasingly rich source for analysis. Even with the limited data from the relatively small sample size of Phase I, it is possible to predict and/or confirm some market actions.

Finally, as seen in Section 8, this report demonstrates that it is possible to perform more rigorous analyses of demand than heretofore possible by incorporation of actual inventory dynamics.

SECTION 1

INTRODUCTION

Since the autumn of 1973 when OPEC made its existence dramatically known, the demand for oil, and the supply thereof, have become major foci of attention for the consuming nations of the world, both industrialized and industrializing. In the past seven years, security of energy supply has become recognized not only as a major concern affecting a nation's economic health, but also as a key element of a country's overall national security. During the decade of the 1970's, governments began to rely less on "free market" mechanisms for the supply of strategic materials, and began to place more emphasis on establishing or strengthening strategic bilateral trade relationships. This sensitivity to external dependencies, belated though it may have been, can be expected to be heightened further during the next twenty years.

In energy, some nations are more vulnerable to supply disruptions than others. The energy and raw material dependency of Japan, for example, is well known. Some nations have more economic, military, political or ethnic leverage in the world community and in world trade than others. Some nations have traditional and strong trade relations with other countries. Some do not. As a result, each nation tends to evolve its own individual approach towards increasing the security of its supplies of critical materials. In the final analysis, the last but surest form of short to intermediate-term protection against unforeseen contingencies is the maintenance of inventories. The size inventory that is maintained by any organization, be it country or company, is a function of its management's perception of its risks, and its judgement about the level of inventory that the organization can afford.

In oil, for example, the International Energy Agency (IEA) was established in 1974 by seventeen consuming nations to help ameliorate the damages to any member(s) of losing a key petroleum supply. One of the IEA's first tasks was to develop guidelines for sharing available oil supplies among its members when the supply to one or more members had been reduced below a certain "trigger" level of sustaining requirements. The consuming nation(s) affected must first reduce normal consumption by 7%, then all the other members pool their resources to help out the affected member(s). Underlying this whole scheme, however, is the requirement that each participating country has to maintain an inventory.

Historically, the level of inventory held by consumers of any commodity has also been a concern for the suppliers of that commodity. Suppliers perceive large inventories as a sort of Sword of Damocles hanging over their heads threatening price stability. Again, in oil for example, a debate ensued in the Spring of 1980 between the United States and Saudi Arabia over the size to which the U.S. Strategic Petroleum Reserve should be built, with the Saudis arguing to minimize the size of the U.S. inventory.

What has been true for oil is no less true for uranium. It should be recognized though, that however complicated international trade in oil may be, oil is inherently a simpler commodity than uranium. Oil is, after all, only an "energy commodity" whereas uranium is a "nuclear energy commodity". The addition of the "nuclear" aspect with its attendant non-proliferation ramifications further complicates the amenability of the classic free market mechanisms to international trade in natural and enriched uranium and plutonium.

Nuclear power continues to represent an increasing fraction of total electric generating capacity around the world. Despite a rash of delays, deferrals and cancellations of nuclear projects between 1975 and 1980, the plants ordered in the early 1970's continue to advance in construction and to achieve commercial operation. Many countries consider these nuclear projects as critical, not only for economic well-being and energy self-sufficiency, but also as elements which affect their national security. With a growing reliance upon nuclear power, questions of external dependencies and orderly supplies have becomes increasingly important for nuclear fuel also. A profile of national self-sufficiency versus external dependencies for the countries in this study is shown in Table 1.2.1 following.

TABLE 1.2.1.

Countries Included in this Inventory Study Which Are Consumers and/or Suppliers of Nuclear Fuel

(Listed in order from most dependent to least dependent on external supply sources.)

Demand	Supply			
Nuclear Power Programs	Fabrication	Enrichment	Conversion	Uranium
Asia				
Philippines				
Republic of China				
Korea	Korea (will build)			
Japan	Japan	Japan (pilot)		
Europe				
Finland				
Switzerland				
Spain	Spain (will build)			
Sweden	Sweden			
Germany	Germany	Germany (will build)		
England	England	England	England	
France	France	France	France	France
North America				
Canada	Canada	Not Applicable	Canada	Canada
United States	United States	United States	United States	United States

Delays in the operation of a nuclear power plant are extremely expensive to a utility. The down-time costs for replacement power and interest expense are hundreds of thousands of dollars per day. To protect against delays in operation because of non-delivery of required fuel, electric utility companies and their supply agents develop corporate programs and policies to provide for supply assurance. Typically, supply assurance programs have two components - diversification of supply sources and stockpiling of extra fuel.

For several years it had been recognized that significant inventories already existed at various steps in the nuclear fuel cycle. Furthermore, the level of inventories are projected to grow to quite significant proportions during the decade of the 1980's. These inventories, and how they are managed, can contribute to, or endanger, the stability of the international nuclear fuel industry.

The purpose of this study was to formally research the nuclear fuel inventory policies and attitudes for a major portion of the free world consumers of nuclear fuel. From 1977 to 1979, NRI had been conducting its own informal research into corporate inventory policies of electric utilities around the world. However, prior to this study, essentially no formally structured fundamental research had been done by anyone on the subject. As a result, essentially nothing was known of the dynamics by which these inventories could affect the development of the market.

This report presents a compilation and analysis of the policies, attitudes, and actual quantities of nuclear fuel inventories as of the beginning of calendar year 1980. The primary analysis is presented on a regional basis using aggregated data to respect the requests by participants in the study for confidentiality of discrete data. Country data is presented where identification of sources allowed. The information presented in this report was gathered by NRI from various organizations on the consumer side of the nuclear fuel market. The data is the result of direct interviews with the appropriate persons involved in the management of each organization's nuclear fuel inventories, and as such represents the most accurate and current information available.

SECTION 2

BACKGROUND THEORY, DEFINITIONS AND ORGANIZATION OF THIS REPORT

2.1 The Initial Development of Nuclear Fuel Inventories

The commercialization of nuclear power began to take hold inside the United States and in most of the other major industrialized countries in the late 1960's. At this time, the United States Atomic Energy Commission (USAEC) was essentially the sole supplier of reactor-grade enriched uranium to the free world. From 1964 to 1969, nuclear fuel was delivered to utility customers in the United States under Special Nuclear Material (SNM) Lease Agreements, and to customers outside the United States under special Deferred Sales and Barter Agreements. The delivery of fuel was both orderly and timely. "Uncle Sam" was trusted, and his nuclear technology was respected and desired. National nuclear power programs were in their infancy, and countries were accordingly content to rely almost entirely upon the United States.

The electric utilities which were starting to go nuclear simply placed their orders for enriched uranium with the USAEC. The utilities did not have to concern themselves with arranging for the various components of the nuclear fuel supply, and utilities were relatively unconcerned about building any significant inventories.

With the advent of private ownership of nuclear fuel, and the initiation of commercial toll enrichment by USAEC on January 1, 1969, the individual utility customer of USAEC had to assume personal responsibility for assuring fuel supplies for each of the stages of the nuclear fuel cycle. Utilities for the first time had to contract directly for U_3O_8, conversion services (U_3O_8 to UF_6), enrichment services, and fuel fabrication. U_3O_8, however, was plentiful and cheap, as was conversion. In this competitive environment, suppliers of both U_3O_8 and conversion were forced to write their contracts to match USAEC's enrichment contracts.

The basic long-term contract under which USAEC sold the toll enrichment service was the "Requirements-type" contract. This contract insured that USAEC would supply all the enrichment required for a utility to run a given nuclear power plant. The contract required only 180 days advance notice by the customer to order any given monthly delivery of enriched uranium product. The flow of material was relatively unencumbered, and large inventories of nuclear fuel were neither economically desirable nor functionally necessary. In short, the requirements-type environment worked to minimize inventories of all forms of nuclear fuel.

Over a period of five years starting in 1973, four separate events occurred which led to the initial build-up of inventories and, ultimately, to the development of specific inventory policies by nuclear utilities in the United States and around the world:

- the OPEC price increase of October 1973 and the subsequent Arab oil embargo;
- the rush by utilities in 1973 and 1974 to sign new enrichment contracts;
- the explosion of a nuclear device by India in 1974; and
- the introduction by DOE in 1978 of the Adjustable, Fixed-Commitment (AFC) Contract for enrichment.

The oil embargo in 1973 led to a rash of nuclear plant ordering by utilities of all industrialized nations to relieve their dependency on oil. This required that new nuclear fuel purchase contracts be concluded in each of the stages, particularly U_3O_8, conversion and enrichment. A spurt of contracting activity ensued, such that between September 1973 and August 1974, USAEC sold out <u>all</u> of its available and authorized enrichment capacity to the end of the century. In addition the initial offerings of three new European enrichers - Eurodif, Techsnabexport and Urenco - were also sold out. In 1974-1975, a period of high cost of money developed along with a deepening recession around the world and "stagflation" became a reality. One consequence was that construction schedules of capital intensive nuclear reactor projects suffered extensive delays for lack of money and decreasing projections of future electricity demand projects. Since 1975, reactor programs have faced continual delays for these reasons. In the United States alone, over 5000 reactor-months of delays occurred between 1976 and 1980.

However, by the time of the intense contracting activity of 1974-1975, the major enrichers had replaced the very flexible Requirements-type contract with various versions of fixed-commitment contracts, which were much more rigid. Utilities were contractually bound to take fuel deliveries, and because of delays, these deliveries were well in advance of actual needs. Consequently inventories began to build. Since the inventories that resulted at that time were not the result of conscious and deliberate corporate policy, this build-up occurred inadvertently. The first trading of excess nuclear material in the U.S. and international marketplace began and was encouraged by the U.S. Administration as part of a move toward privatization of the entire enrichment enterprise.

The atomic explosives testing by India in 1974 had a somewhat different effect on nuclear fuel inventories. Canada had supplied the uranium for the fuel which was ultimately used in the Indian explosive. Canada was shocked that its fuel could be so used under a loophole in what it considered to be tight non-proliferation conditions of sale and export. In response, Canada instituted an export embargo on its uranium until such time that tighter safeguards arrangements could be negotiated with importing countries. The immediate result was that several utilities in Japan, Western Europe and the United States were unable to get their scheduled fuel supplies. Utilities around the world began to develop inventory policies to ensure that deliberate inventory levels were maintained to guard against similar future supply interruptions. The Australian and U.S. safeguards policies as reflected in the U.S. Nuclear Non-Proliferation Act of 1978 augmented this movement.

As the 1970's came to a close, significant inventories had developed throughout the free world for various reasons. For the most part, these inventories had developed inadvertently but, as many utilities began to perceive possible threats of supply interruptions, deliberate policies were developed to maintain contingency supplies of nuclear fuel.

The introduction by US DOE of its new AFC enrichment contract in 1978 completed the evolutionary process. The AFC contract contains flexibility provisions that allow customers to control their inventories but require the customer to plan three to six years in advance on what he intends to do. Thus, the introduction of the AFC enrichment contract forced all holders of that contract to think practically about inventory management.

2.2 Basic Definitions Used in the Study and Report

Inventory - a stockpile of uranium. The terms "inventory" and "stockpile" will be used interchangeably in this report.

Inadvertent Inventories - inventories which develop not according to plan, such as those inventories which result primarily from reduced demand due to reactor delays or cancellations. Most of the stockpiles currently held were originally developed inadvertently, but may have now become, through corporate policy, "deliberate inventories".

Deliberate Inventories - those inventories of U_3O_8, natural UF_6, enriched UF_6, or fabricated fuel assemblies that are, by decision, developed and maintained as a matter of policy for strategic or tactical reasons, or in compliance with regulatory requirements.

Minimum Inventory Level - that amount of material in any form which a company would plan to carry as a minimum level of that form. This minimum can, of course, change with time and the number of reactors in the program.

Desired Inventory Level - that level which a company feels comfortable carrying economically, and which it deems sufficient to provide a prudent amount of coverage against unforeseen disruptions in supply. This desired inventory can be composed of various forms of fuel, and the respective quantitites of each type can vary through time and with different numbers of reactors.

Maximum Inventory Level - that level of inventory of each form of nuclear fuel that a company considers to be the most it could justify carrying economically or politically.

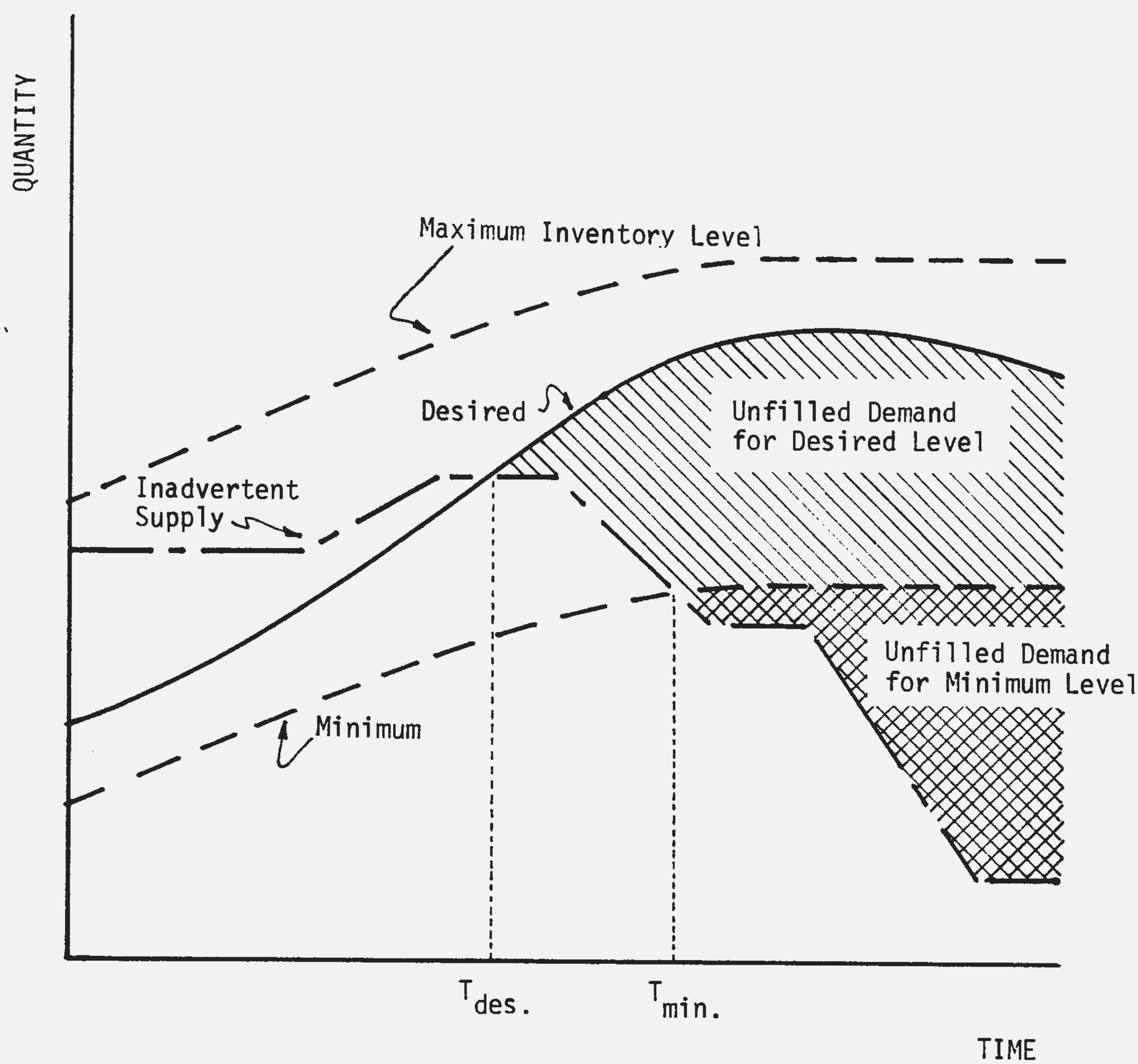
Trigger Level - that level of coverage (which can be above, equal to, or below the Maximum Inventory Level) at which a company starts to dispose of inventory in one form or another. The "Trigger Level" and the timing of disposition may be a complex blending of psychological attitudes of senior management, corporate economics, the regulatory climate, and the fuel manager's perception of current and future market conditions.

2.3 The Theoretical Background for Inventory Management and this Study

As discussed earlier, stockpiles have built up over the years inadvertently beginning with the first wave of reactor delays in the early 1970's. This buildup was closely followed by a recognized need for inventories and an associated inventory management system. A theoretical approach to the dynamics of inventory levels is presented in Figure 2.3.1.

Figure 2.3.1

Inventory Level Dynamics



A typical inventory policy for each stage in the fuel cycle would theoretically include a desired level of inventory which may or may not vary with time. This level is bounded by a minimum and maximum inventory level which, in essence, allows the necessary flexibilities in managing a series of interconnected contracts. These curves represent the demand function in inventory analysis. Overlaying an arbitrary supply curve, two distinct areas are outlined. The first area is the difference between the amount of supply and the desired inventory level. This difference represents an open market demand for the quantity of material to be purchased to maintain the desired level. The second area represents the minimum quantity to be purchased to meet the policy's minimum criteria for inventory. The supply curve, although arbitrary, is typical of the current situation, since most inventories which do exist today did develop inadvertently and are generally currently above the desired level. However, if at any point supply should exceed the maximum demand curve, the resultant area would represent a potential, or secondary, source of supply of the service or product into the market.

As a practical matter, NRI found in its research that while consumers interviewed appreciated the concept of a minimum and a maximum boundary for managing their stockpiles, most consumers have not so far established minima and maxima stockpile levels. When actual inventory levels are below the minimum criteria, though, the condition will usually encourage purchasing. This was evidenced, for example, by purchases in the spot market in 1978 and 1979 by Korea and the Republic of China. However, when actual levels exceed maxima criteria, this does not necessarily spark disposition of the excess material. Often it depends on the nature of the particular market.

In Japan, for example, essentially no one plans to sell off excess inventories. That would not be true in the United States, however. In spite of these caveats, the foregoing conceptual model does provide an understandable and useful basis for discussion and for examining the worldwide inventory situation.

Inventory management may be further complicated by the existence of inventories necessary for the timely manufacture of fuel (i.e. the material in the "pipeline"). These inventories are essentially the reactor requirements adjusted for lead times between the different stages of the fuel cycle. Pipeline inventories are addressed as "demand" in traditional supply/demand studies, not as inventories, and as such are not treated as inventories in this report. Instead, the focus is on the tactical and strategic inventories. Material in the pipeline may, however, in an emergency, be used as a kind of tactical inventory.

Inventories of both a tactical and strategic nature are maintained to provide protection against disruptions in delivery of material. The tactical inventory is essentially designed to protect against minor interruptions in the timing of the material flow. The tactical inventory typically represents a few months' coverage. The strategic inventory, on the other hand, is designed to cover changes in both timing and quantity, and typically is maintained to provide protection against major interruptions.

Tactical inventories allow for contractual commitments further along the chain to be met even though a specific delivery is delayed. The key to this definition is that the ultimate delivery of the material is not in question--it is simply late (e.g., delayed perhaps by a transport strike). When such a disruption occurs, material from the tactical inventory is substituted for the delayed material, maintaining the subsequent contractual schedules. Sometimes with larger programs and material flows, the needed amount may be "borrowed" from the pipeline by compression of the normal lead times among the various stages of material flow. Ultimately, the substituted material is restored to the inventory when the delayed material is delivered. Once restored, there is no net increase or reduction in the inventory level.

The strategic inventory, on the other hand, protects against the net loss to supply of scheduled deliveries which ultimately will <u>not</u> be made. If an export license is not granted, or a contract cancelled, the consumer must evaluate whether or not to make an additional purchase, or perhaps reduce his inventories by a corresponding amount of material. Regardless, the shortage of material in the pipeline is made up by material in the strategic inventory and, short of an action by the consumer to replace the material with a new source, the net effect on his stockpiles is a net reduction in the amount of material carried.

This differentiation between tactical and strategic does not imply that utilities carry two distinct "pots" of inventories. Instead, it allows the identification of strategically important steps in the fuel cycle. For example, a utility may carry a three month forward inventory in all stages of the fuel cycle except U_3O_8, where it might carry one year's advance supply because it can foresee possible major interruptions in its U_3O_8 supply. Consequently, the amount of inventory of U_3O_8 is greater than the ordinary three months tactical inventory, and is carried as a strategic inventory. In general, each utility identifies strategic points in its fuel cycle supplies that require additional contingency coverage and fashion its inventory policy to accomodate these concerns.

2.4 The Organizational Framework for the Study and Report

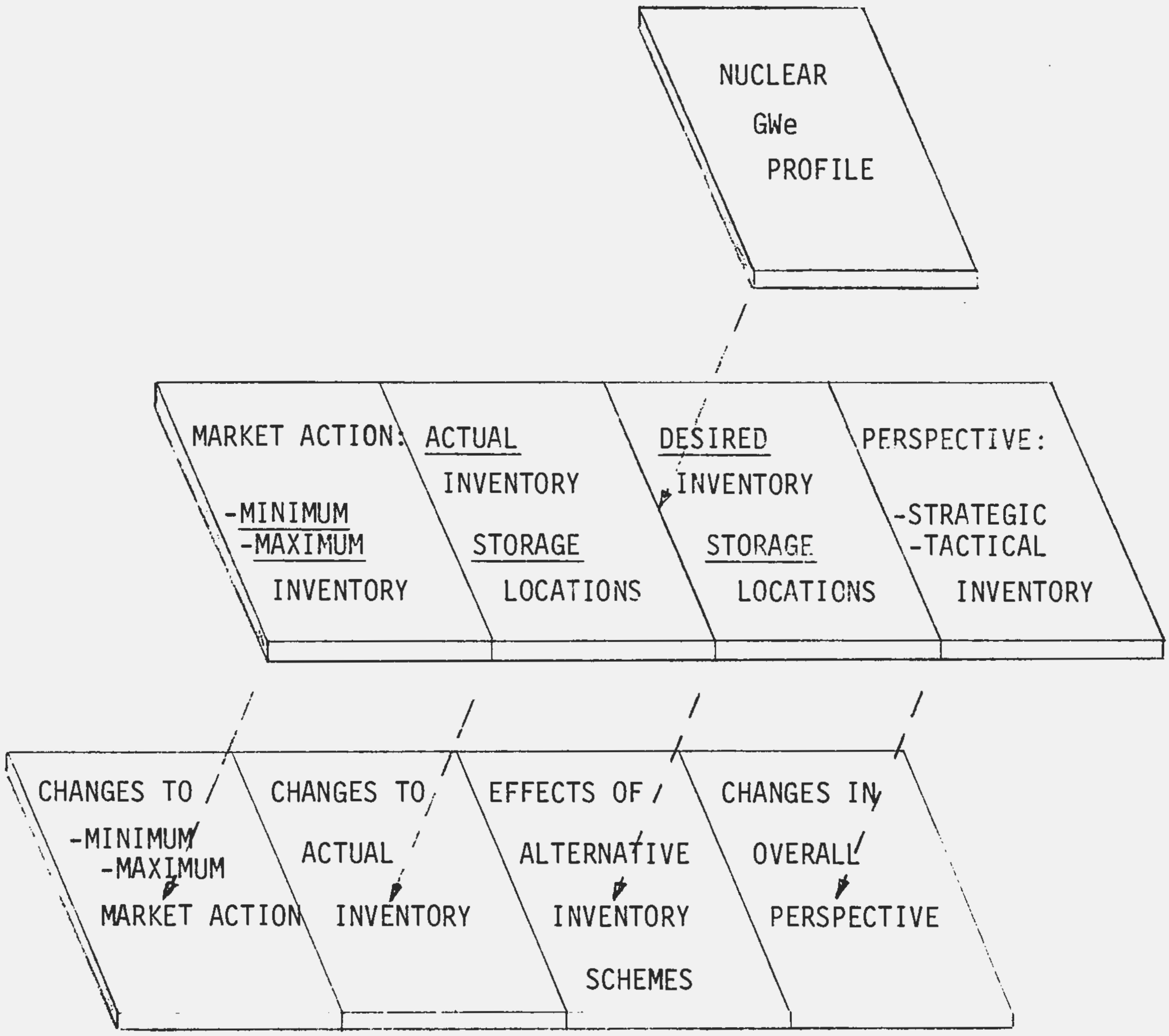
A conceptual layout for how the study was organized is described graphically in Figure 2.4.1. The GWe nuclear profile for a utility, the types of reactors employed, and the lead times between stages in the fuel cycle create the basic demand for uranium, conversion, enrichment and fabrication. This base demand must then be adjusted for the desired inventory levels of the buying organizations. The desired inventory levels are set by each major consumer on the basis of his individual perspective of the strategic and tactical considerations which he feels must be taken into account to provide for an assured supply, constrained by what he can afford. The reasons why the participants in the study carry inventories are presented in Section 3 and their resulting desired levels of inventories are described in Section 4.

Contrasted against the desired inventory level and preferred storage locations are the actual inventory levels and storage locations that have developed, or will develop, over time. The actual 1980 inventory levels of study participants are presented in Section 5. Comparison of actual levels against an organization's minimum and maximum inventory criteria defines potential market actions that reshape supply/demand calculations. The minima and maxima inventory criteria of respondents and possible market actions make up Section 6.

Consumers' concerns regarding supply assurance problems in some cases change with their perceptions of how the future may evolve. Some of the ways that supply assurance mechanisms may develop in concert with non-proliferation objectives were explored during the International Nuclear Fuel Cycle Evaluation (INFCE) in Working Group 3 "Assurances of Long-Term Supply of Technology, Fuel and Heavy Water and Services in the Interest of National Needs Consistent with Non-Proliferation". NRI sought the attitudes of the study participants in its research on the question of how alternative inventory schemes would affect the organization's inventory policy, and in turn how that revised policy might precipitate the development of different actual inventories or create different market actions. NRI's questions on alternative inventory schemes and participant responses are contained in Section 7.

Figure 2.4.1

Organization of the Study



Finally, to make the data collected useful for supply/demand analyses of the uranium market, NRI has developed two simple models - a utility model and a regional predictor for inventory levels. Based on the normalized statistics, the overall inventory policies for 1980, 1985, and 1990 for minimum, desired and maximum levels for Asia, Europe and North America are presented in Section 8.

SECTION 3

THE PARTICIPANTS IN THE STUDY AND THEIR REASONS FOR HOLDING INVENTORIES

3.1 The Participants in the Study and Their Respective Market Shares

NRI personnel conducted direct interviews with a representative sampling of twenty large, medium and small nuclear electric utilities in twelve countries where the use of nuclear power is fairly firmly established. The companies involved in the study are presented in Table 3.1.1 below and the installed nuclear capacity which each projected for the future follows in Table 3.1.2.

TABLE 3.1.1

Phase I Countries and Organizations

Region	Country	Organization
Eastern Asia	Japan	The Chubu Electric Power Co.
		The Kansai Electric Power Co.
		The Tokyo Electric Power Co.
	Korea	Korea Electric Co.
	Philippines	National Power Corporation
Europe	Germany	Gemeinschaftskernkraftwerk Neckar
		Preussische Elektrizitats AG
		Rheinisch Westfalisches Elektrizitatswerk
	Finland	Teollisuuden Voima Oy
	France	Electricite de France
	Spain	Empresa Nacional del Uranio S.A.
	Sweden	Swedish Nuclear Fuel Co.
	Switzerland	Bernische Kraftwerke AG
	United Kingdom	Central Electricity Generating Board (UPD)
North America	Canada	Ontario Hydro
	United States	Baltimore Gas & Electric Co.
		Carolina Power & Light Co.
		Duke Power Co.
		Duquesne Light Co.
		Tennessee Valley Authority

TABLE 3.1.2

Nuclear Generating Capacities in Phase I Countries

GWe Projections as Provided by Study Participants to NRI

Region	Country	Company	Capacity (GWe) 1980	1985	1990
Eastern Asia	Japan	Chubu EPC	1.4	2.5	2.5
		KEPCO	5.7	7.4	11.0
		TEPCO	4.7	10.2	15.7
		SUBTOTAL	11.8	20.1	29.2
	Korea	KECO	0.6	3.8	11.2
	Philippines	NPC	0.0	0.6	0.6
	TOTAL		12.4	24.5	41.0
Europe	Federal Republic of Germany	GK Neckar	0.8	0.8	1.6
		PREAG	0.6	1.9	1.9
		RWE	2.4	6.1	9.9
		SUBTOTAL	3.8	8.8	13.4
	Finland	TVO	1.3	1.3	1.3
	France	EdF	16.1	44.3	72.5
	Spain	ENUSA	2.0	8.7	15.7
	Sweden	SKBF	5.5	8.4	9.5
	Switzerland	BKG	0.3	0.3	1.5
	United Kingdom	CEGB (UPD)	6.9	8.8	15.2
	TOTAL		35.9	80.6	129.1
North America	Canada	Ontario Hydro	5.2	9.4	14.4
	United States	Duke Power Co.	3.8	7.3	8.6
		TVA	4.3	11.6	17.8
		CP&L	2.3	3.2	5.0
		BG&E	1.7	1.7	1.7
		DLC	0.8	0.8	1.7
		SUBTOTAL	12.9	24.6	34.8
	TOTAL		18.1	34.0	49.2

Compared with the total projected generating capacity in the regions for 1990, the proportional capacity represented by these Phase I organizations is actually quite high. Based upon projections of installed nuclear capacity, the European responses in the survey are associated with 76% of the OECD-Europe region total for the INFCE low projection (60% of INFCE's high projections). The Eastern Asian responses represent about 70% of that region. The North American portion includes only about 30% of the total projected capacity of that region. This smaller fraction occurs because the sample size of U.S. utilities was deliberately limited to only five companies, whereas the actual U.S. nuclear program involves some 54 different utilities in 36 states.

It should be noted that none of the nations outside these regions was included in Phase I. The excluded regions were:

- Central America
- South America
- Africa
- Middle East
- Central Asia

The programs of the countries in these regions could be included in the Phase II report.

The second phase, scheduled for fiscal year 1981, is designed to collect and analyze a greater portion of the free world inventory policies and update the data in this study. Many significant uranium-consuming organizations would thus be included in the results. Aside from the obvious benefit of reporting on essentially the total non-U.S. market, the completion of this phase will allow presentation of almost all data on a country level rather than as aggregated data on a regional level. Enough organizations in each country will be included in the survey so as to assuage the concerns of companies providing discrete data about the identification of data with specific sources.

3.2 The Regional Distribution of Respondents in Phase I

Because of the qualitative nature of much of the data on inventory policies, quantitative analyses are normally presented in terms of a frequency distribution (the number of occurrences). As a basis for these distributions, the sample size of the participants in the study, previously identified by name in Table 3.1.1, is quantitatively described in Table 3.2.1 following.

TABLE 3.2.1

Distribution of Respondents in Phase I

Region	Number of Nations	Number of Organizations
Eastern Asia	3	5
Japan	1	3
Europe	7	9
Germany	1	3
North America	2	6
U.S.	1	5
TOTAL	12	20

Each region contains between 2 and 7 countries, and between 5 and 9 respondents. Where more than one respondent is available in a country, it is possible to describe a country's policy by use of aggregated data, while at the same time respecting the requests for confidentiality expressed by some individual respondents. Where possible the data are presented on both a regional and national level to allow comparison of the results.

It is recognized that any analysis of inventory policies is considerably enhanced by the ability to study all data country by country. However, this research was designed to test feasibility at minimum cost, and thus utilized single national sources wherever possible to maximize economy and efficiency. Nevertheless, the study was successful and the sample itself represents a high coverage on an installed GWe basis. The study results can therefore be recognized as being reasonably reflective of attitudes within a region.

3.3 Government and Corporate Requirements to Maintain Inventories

In conducting our survey, we found that maintaining stockpiles of nuclear fuel in some form was considered prudent by all of the organizations approached in the study. However, not all organizations have a formal requirement or directive to stockpile fuel. Some managers simply include inventories as part of their operating plans. In some organizations, specific policies have been formulated and may exist at both governmental and corporate levels.

Table 3.3.1 presents a summary of the existence of specfic inventory policies for the Phase I organizations. Europe was the only region where some countries had governmentally established requirements to carry inventories. Three of the seven countries in Europe in the study have some such form of requirement. In two of the cases the policy exists as a recommendation to build inventories at certain stages in the fuel cycle. The third is an actual government requirement to carry a forward reserve equivalent to the fuel necessary to allow reactor operation for one year (i.e. a one-year forward inventory).

TABLE 3.3.1

Established Inventory Policies

Region	Governmental Requirement for Consumer Stockpiles		Formal Corporate Policy for Consumer Stockpiles		Under Development
	Yes	No	Yes	No	
Eastern Asia	0	5	2	3	
Japan			2	1	
Europe	3	6	5*	3	1
Germany			2	1	
North America	0	6	5	1	
United States			4	1	
TOTALS	3	17	12	7	1

* Two respondents have policies in effect for certain stages of the nuclear fuel cycle (such as U_3O_8) and are developing, or have no policy, for other stages (such as natural UF_6).

As Table 3.3.1 shows, most inventory policies exist at the corporate level. The North American region has the highest percentage of companies with formal corporate policies (83%), while 56% of the European organizations have policies. In this region, only one of the companies subject to governmental inventory policies does not have a corporate policy also. Eastern Asia has the smallest percentage of formal corporate policies with 40% of the organizations having an established policy.

The above percentages can be misleading, however. The existence of a formal corporate inventory policy simply implies a more rigid stockpile requirement. All of Phase I organizations desire to maintain inventory levels above the minimum required for the fuel supply "pipeline" and, where a corporate or governmental policy does not exist, the level of inventory (and material form) is determined by the individual fuel manager within the constraints of his existing supply contracts. The data, therefore, do not indicate only the percentage of those organizations that have some form of inventory policy for nuclear fuel. Nor do the data indicate where consideration of inventories has been furthest advanced. The data simply indicate where formal policies exist as an additional constraint on the fuel manager. Thus, it is more important to understand why inventory policies--formal or informal--exist, having recognized, in fact, that they do exist in all cases researched. We should point out that the fact that all organizations now have some form of inventory policy is, itself, a change from two years ago, when informal studies by NRI indicated the existence of such corporate policies in less than half the organizations interviewed.

While the holding of inventory is ultimately aimed at supplying fuel to the reactors, organizations are particularly sensitive to specific facets of fuel management. These are:

- economics
- integrity of certain contracts
- integrity of certain supplies or supplier countries, and
- politics of consumer versus supplier countries.

Because of the importance of these ancillary facets, in their responses to NRI fuel managers tended to de-emphasize the operation of the reactors per se and emphasized other considerations. For the most part, these responses came from the European region where specific concerns were to:

- ensure the supply of enriched fuel to the country's reactors
- ensure enriched uranium feed to the fabrication contracts
- ensure natural uranium feed to the enrichment contracts.

The following subsection takes a deeper look at these bases, addressing more specifically the perceived changes in supply for which stockpiles are deliberately created to protect against.

3.4 The Major Perceived Threats to Supplies

Inventories are deliberately built to protect against two types of problems. The first problem encompasses the operational concerns of the reactor itself. With very little advance knowledge, the annual reload requirements can change for simple technical reasons such as a higher than expected capacity factor or the replacement of some failed fuel. Invariably it is utilities who are concerned with this type of problem, as opposed to national supply agents, for example, who provide the natural or enriched uranium. Where utilities have included such protection in their policies, the inventory will exist as fabricated fuel, usually stored at the reactor site. The second major concern is the integrity of the basic fuel supply chain. Political embargoes, fires, transportation strikes and price stability are examples of the types of problems that can occur within the fuel cycle. Typically, stockpiles of fuel as U_3O_8 concentrates, natural UF_6, and enriched UF_6 will be used to guard against these concerns in countries which have their own fabrication facilities.

Table 3.4.1 presents the specific concerns leading to the formation of the inventory policies as expressed by the various organizations in Phase I. It should be noted that the specific responses were spontaneous. The fuel managers were not asked to choose their concerns from a predetermined list of potential problems. Thus, the responses are a realistic indicator of their perceptions of the nuclear fuel market and its problems. By far the major concerns were political and force majeure considerations.

Political problems reflect directly on the perception of a supplier country's reliablity. The specific examples cited by respondents were the Canadian safeguards embargo, the Nuclear Non-Proliferation Act of 1978, and the Australian safeguards policy. Once an organization has experienced lengthy delays in the supply line, and the higher costs and increased administrative "hassles" associated with these considerations, political contingencies become very real concerns. By 1990, three countries - Canada, Australia and the United States - will represent two-thirds* of the Free World's attainable production of natural uranium.

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* OECD/IAEA, Uranium Resources, Production and Demand, OECD, Paris, December 1979.

TABLE 3.4.1

Protection Afforded by Inventory Policies

Region	A	B	C	D	E	F	G	H	I	J	K	L	M
	Number of Responses												
Eastern Asia	3	3		2			1		1	1			
Japan	1	1		1			1		1	1			
Europe	9	6	4	1		1		1			1	1	1
Germany	3	1										1	
North America	2	4		1	2	1	1						
United States	2	2			1	1	1						
TOTALS	14	13	4	4	2	2	2	1	1	1	1	1	1

Key to the Risks Offset by Inventories:

A - political
B - standard force majeure (fire, strikes at facility, etc.)
C - other strikes (not at production facility)
D - commercial problems (arriving at price, etc.)
E - general non-delivery (specifics not stated)
F - uranium shortage/capacity shortages
G - operational (damaged fuel)
H - operational (higher load factor)
I - interruption of enrichment supply
J - transportation problems
K - administrative problems
L - avoid buying during price peaks
M - keep suppliers in business

In enrichment, the United States provided the vast majority of enrichment services up to 1980. Although the U.S. market share for enrichment will continuously decline to 1990, primarily because of the commercial operation of the French EURODIF plant, most countries with major nuclear programs will be dependent during the decade of the 1980's upon fuel supplies of one form or another from Canada, Australia, France and the United States. Recognizing this dependency, many utilities have formulated their inventory policies to circumvent potential supply interruptions from these countries that might result from political intervention.

Force majeure concerns, while considered almost as frequently as political interruptions, are certainly less controversial. Supply assurance usually implies long-term contracts for uranium concentrates, enrichment and perhaps conversion. The uncertainties of future production make the force majeure clauses of the contract extremely important. A fire at the large Rossing uranium mill in Namibia caused certain consumers to have to find replacement material. In addition strikes, or threats of strikes at Eldorado Nuclear's UF_6 conversion plant in Canada, at U.S. seaports, and by coal miners in England have occurred. The maintenance of nuclear fuel inventories to protect against such random events was considered prudent fuel management by participants in the study.

For the most part, the responses noted in the table are not unexpected. It is interesting to note, however, that only three organizations were concerned with maintaining inventories for operational concerns. The following sections will show that this may be misleading in that several organizations desire to maintain stockpiles of nuclear fuel in its most completed form - as fabricated fuel assemblies. While such fuel may be stored for strategic reasons, it also provides a concurrent coverage for operational problems. Thus, the number of those utilities implicitly concerned about operational problems may be greater than explicitly mentioned in the survey.

Undoubtedly, political and economic forces will modify and shape the inventory policies of the future. This discussion highlights one possible advantage of international or multinational supply assurance programs. Theoretically, such programs could aid in the continuing orderly development of the nuclear fuel industry by providing buffer demand or supply to the marketplace. However, few uranium producers have perceived this theoretical benefit up to this time. This subject is discussed further as part of the discussion on alternate inventory schemes in Section 7 of this report.

SECTION 4

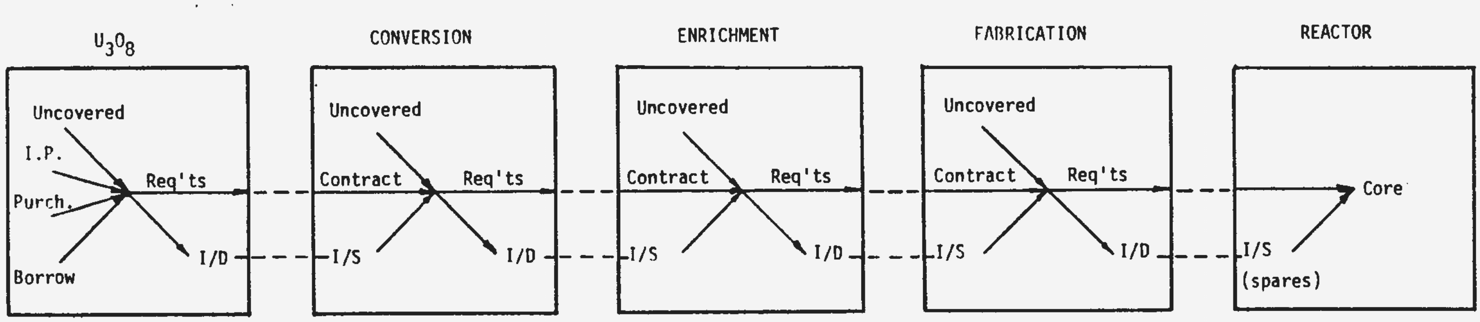
DESIRED INVENTORY LEVELS AND STORAGE LOCATIONS OF STUDY PARTICIPANTS

4.1 Description of Data

This section of the report will describe the nuclear fuel stockpile levels which participants in the study stated as their desired inventory levels. The format used in this section will be maintained throughout the remainder of the report to also describe actual, minimum and maximum inventory levels. It is appropriate at the outset, therefore, to call attention to several key considerations which should be borne in mind by the reader to properly understand the data presented.

First, the data collected will be presented in separate tables of statistics for each of the four major steps in the front end of the nuclear fuel cycle: fabricated fuel, enriched UF_6 (enrichment), natural UF_6/UO_2 (conversion) and U_3O_8. The second point that will become immediately apparent upon comparison of the four statistical tables in this section is that not every organization has an inventory policy for each of the steps. In fact, there is a considerable variation. Figure 4.1.1 below illustrates the flow and upgrading of the uranium at each stage of the nuclear fuel cycle.

Figure 4.1.1
Nuclear Fuel Supply--Material Flow



I.P. = Internal Production I/D = Inventory Demand I/S = Inventory Supply.

For organizations whose enrichment supply is covered by Requirements-type contracts with USDOE and Urenco, there tends to be an integrated optimization of inventories among the various stages. Where the enrichment supply is covered by the various forms of fixed-commitment contracts with USDOE, Eurodif, Techsnabexport, one tends to find different amounts of inventory accumulating inadvertently in the different stages. Where an organization has different inventory strategies for each stage, it is necessary to see when and how these various strategies become synthesized into the final supply to the reactor. Table 4.1.1 below summarizes for each of the four stages in the fuel cycle the existence of inventory policies among the 20 participants in the study.

TABLE 4.1.1

The Fraction of Respondents with Policies in Each Stage

Fabricated Fuel	50%
Enriched UF_6	25%
Natural UF_6/UO_2	10%
U_3O_8	75%

It should be noted that the above percentages total more than 100%. An organization can have a policy for each stage, and that policy can be to maintain zero (0) inventory in that form. Since utilities can have policies for all or only some of the stages, it quickly becomes apparent that quantitative assessment of the data and the drawing of statistical inferences pose difficult problems.

The data presented in the rest of this report express inventory levels in terms of weighted average number of months of coverage for desired, actual, minimum, and maximum levels, for three regions - Asia, Europe and North America - for three time periods - 1980, 1985 and 1990. In order to make the data statistically useful, the months of coverage that are presented in the main body of the report are the averages, weighted by gigawatts, of only those respondents who had a policy for that stage (form) being described. The range of answers provided for each region will also be presented so that the reader can compare the weighted average responses with the ranges.

4.2 Desired Inventory Levels - Fabricated Fuel

Table 4.2.1 below presents the data for desired inventory levels for fabricated fuel.

TABLE 4.2.1

Desired Inventory Levels

Weighted Only for Countries with Policies

FABRICATED FUEL

Region	Number of Organizations with policy	without policy	Range(1)	Months of Coverage 1980	1985	1990
Eastern Asia	3	2	6-24	13.8	13.8	12.9
Japan	3	0	6-24	13.8	13.8	12.9
Europe	5	4	3-12	3.3	3.2	3.2
FRG	1	2	6	6.0	6.0	6.0
North America	2	4	0-12	10.5	10.4	10.5
U.S.	1	4	12	12.0	12.0	12.0

One observation that can be made is that in Asia (specifically in Japan) and in North America, an average inventory of approximately 1 year's worth (one reload) of fabricated fuel is desired among the respondents as opposed to only about one quarter of a year in Europe. On the other hand, we should point out that the U.S. data is for only one organization which had a policy and that the inclusion of Canada heavily weights the North American average. In fact, some utilities in Japan want two reloads per operating reactor. The Japanese, very conservative regarding the relative "youth" of the nuclear technology, are particularly

(1) The Range reflects the spectrum of responses of participants in Phase I and applies to each time period 1980, 1985 and 1990. (This footnote applies to the Range in each table of this format throughout this report.)

concerned about the possiblity of finding failed fuel during a refueling, and want entire extra reloads available. It was noted that if future experience shows the fuel to be reliable, then the coverage for this contingency could be reduced to perhaps a half a reload per reactor. It was considered unlikely that fabricated inventories would ever return to the early concept of having only 2-4 spare fuel assemblies per reactor.

The absence of a policy specifically for fabricated fuel may, in many cases, be interpreted as an implicit decision to not hold such an inventory. In other cases, absence of a policy in any area simply indicates that the organization has not thought about it.

The preferred storage location for fabricated fuel in every case is on the reactor site. In those cases where there would be more fabricated fuel in inventory then can be accommodated on-site, the excess is stored at the fabricator.

In Europe the maintenance of a 3-4 month advance supply at the reactor site is designed primarily as a tactical inventory to protect against strikers picketing a reactor site preventing deliveries for a refueling, or other strikes or difficulties in transport from the fabricator.

Finally, although the primary purpose of a fabricated fuel inventory is usually to provide tactical/operational protection, fabricated fuel, by definition, represents the ultimate form of inventory for strategic purposes as well. It is for this reason that a very clear pattern (of which only Japan is the exception) was perceived. In a country that does not have an indigenous national fuel fabrication capability, or where the national supply is questionable for some reason, such as limited capacity or financial strength of the fabricator, a utility will hold a definite amount of fabricated fuel equal to one half to one year's worth of coverage in inventory. In those countries where there are fabrication plants, utilities tend to carry minimal levels of fabricated fuel inventories, and instead concentrate on the step prior to fabrication in their fuel supply chain, which is enriched UF_6 for the LWR's and AGR's and UO_2 for the CANDU and Magnox reactors.

4.3 Desired Inventory Levels - Enriched UF_6

Table 4.3.1 below presents the data for desired inventory levels for enriched UF_6.

TABLE 4.3.1

Desired Inventory Levels

Weighted Only for Countries with Policies

ENRICHED UF_6

	Number of Organizations		Months of Coverage			
Region	with policy	without policy	Range	1980	1985	1990
Eastern Asia	2	3	12	12.0	12.0	12.0
Japan	2	1	12	12.0	12.0	12.0
Europe	3	6	6-12	7.6	7.6	7.6
FRG	0	3	-	0	0	0
North America	0	6	-	0	0	0
U.S.	0	5	-	0	0	0

Enriched UF_6 is stored either at the fabricators or at the enrichment facilities. Of particular note is Japan's situation, which results in essentially all of Japan's enriched UF_6 which is in excess to that needed for fabrication being stored either at USDOE or EURODIF. Spain also has storage outside the country, but plans to construct a national storage facility along with a fuel fabrication plant.

4.4 Desired Inventory Levels - Natural UF_6 and UO_2

Table 4.4.1 below presents the data for desired inventory levels for natural UF_6 and UO_2.

TABLE 4.4.1

Desired Inventory levels

Weighted Only for Countries with Policies

NATURAL UF_6 & UO_2

	Number of Organizations			Months of Coverage		
Region	with policy	without policy	Range	1980	1985	1990
Eastern Asia	0	5	-	0	0	0
Japan	0	3	-	0	0	0
Europe	0	9	-	0	0	0
FRG	0	3	-	0	0	0
North America	2	4	3-17	6.0	4.6	4.3
U.S.	1	4	17	17.0	17.0	17.0

This material is desired to be stored at the convertor in the case of UF_6 and at the fabricator in the case of UO_2. In actual practice, for expediency, a considerable portion of natural UF_6 ends up being stored at enrichers, primarily USDOE (U.S.) and EURODIF (France) and at the five convertors: Allied Chemical and Kerr-McGee (U.S.), British Nuclear Fuels Limited (England), Comurhex (France), and Eldorado Nuclear (Canada).

4.5 Desired Inventory Levels - U_3O_8

Table 4.5.1 below presents the data for desired inventory levels for U_3O_8.

TABLE 4.5.1

Desired Inventory Levels

Weighted Only for Countries with Policies

U_3O_8

	Number of Organizations		Months of Coverage			
Region	with policy	without policy	Range	1980	1985	1990
Eastern Asia	4	1	12-30	22.6	21.3	18.4
Japan	2	1	18-30	25.5	25.6	21.4
Europe	7	2	12-24	16.3	16.8	16.2
FRG	3	0	24	24.0	24.0	24.0
North America	4	2	3-24	10.7	12.6	12.3
U.S.	4	1	3-24	10.7	12.6	12.3

The usual preferred storage location for U_3O_8 is at the conversion facility. Some organizations, however, prefer to store excess U_3O_8 at the U_3O_8 production facility (mine site), and a few choose to utilize independent storage facilities.

4.6 Some Perspective on Desired Inventories and Storage Locations

Some of the factors that are taken into account by utilities in the development of desired levels of inventory are included in Table 4.6.1 below. These factors are not mutually exclusive.

TABLE 4.6.1

Factors Utilities Consider in Setting Desired Inventory Levels

- degree of import dependence
- size of their program (number of reactors)
- their ability to diversify supply sources
- cost of money
- their ability to finance the inventory
- the expected reliability of their suppliers
- prior difficulties experienced
- availability of storage
- national dependence on a supplier country

Concerning import dependence, 75% of the companies are 100% dependent on imported uranium. Of 11 utilities interviewed in Europe, only in Spain and France were there some degrees of independence for U_3O_8 supplies ranging today from 10% to 33%. In the future, that range decreases to 10% to 20% as the sizes of each nuclear program expands relative to each country's internal uranium production capability. In Asia, 100% of the utilities are 100% dependent on external sources for U_3O_8. In North America, the opposite pattern holds. All but two utilities in the survey presently are entirely independent of foreign sources of U_3O_8 and those two are only getting about 10% of their supply from outside the United States. The degree of import dependence can be expected to grow in the United States in the future, though, as more utilities contract for limited fractions of their needs with new Australian and Canadian suppliers.

Because UF_6 conversion facilities only exist in four countries in WOCA (Canada, England, France and the United States), utilities in all other countries are 100% dependent on foreign conversion. Thus, among the respondents to the study, 100% of consumers in the Asian region, and 80% of those in in Europe are vulnerable at the point of conversion. None of the utilities in the study from North America are similarly vulnerable to external conversion except for a small portion (10%) of one U.S. utility's supply from Canada. (There are some U.S. utilities, not in the study, which have some conversion performed in England.) As will be seen later, this dependency on external conversion by Asia and Europe will have a significance associated with storage locations.

The greatest degree of national autonomy and control is in the area of fuel fabrication. Of the 12 countries included in this analysis, 7 countries have their own internal fabrication capability and 2 more have firm plans to add it. Thus, in the future, about 75% of the major industrialized nations will be able to assemble their own nuclear fuel. Of these, 25% (3) would still be partially dependent on imported fabrication for 25% to 50% of their total requirements.

NRI asked participants which form of nuclear fuel they primarily think in when they think about or discuss inventories. We found that 70% of utilities immediately think of U_3O_8 whereas only 25% think of natural UF_6. Thus, although there is some overlap, almost all utilities report thinking at least in terms of natural uranium. When discussing inventories another 30% as respondents think first in terms of fabricated fuel. Again, as shown in Table 4.1.1, the percentages need not necessarily add to 100% because inventories in various forms are not mutually exclusive. Among the 30% whose first concern is maintaining an inventory of fabricated fuel, a clear pattern exists where the distinguishing characteristic is that all but two in the group are utilities which do not have fuel fabrication capabilities in their own country. Where a national fabrication capability exists, utilities in that country first think of inventories in terms of enriched UF_6, the next lower economic cost form. Overall, 55% of the utilities in the study with light water reactors think of inventory in the more enhanced forms of enriched or fabricated fuel in addition to an almost universally shared concern about maintaining some separate additional coverage of natural uranium. The universal sensitivity to natural uranium, and particularly U_3O_8, however, cannot be missed.

The costs of money used by companies in evaluating inventory levels vary considerably from country to country. The cost of money is often also a function of whether the utility is a public or privately owned company. If public, the cost of money is usually less. The cost of money for evaluation purposes was highest in the United States and England, lower in Europe and lowest in Switzerland, Japan, and Germany. Almost every utility recognized that the cost of money is related to the general inflation rate. In the United States, the record high interest rates of 1979-1980 prompted some utilities to consider selling off U_3O_8 inventories as an economy move. Thus, as a general rule, the lower the cost of money, the more material that can be carried in inventory relative to the overall size of an individual nuclear program, and this pattern was observed.

Two other financial considerations can be important. A utility which has good overall financial strength can afford higher debt limits, and can, if it chooses, negotiate larger size leases, trusts or other fiduciary arrangements for carrying inventories. Also some governments can subsidize their utilities' inventory by arranging for lower cost money, or covering part of the cost. Finally, some utilities can carry inventory in their rate bases, facilitating the carrying of higher levels of inventory. NRI feels that greater emphasis should be placed on these economic factors in future studies on inventories. Strangely enough, a number of fuel managers in U.S. utilities do not know if nuclear fuel inventories are included in their rate bases.

NRI inquired into what the utilities considered determines or "drives" their U_3O_8 purchase contracts. For the two organizations with natural uranium fueled systems, the plant schedule was seen as the driver. This answer is logical because these are systems where new fuel is being continuously loaded into the reactors. In the light water reactor systems, fuel is loaded in batches or "reloads" of 1/4 to 1/3 of a core every year to eighteen months. For the 18 utilities with LWR's, the U_3O_8 "driver" was perceived to be the enrichment contracts by 72% of respondents, the plant schedules by 50% of respondents, and fabrication schedules by 11%. Of the 50% who felt that the reactor operations (plant schedule) drove their U_3O_8 demand, it should be noted that 60% of those had USDOE requirements-type contracts for enrichment and thus their enrichment contracts acted like a "pass through" for the plant schedule. These data confirm the inherent weaknesses of defining demand in supply/demand analyses based upon only reactor requirements or upon only purchase contract commitments. Again, note that the percentages need not add to 100%. This is another example of the tricky nature of the data and the need to construct a model before statistical inferences can be made.

Some utilities have definite limits on their abilities to enhance supply assurance through diversification of supply sources for the following reasons: 1) small size, 2) prior large contract commitments to only one or two major suppliers for most or all of one's supply needs, or 3) a less innovative corporate personality. Some utilities and agents, on the other hand, take a large measure of pride in their design and administration of a highly diversified and complex fuel supply network whose various pieces need to be carefully integrated into an optimum overall supply. In many cases, the existence of such an approach is not only a function of the national or regional position of the utility, but, perhaps even more so, a function of the desire by individual fuel managers for the intellectual and professional challenge of managing such a system. However, there is a definite economic cost incurred by utilities with diversified supply because of longer lead times (and therefore carrying times) in their fuel supply pipelines and additional contract administration. A simple lead time for a U.S. utility, for example, can be as little as nine months from U_3O_8 delivery to delivery of fabricated fuel to the reactor. The lead time for some diversified supply chains that can be twice as long. The costs associated with having a diversified supply can be compared with those of holding inventories, and an optimum mix of diversification and inventory holding can be found. Where it is possible for a utility to pass through the costs of diversifying supply or holding inventories to its customers or the government, the utility receives an economic grant in the form of greater assurance. In lesser developed countries, utilities and their government's are not always able to finance diversification of supply and inventories in this way, and thus are more favorably inclined to alternative inventory schemes like the INFCE fuel-bank.

The findings with respect to storage represent one of the more curious aspects of the study. In theory, if a utility or nation is concerned about politically motivated supply disruptions (and we saw from Table 3.4.1 that fully 70% of participants were), it is logical that once an inventory is established, a utility would want it stored under its direct control, or at least inside its national borders. It was surprising to discover the extent to which large inventories owned by potentially vulnerable utilities were not maintained inside the utility's own country. In fact, utilities own large inventories of U_3O_8, natural UF_6, and enriched UF_6 that are scattered all around the world at mine sites, convertors and enrichers. One reason for this dispersion is there are no licensed storage facilities for such material in the countries in which the utilities operate. Why there are no licensed storage facilities is an interesting question. In Japan, the most anamolous case, it has not been considered politically acceptable to store any more nuclear fuel in the country than is needed to operate the reactors. Therefore, all of Japan's indigenous inventory is in the form of fabricated fuel. All of its enriched UF_6 and much of its natural UF_6 is at USDOE and EURODIF. The rest of its natural UF_6 and U_3O_8 is at convertors and mine sites in Canada, France, England, South Africa, and the United States. Not just for Japan, but in general, one can observe that large inventories of foreign-owned nuclear fuel commodities are maintained in only four countries--Canada, England, France and the United States--where the main convertors and enrichers are located with some U_3O_8 inventory also held in buyers' accounts in South Africa.

Finally, of some note is the situation where one country is already so dependent on another country or group of countries--whether economically, for defense, or politically--that it doesn't make much sense to maintain expensive strategic inventories of uranium. In the long run, it's probably just as effective, and a lot cheaper to simply trust that a reliable relationship will continue. Korea is a good example of this mentality. This basic approach to inventories can actually be seen in the way the policies of several utilities in diffferent countries have been established.

SECTION 5

ACTUAL INVENTORY LEVELS OF STUDY PARTICIPANTS

5.1 Actual 1980 Inventory Levels - Fabricated Fuel

Table 5.1.1 below presents the actual 1980 inventory levels for fabricated fuel in terms of the weighted average months of forward coverage for participants in Phase 1 of the study who have such an inventory in 1980.

TABLE 5.1.1
Actual Inventory Levels Weighted Only
for Countries with Policies
FABRICATED FUEL

Region	Number of Organizations with inventory	Number of Organizations without inventory	Months of Coverage Range	Months of Coverage Weighted Average
Eastern Asia	2	3	6-12	10.8
Japan	2	1	6-12	10.8
Europe	7	2	1-12	3.7
FRG	2	1	2-12	6.6
North America	1	5	7	7.0
U.S.	0	5	0	0

5.2 Actual 1980 Inventory Levels - Enriched UF_6

Table 5.2.1 below presents the actual 1980 inventory levels of enriched UF_6 in terms of the weighted average months of forward coverage for participants in Phase 1 of the study who have such an inventory in 1980.

TABLE 5.2.1

Actual Inventory Levels Weighted Only for Countries with Policies

ENRICHED UF_6

	Number of Organizations		Months of	
Coverage Region	with inventory	without inventory	Range	Weighted Average
Eastern Asia	3	2	5-112	17.8*
Japan	3	0	5-112	17.8
Europe	5	4	6-32	7.8**
FRG	3	0	6-32	9.6
North America	1	5	12	12.0
U.S.	1	4	12	12.0

* not included is one initial core already purchased for a reactor not yet constructed.

** not included are between 2-3 initial cores in two countries awaiting fabrication.

5.3 Actual 1980 Inventory Levels - Natural UF_6 and UO_2

Table 5.3.1 below presents the actual 1980 inventory levels for natural UF_6 and UO_2 in terms of the weighted average months of forward coverage for participants in Phase 1 of the study who have such an inventory in 1980.

TABLE 5.3.1
Actual Inventory Levels Weighted Only
for Countries with Policies
NATURAL UF_6 & UO_2

	Number of Organizations		Months of Coverage	
Region	with inventory	without inventory	Range	Weighted Average
Eastern Asia	2	3	0-30	26.1*
Japan	2	1	0-30	26.1
Europe	2	7	2-9	8.6
FRG	1	2	2	2.4
North America	3	3	1-24	6.5
U.S.	2	3	18-24	20.0

* does not include material stated as a single quantity held in both U_3O_8 and natural UF_6.

5.4 Actual 1980 Inventory Levels - U_3O_8

Table 5.4.1 below presents the actual 1980 inventory levels for U_3O_8 in terms of months of forward coverage for participants in Phase 1 of the study who have such an inventory in 1980.

TABLE 5.4.1
Actual Inventory Levels Weighted Only
for Countries with Policies
U_3O_8

	Number of Organizations		Months of Coverage	
Region	with inventory	without inventory	Range	Weighted Average
Eastern Asia	2	3	3-18	15.4
Japan	1	2	18	18.0
Europe	8	1	1-48	11.5
FRG	3	0	12-24	13.2
North America	4	2	8-12	11.8
U.S.	4	1	8012	11.8

5.5 Comparison of Current Actual Levels of Inventory with Desired Levels

A comparison of the weighted average months of inventory levels desired by participants in the study with the actual 1980 inventory levels is presented below in Table 5.5.1 for Asia, Europe and North America.

TABLE 5.5.1

Comparison of Actual with Desired 1980 Levels of Inventory

(For Those with Policies and Inventories in 1980)

	Desired Inventory	Actual Inventory	Difference (Actual-Desired)
Eastern Asia			
Fabricated Fuel	13.8 mos.	10.8 mos.	(3.0) mos.
Enriched UF_6	12.0	17.8	+5.8
Natural UF_6	-0-	26.1	+26.1
U_3O_8	22.6	15.4	(7.2)
Months Equivalent U_3O_8	48.4 mos.	70.1 mos.	+21.7 mos. excess
Europe			
Fabricated Fuel	3.3 mos.	3.7 mos.	+0.4 mos.
Enriched UF_6	7.6	7.8	+0.2
Natural UF_6	-0-	8.6	+8.6
U_3O_8	16.3	11.5	(4.8)
Months Equivalent U_3O_8	27.2 mos.	31.6 mos.	+ 4.4 mos. excess
North America			
Fabricated Fuel	3.8 mos.	7.0 mos.	+ 3.2 mos.
Enriched UF_6	-0-*	-0-*	-0-
Natural UF_6	6.0	6.5	+0.5
U_3O_8	10.7	11.8	+1.1
Months Equivalent U_3O_8	20.5 mos.	25.3 mos.	+ 4.8 mos. excess

As can be seen, the overall actual inventory levels expected to exist in 1980 exceed the desired levels in every one of the regions. However, the Eastern Asia area has the most severe problem. The explanation for a large part of this problem is found in Japan.

* One U.S. utility wanted 12.0 months of EUF_6 for one plant and had that level. The rest of North American utilities desired to have no EUF_6 and had none. That one reactor reload of enriched UF_6 is, therefore, not considered statistically significant and is excluded.

A second pattern can be seen in the comparison between actual and desired inventory levels for U_3O_8 and natural UF_6. In Europe and Asia the utilities prefer to carry between 1 1/4 and 2 years of natural uranium in inventory in the form of U_3O_8, and not as UF_6. However, for both regions, their actual U_3O_8 levels are lower than their desired levels while the actual levels for natural UF_6 considerably exceed the desired levels. There is a simple explanation for this phenomenon. Much of the storage of excess U_3O_8 is at conversion facilities. As delays and deferrals occur to the reactor the lessened demand works back through fabrication and enrichment (where the contracts permit) and creates a lessened annual demand for the convertors. But conversion is a continuous chemical process and the convertors need to keep their plants running. So, the convertors offer the utilities free or very inexpensive storage for U_3O_8, provided that the convertor can use the U_3O_8 as he chooses to keep his plant in an optimum operational mode. Thus, what would otherwise be held as U_3O_8 gets converted to UF_6 for the operational convenience of the convertor.

Whether the utility incurs the added cost of conversion is a subject of negotiation between convertor and utility. The convertors' economic performance is severely impacted by these reductions since conversion is the lowest cost element in the fuel supply chain, accounting for only about 3-4% of the value of enriched UF_6. As a result, the convertor tries to hold his customer to the original payment schedule in the contract. In many cases the customer accedes to the request after some negotiation for the sake of maintaining harmonious long-term contractual relations.

Enrichment, on the other hand, is quite a different cost element. Enrichment and U_3O_8 are the two most expensive components of nuclear fuel - with each worth $13 to $26 million per reload region for a standard large reactor. As a rule, utilities want no more of either commodity on their books than is needed for their reactor requirements and inventory policies. The absolute trust by U.S. utilities in USDOE's supply of enrichment is seen by U.S. policy to have zero (0) desired inventory level of enriched UF_6.

The general lack of concern by U. S. utilities in general about potential supply disruptions is apparent in that the U. S. has both the lowest desired and lowest actual inventory levels of any of the regions studied. This may be partly explained by the fact that 80% of all enrichment contracts held by U.S. utilities with scheduled deliveries through 1980 are U.S. DOE's Requirements-type contracts. Even through 1985, 60% of all U.S. utility enrichment contracts are Requirements contracts. Non-U.S. utilities and customers of the non-U.S. enrichers have significantly lower percentages of such flexible coverage, and thus higher inventories. The U.S. utilities have enjoyed, as a result, the luxury of economic optimization of nuclear fuel costs and inventories to a much greater extent than their non-U.S. counterparts.

A second explanation for the more casual attitude of U.S. utilities toward inventories is that the U.S. has had more indigenous capability to produce U_3O_8, conversion, enrichment and fabrication than the U.S. utilities can use. There is excess capacity at each stage and the U.S. is a net exporter of all but U_3O_8. Thus there is the basic confidence that needed material can always be quickly found in the marketplace in an emergency.

Finally, there is a single coordinated legal system to enforce domestic contracts. For domestic contracts, then, the difficulties associated with contract disputes and legal enforcement of international contracts are thus eliminated. As a result, U.S. utilities do not perceive their domestic supply contracts as making them strategically vulnerable to politically inspired disruptions in supply, and accordingly tend not to maintain strategic inventories for that purpose.