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LONG-TERM URANIUM SUPPLY-DEMAND ANALYSES

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FOREWORD

Studies undertaken in the International Nuclear Fuel Cycle Evaluation (INFCE) [4] exercise in the late 1970 showed the importance of long-term projections of uranium supply possibilities in relation to reactor-related demand. Projections of maximum production capability from known uranium resources were initiated by the U. S. Department of Energy using the computer model RAPP (Resources and Production Projection). A modified version of the model was later used to project future production from undiscovered uranium resources estimated by the International Uranium Resource Evaluation Programme (IUREP) [5].

The present analysis over the period 1985 - 2035 applies a later modified version of RAPP 3, using the 1983 revised Speculative Resource estimates, as well as resources of the RAR and EAR-I and II categories, production capability and reactor related uranium demand data developed for the OECD(NEA)/IAEA report "Uranium Resources, Production and Demand" 1986, [9]. Both resource and demand ranges used in this study are such that they should cover even situations, like those to be expected as consequence of the recent Chernobyl reactor accident.

In May 1985, a group of consultants, consisting of Messrs. P. de Vergie, W. Gehrisch and D. Taylor, reviewed the input assumptions of RAPP 3 and made the recommendation to incorporate means to limit the market share of any given supplier country. This modification was carried out by the model's author, Mr. de Vergie, under contract to the IAEA in October 1985.

Responsible IAEA staff members were Messrs. D. McCarn and E. Müller-Kahle.

EDITORIAL NOTE

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SUMMARY

A long-term uranium supply-demand study has been made using an improved version of the RAPP 3 computer model [2].

Supply and demand input data have been taken from the OECD (NEA)/IAEA report "Uranium Resources, Production and Demand", edition 1986 ("Red Book") [9]. In addition, estimates of Speculative Resources used for this study were made by the former Joint NEA/IAEA Steering Group on Uranium Resources [5]. Although some of the demand information have been used from an earlier draft of the Red Book, the difference to its final version is not significant for the purpose of this study.

The basic assumptions for the supply-demand studies, the theoretical "could do" supply projection and the different supply-demand sensitivity studies and their analyses, are as follows:

1. Three uranium demand cases for the period 2000-2035, based on different reactor strategies were selected for this exercise:

   A. <u>a Low Case</u>, based on the low range of the improved LWR with an annual demand, increasing from 63,500 t U to 107,100 t U, equivalent to an average annual growth of about 1.75%,

   B. <u>a High Case</u> adopted from the high Pu recycling reactor strategy with an annual demand, increasing from 63,500 t U to 226,500 t, equalling an average annual growth of 3.5%, and

   C. <u>a Base Case</u>, a mixed reactor strategy, as average of the above two cases, annual demands increasing from 63,500 t to 166,000 t U, equalling an average growth rate of 3% per year, this case was selected as "Base Case", for this studies as the mixed reactor strategy is considered the most realistic of the demand.

2. For the resource base from which the future supplies will be produced three cases were used as follows;

A. a Low Case:

- RAR + EAR-I and II recoverable at a cost of $130/kg U or less — plus low range SR

B. a High Case:

- RAR + EAR-I and II recoverable at a cost of $130/kg U or less — plus high range SR

C. a Base Case:

- RAR + EAR-I and II recoverable at a cost of $130/kg U or less — plus low range of the most favourable quartile SR

The resource case using the low range of the most favourable quartile SR was selected as the Base Case.

3. Seven supply-demand studies (Cases 1 - 7) were made, using different combinations of the above demand and supply cases as shown in Table 3. The results can be summarized as follows:

- uranium supplies from the Low Resource Base could meet the demand of the Low Demand Case (improved LWR) and of the Base Demand Case through the year 2035 (Cases 1 and 5);

- supplies from the Low Resource Case do not fill the demand of the High Demand Case (Pu recycling reactor strategy): the resulting gap occurs between 2030 and 2035 and totals about 63,000 t U, equalling about 5% of the demand of that period (Case 2);

- supplies from high and from Base Case Resources (low range of the most favourable quartile SR) could cover the demand of all reactor strategies within the projection period (Cases 3, 4, 6 and 7 equalling "Base Case").

4. An analysis (Case 8) was carried out to determine the distribution of supplies for the Supply-Demand Base Case (Case 7) from the different resource categories (RAR, EAR-I and II, SR).

It shows that currently known RAR and EAR-I resources recoverable at costs of $130/kgU or below can provide all the supplies for the Base Case through about 2015. Thereafter, through 2035 there are sufficient resources of these categories to support the production capabilities projected in the 1986 Red Book as well as additional centres modelled by the RAPP programme. In addition, EAR-II and SR are required to supplement the known resources between about 2015 and 2035. The projected amount of these resources is only about 15% of those currenty estimated. In fact, the EAR-II (-$130/kg U) above would match the additional needs between 2015 and 2035.

5. Theoretical "could do" supply cases (Cases 9, 10, and 11) were undertaken to illustrate the highest technically feasible supply based on the three resource cases (Low, High and Base), subject, however, to the constraints of the model (lead times, resource development rates, etc.). "could do" supplies were compared to the demand base case, to provide the necessary perspective.

The results of the "could do" studies, for the different resource cases are:

- Low Resource Case (Case 9): oversupply of between 220% in 1995 and 172% in 2010 occur in this case to about 2020 when supplies balance demand, decreasing to 86 and 76% of supply in 2030 and 2035 respectively.

- High Resource Case (Case 10): "could do" supplies are consistently higher than demand; the excess decreases slightly from over 250% in 2000 to an estimated 140% in 2035;

- Base Resource Case (Case 11): a similar trend is indicated by this supply curve: decreasing from a peak of 250% in 2000 to 111% of demand in 2035;

6. To test the impact of modified RAPP model input parameters a number of sensitivity studies were made on the Base Demand and Supply Cases (Table 3).

6.1. The resource development rate (Cases 12 and 13), i.e. the time required to develop undiscovered resources into reserves, was increased by factors 2 (Case 12) and 3 (Case 13) in relation to the Base Case.

It was found that the supply-demand projection was highly sensitive to this parameter. When applying a factor of 2, a supply deficit occurs between 2022 and 2035, totalling about 263,000 t U, or about 8% of the demand of this period.

Applying a factor of 3, the shortage occurs between the years 2014 and 2035 and reaches a total of over 1 million t U or about 38% of total cumulative demand of the same period.

6.2. The lead times from the start of projection of uranium exploration to production were increased by the factor of 2 and 3 (Cases 14 and 15) in relation to the Base Case.

This study revealed that in the case of doubling the lead times (Case 14), supply would still be adequate to meet demand. Applying, however, a factor of 3 (Case 15), a supply gap occurs between 2015 and 2035, amounting to a total of about 825,000 t U, or to 28%.

6.3. The contribution of major supplier countries was modified by eliminating all production for one at a time each for the following countries: Australia, Canada, South Africa and USA (Cases 16-19).

The results indicated that there are no consequences on the total supply would still be adequate with the elimination of the production from any single major producer.

6.4. The maximum market share of any one of the major producers, originally limited to no more than 30% was lowered to 15 and

12% of the Base Demand (Cases 20 and 21). At 15%, maximum share of market, demand of the Base Case can still be met, while at 12% of demand a deficit occurs between 2011 and 2035, totalling about 12% of the total demand over this period.

It is concluded that the minimum market share for each major supplier, at which demand can still be filled lies somewhere between 12% and 15%.

6.5. The resource base was modified through a lower cost category of up to $80/kg U, to better reflect the current average of long-term uranium prices (Cases 22 and 23).

In these two cases, the RAR and EAR-I portions of the up to $80/kg U cost category were used, while for the EAR-II and SR a slower resource development rate of a factor of 2 and 4 respectively were used compared to the Base Case. It is assumed that this would in effect divide these resources by 2 and 4 respectively and that these portions would represent the below $80/kg U cost categories of the EAR-II and SR.

These tests show that the model is very sensitive to a reduction to the resource base: in both cases the Base Demand Case cannot be filled through 2035. In the case of the decrease of EAR-II and SR to 50%, the supply gap occurs between 2014 and 2035, totalling 0.75 million t U or 25% of the cumulative demand. In case of a decrease of these resources to 25%, demand can be filled only through 1999. The resulting shortage amounts to 1.9 million t U, or 45% of the cumulative demand.

CONCLUSIONS

The conclusions that can be drawn from the results of the different analyses and the results of their results described above, can be summarized as follows:

1. The uranium supply situation especially for the likely Base Demand Case could be adequate through the period through the year 2035. This, however, assumes a timely discovery of presently unknown resources and an undelayed development of known resources both of the $130/kg U cost category and the construction of production centres.

2. The uranium supply distribution of WOCA shows that there are two groups: the major suppliers and other suppliers. The first group includes Australia, Brazil, Canada, Namibia, Niger, South Africa and USA and has a combined share of the total supplies projected in this study from about 80 to 95% of the total. The balance of supplies are divided among the other group including 11 to 19 countries with Argentina, France, India, and Spain being among this group's larger suppliers.

3. The analysis of the resource distribution reveals that the Base Case Demand through 2035 can be covered by currently known RAR and EAR-II recoverable at costs of below $130/kg U and estimated EAR-II of the same cost category. In addition, the Base Case SR of over 9 million t U equivalent to nearly twice the cumulative demand 1985-2035 of slightly more than 5 million t U an untapped potential.

4. The theoretical "Could Do" supplies exceed for most of the resource cases the projected Base Demand. The suppliers are thus assumed to be able, given the proper economic climate, to fill higher demands if needed. It indicates that the supply of uranium does not appear a limiting factor for nuclear energy growth.

5. Assessing the results of the sensitivity test, the following conclusions can be drawn as regards the most sensitive modifications made.

The application of a lower cost category of both known and undiscovered resources was shown to have the strongest impact of all sensitivity tests made. It must be concluded, given the continuation of the current uranium prices (and there are good chances that prices will stay near in the current price levels for sometime) and the assumed demand, that there will be a need for additional supplies from newly discovered low cost (-\$80/kg U or even -\$50/kg U) resources sometime between 2000 and 2015. New discoveries of the low cost resources can only be made, with experienced staff and capital, put to work in geologically favourable areas, and large investments are required to construct production centres that transfer resources into supplies. At present, exploration expenditures and manpower used are at a low and most efforts are supported by a few countries (France, FRG, Japan, United Kingdom) mainly abroad (Australia, Canada, USA). Under these conditions, it cannot be guaranteed that future demand can be met and the uranium mining industry is well advised to carefully assess the resource and supply situation.

The next stronger impact on supplies was caused by the modification of the resource development rate; slippages in the time needed to convert undiscovered resources into known resources have significant consequences on the supply situation and it is not ensured that the uranium industry, being in a state of profound changes as regards its structure, organization and assets, will be able to carry out projects in a timely manner. To avoid future problems in this area, a technically and financially healthy industry is needed.

The modifications of the total lead times though not of the same degree as the other two parameters discussed, have also a notable effect on supplies as shown. In addition, lead times in general, have an economic impact on the costs of a project, and thus practically on the cost category of the resource*. Experience in relatively recent uranium mining projects has shown, that lead times vary from 11 to 16 years, when not affected by adverse market conditions. As lead times appear somewhat related to the resource development rate, similar conclusions can be drawn.

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*As explained in the Glossary, the cost categories used in the Red Books, do not include sunk costs, which, however, ought to have an influence.

RECOMMENDATIONS

Analysis of the long-term supply-demand situation as well as the testing of various sensitivities using the RAPP 3 computer model and the available supply and demand data bases are considered a very useful exercise to determine the weak links of the supply-demand chain.

It is strongly suggested to improve the knowledge of the below $80/kg U cost resources, especially those of the EAR-II and SR categories, and to use them as input for future supply-demand scenarios. These should also use as resource input data, RAR and EAR-I, recoverable at costs of below $80/kg U, reduced to a range of 60 to 80% of the current estimate to compensate for optimistic overestimates by some countries.

Should uranium prices continue to remain at low levels, a lower resource cost category, e.g. $50/kg U, should be introduced in the future joint OECD/NEA-IAEA data collections and reports on "Uranium Resources, Production and Demand".

As the input data used for this study, are subject to modifications it is recommended to repeat a similar study when new resource, supply and demand data become available, from future editions of the Red and Yellow Books.

1. INTRODUCTION

The projection of uranium production capability using the RAPP computer model (Resources and Production Projection) developed by the US-DOE was first used for the International Fuel Cycle Evaluation project (INFCE) in 1978-80 [4]. An updated version of RAPP was described in the IAEA International Conference on Nuclear Power held in Vienna in September 1982 [1]. Subsequently, RAPP was modified in order to relate the production capability projection with future reactor-related uranium demand cases.

In 1985, IAEA decided to use the RAPP 3 version model for a long-term (-2035) supply-demand analysis using as input data the revised Speculative Resource estimates, developed by the International Uranium Resources Evaluation Project (IUREP) [5], as well as resources of the RAR and EAR-I and II categories, production capability estimates and demand projections developed for the 1986 edition of the OECD (NEA)/IAEA report "Uranium Resources, Production and Demand" [9].

2. SCOPE OF THE ANALYSES

It is the intention of this study to investigate the long-term uranium supply demand situation using a number of supply and demand related assumptions, considering only for WOCA.

For supply, these assumptions as used in the RAPP model include country economic development status, and consequent lead times for exploration and development, uranium development status, country infrastructure, and uranium resources including the Reasonably Assured (RAR), Estimated Additional, Categories I and II, (EAR-I and II) and Speculative Resource categories.

The demand assumptions were based on the "pure" reactor strategies developed by the NEA Working Party on Nuclear Fuel Cycle Requirements for the 1986 OECD (NEA)/IAEA reports "Nuclear Energy and its Fuel Cycle: Prospects to 2025" (Yellow Book) [10] and "Uranium Resources, Supply and Demand" (Red Book) [9] projecting demand until 2025 and extrapolating through 2035. In addition for this study, a mixed strategy case was computed using the averages of the Plutonium (Pu) burning LWR high, and the improved LWR low cases.

It is understandable that such a long-term analysis cannot present hard facts, but it can show which variables may in fact influence the long-term supply-demand situation. It is hoped that results of this study will provide valuable information for planners in the uranium supply and demand fields. Periodical re-analyses with updated data bases will be needed from time to time.

3. THE RAPP MODEL

3.1 General

In general, the RAPP 3 computer model [2] estimates uranium production attainable from estimated resources by simulating the processes, events and time involved in the exploration, discovery, production and depletion of uranium resources, on a country by country basis. The model uses information from a number of sources to model future supply to meet an aggregate reactor related uranium demand under a defined set of assumptions.

In summary, the input data includes:

a) for each country:

- Resources in various categories and geologic types.
- Production capability, existing and committed.
- Economic development class of the country.
- Uranium development status of the country.
- Accessibility of the resources.

b) for WOCA:

- Reactor related demand.

The following assumptions are made to operate the model;

- Resource development rate: the rate at which resources are discovered and converted to reserves.

- Production centre characteristics by geologic type.
- Optionally, the share of market that one country would have.

The model considers existing and committed production centres and the resources committed to those facilities and then using the resource estimates and deposit characteristics, works out scenarios for the discovery, development and production of the remaining resources.

Model output includes

- Attainable production capability projections.
- Supply projections, fitted to demand cases.
- Sensitivity analyses of model inputs and parameters.

RAPP 3 models the specific sequence of events that take place during the exploration and development of uranium resources. Basically, it uses four lead times to develop a production centre and a fifth one to exhaust the reserves committed during the production life of that centre. In more detail, these time portions are:

T1: The years from the date of the analysis to start of exploration.

T2: The years from start of exploration to the first discovery.

T3: The years for development of adequate reserves to justify constructing a production centre.

T4: The years for construction of the production facility including the environmental studies, engineering, access preparation, and facility construction.

T5: The years of production life of the facility.

3.2. Input Data for each Country

Uranium Resources

Reasonably Assured Resources (RAR) and Estimated Additional Resources, Category I (EAR-I) at the cost category of $130/kg U were taken from the NEA/IAEA report "Uranium Resources, Production and

Demand" 1986 ("Red Book") [9] covering the WOCA area. Such resources, not committed to existing or planned production centres are assigned to "Special Resource Units" as little or no exploration is required. These are analyzed separately.

Estimated Additional Resources, Category II (EAR-II) at the cost category of less than $130/kg U were also used from the Red Book and the Speculative Resource estimates of 1982/83 from the former Joint NEA-IAEA Steering Group on Uranium Resources [5]. "High", "Low" and "Most Favorable Quartile" estimates of Speculative Resources were made.

The resources in all categories have been classified by geologic type of deposits. The characteristics of these types are used to establish the resource development rate and the production facility sizes and economics for those resources not committed to existing and committed production centres.

Production Capability

RAPP 3 production capability projections utilize the 'production centre' concept. A production centre is defined as a production unit consisting of a mine and mill complex and the resources that are tributary to it. Each production centre is characterized by a production start-up year, production rate, and number of years of operating life. The production rate and plant life are those determined by the production attributes assigned to the geologic type of the resources on which the unit will operate. Production from by-product sources is not included in this study.

The model includes production capability projections as reported in the Red Book for existing and committed centres supported by RAR + EAR-I resources. These are considered in the model as "initialized production" centres. Resources (RAR and EAR-I) not committed to the initialized production centres are placed in a category as "uncommitted". Any initialized production capability in excess of the demand is considered as lost and not carried over as a preproduction inventory. After the period in which initialized production exceeds demand, the model projects no excess production above the projected demand.

Economic Development Classes of Countries

To consider the different situations in the various countries and their state of development, all countries were assigned one of six economic development classes. For each class base lead times and maximum growth rates were assigned. The first five classes were based on ranking by gross domestic product per capita (GDP) averaged over 10 years, from 1975 to 1984 (from UNIDO Statistical Data Base, 1975 Constant Dollars). The sixth class is a special case for countries actively exploring for and/or with a history of producing uranium. These classes are defined below. It is assumed that countries with less economic development and without a history of uranium exploration or production will have longer lead times for discovery and development of their resources.

ECONOMIC DEVELOPMENT CLASSES OF COUNTRIES

Economic Development Class	Description
1	GDP greater than $3000 per capita
2	GDP < $3000 per capita but > $2000 per capita
3	GDP < $2000 per capita but > $ 650 per capita
4	GDP < 650 per capita but > $ 350 per capita
5	GDP < 350 per capita
6	Countries actively engaged in uranium exploration and/or with a history of uranium production.

For each economic development class, base lead times have been set, including T1 (years to start of exploration), T2 (start of exploration to first discovery), and T4 from establishment of adequate reserves to commitment of production. Maximum annual growth rates in production capacity have also been established which vary by country economic development class, recognizing capital, infrastructural and other limits. This constraint provides an upper limit on production growth rates, but is not applied to the 'initialized production' centres. In this study, the constraint on production increase is averaged over a two year period.

The standard lead times for the various economic development classes are summarized as follows.

BASE LEAD TIMES FOR COUNTRIES
OF DIFFERENT ECONOMIC DEVELOPMENT CLASSES

Economic Development Class	T1 Years	T2 Years	T4 Years	Maximum Annual Growth in Production Capacity (t U)
1	3	6	7	2500
2	4	8	8	2000
3	6	9	9	2000
4	8	11	9	2000
5	10	11	9	2000
6	1	5	6	3000

In view of the more advanced status of the Special Resource Units previously mentioned, the above economic development classes lead times are not used to determine their development times, instead the following times are used: T1: 1 year, T2: 2 years and T4: 3 years.

Country Uranium Development Status

To recognize the state of development of the uranium industry in the various countries, the model modifies the base lead times established by the economic development class. Increases to lead times T1 and T2 are applied as set out below. No adjustment is applied to T4 nor to the Special Resource Units. All countries were assigned to one of the following three categories.

Known Uranium Resources 0% Increase
Some Uranium Exploration 25% Increase
No Uranium Exploration 50% Increase.

Accessibility of the Resources

In some countries the uranium areas have special problems of access and transportation. For these countries, adjustments were made to further increase lead times. This adjustment extends the lead times for T1, T2 and T4 by 0, 10, 20, 30, 40 or 50 %, as judged appropriate for the country.

3.3. WOCA Uranium Demand Input

In the RAPP 3 version the projected production is fitted to uranium demand cases developed externally. The demand cases used were developed by the NEA Working Party on Nuclear Fuel Cycle Requirements and are based on cases presented in the 1986 edition of the Red Book [9]. The demand is an aggregate WOCA demand and is not subdivided by country. Three demand scenarios were used in this study, two from the Red Book and a third averaging the two cases. These cases are described in more detail in Chapter 5.

In considering the demands, adjustments were made to reflect an existing stockpile of 130,000 t U in concentrate as reported in the 1986 Red Book [9]. A 1.5 year uranium inventory level was considered as normal and was maintained in each country. That is, inventories were reduced, or added to, to maintain a level equal to 1.5 years of forward requirements. These factors reduced demand in the first nine years of the study through utilization of the excess inventory, and increased demand subsequently to maintain the 1.5 years inventory level.

3.4. Model Assumptions

Basic assumptions are used on the model regarding the way resources are developed into ore reserves, uranium is produced and marketed.

The resource development rate determines the time required to convert estimated Speculative Resources into RAR considering the geologic types of deposits involved. The second assumption concerns production centre characteristics, which involve the nature of the deposits to be mined and processed. These factors influence plant size, ore grades and plant life. In addition, share of market constraints for the producing countries were applied, to account for the buyers' tendency to diversify supplies.

Resource Development Rate

The resource development rate models typical historical rates of conversion of resources to reserves in known uranium provinces. The rate of development is expressed as the cumulative percentage of the estimated uranium resource that could be developed into reserves over a period of time. It applies to the "uncommitted" RAR + EAR-I in the Special Resource Units as well as to EAR-II and SR. It is not used on the RAR + EAR-I committed to the initialized production centres.

After the lead times T1 and T2 are completed and the first discovery leading to significant reserves development has been made, the model begins to calculate annual additional reserves based on the resource development rate factors until all the resources are completely converted to reserves. The resource development rate and the resources in a given geologic type determine the lead time interval T3.

RAPP 3 provides the option of dividing the total resource development rate time into three consecutive periods, recognizing that the conversion rate may vary over the lifetime of a mining district or province. The total resource development rate divided into the number of years required to convert a given percentage of a resource into reserves in different geologic deposit types is shown in the following table.

RESOURCE DEVELOPMENT RATE BY GEOLOGIC TYPES OF RESOURCES

Geologic Type	Yrs.	%	Yrs.	%	Yrs.	%
Sandstone	20	30	20	40	15	30
Bedded	10	40	15	40	20	20
Vein	20	30	20	40	15	30
Dissem. Magm	20	30	15	40	15	30
Surficial Type	15	30	15	40	15	30
Qtz. Peb. Congl.	25	30	25	40	25	30
Unconf-related	15	40	15	30	20	30
"Other" Ore type	15	30	15	40	15	30
Phosphate (Primary)	15	30	15	40	15	30
RAR-EAR-I	10	50	10	50	-	-

The resource development rates may be further modified in the model for sensitivity analyses.

Because the RAR + EAR-I resources included in the model as Special Resource Units were not subdivided by geologic type, a special composite geologic type was created to handle these data. The resource development rate for the Special Resource Units allows complete development of all RAR + EAR-I in twenty years after the lead times T1 and T2 are completed.

Production Centre Characteristics by Geologic Type

Production characteristics of "typical" facilities for each geologic deposit type were established reflecting the anticipated size of deposits and their ore grade characteristics. In addition, a relative scale of production costs for each deposit type was used to prioritize the production centres created by the model as shown below.

PRODUCTION CENTRE CHARACTERISTICS, BY GEOLOGIC TYPE

Geologic type	Production Rates Tonnes U per year (base)	(min.)	Plant Life Years	Average Grade % U	Relative Production Cost
Sandstone	1000	250	15	0.15	127
Bedded	3000	1000	99	0.08	125
Vein	500	250	15	0.25	120
Dissem. Magm	1000	500	25	0.05	126
Surficial	1000	250	10	0.15	129
Qtz. Peb. Congl.	2000	500	20	0.05	124
Proteroz. Unconf	3000	500	10	0.50	118
"Other" Ore type	1000	250	15	0.20	130
Phosphate (Primary)	500	250	15	0.25	129
RAR-EAR-I	500	250	10	0.20	130

Share of Market Constraints

In order to recognize that a single supplier is not likely to take an excessively dominant market share, as consumers will wish assurance of supply by procuring from a diversity of sources, maximum "Share-of-Market" constraints are imposed on each country. This restraint is applied as a percentage of the total annual demand. In the event that supply cannot meet demand, the allowed share of market constraint is relaxed in an attempt to meet demand. If the demand is subsequently met, the constraint assumes its original value.

The relaxation of the share of market constraint is permitted in all cases in this study except for the share-of-market sensitivity analyses (Cases 20 - 21) where it was retained at a fixed value.

3.5. Model Output

Attainable Production Capability Projections

When the first part of the RAPP 3 model is complete and 'earliest-year' production centres have been generated from all available resources, the projection approximates a 'maximum technically feasible' production capability (or 'could do' case). The production levels and timing are those that could occur considering the estimated resources and their possible development according to the model assumptions and subject to the maximum annual growth rate constraint.

Supply-Demand Projections

In the second part, the production from 'earliest years' production centres is modified as needed to fill the demand curve. Such a projection constitutes a production capability needed-to-fill-demand, or 'need to' case.

The demand curve reflects the aggregate annual reactor related uranium requirements in tonnes U. This demand is modified by subtracting 'initialized production' to create a net annual demand which must be filled from uncommitted RAR + EAR-I and undiscovered resources. This demand will be filled by production centres brought into production by the model subject to the original constraints and scheduled to fit demand. The centres selected to fill demand in any given year are determined in RAPP 3 by priority according to the relative cost of production and the share of market constraint.

Sensitivity Analyses

In order to test the sensitivity of the results to the model inputs and assumptions a number of sensitivity studies have been made. Sensitivity analyses with modified parameters used in this study include:

Resource Development Rate (Cases 12 & 13)
Lead Times (Cases 14 & 15)
Major Uranium Supplier Countries (Cases 16 - 19)
Share of Market (Cases 20 & 21)
Resource Base (Cases 22 & 23).

4. DATA BASES USED

The input data used for the supply and demand analysis through 2025 were taken from a few sources. Longer term data, covering the period 2025 - 2035 were generated as shown in more detail further below.

For the supply side the important input data are the uranium resources and production capability, i.e. the resources of the RAR and EAR categories recoverable at costs of below $130/kg U as published in the 1986 Red Book [9] as of 1.1.1985; the Speculative Resources, estimated in 1977 and updated in 1982/1983 in conjunction with the International Uranium Resources Evaluation Project (IUREP), and summarized in an IAEA internal document [5]. The production capability estimates for existing, committed, planned and prospective production centres until 2025 are those published in the 1986 edition of the Red Book. Extrapolations of production capability for the period 2025-2035 were made by IAEA as needed, on the basis of remaining RAR and EAR-I recoverable at costs up to $130/kg U.

The demand data consist of pure (LWR-Pu burning and LWR 15% improved) reactor strategies, as well as a mixed reactor strategy. The demand for the pure strategies for the period up to 2025 was taken from the 1986 edition of the Red Book [9] and extrapolated for the period 2025-2035. The computation of the mixed strategy case was done by taking the midpoint for the Pu burning "high" scenario and the improved LWR "low" scenario.

5. DEMAND PROJECTIONS

Two basic pure reactor strategies (Pu recycling and improved LWR) were used for the illustration of the demand projections. These were developed from the 1986 Red Book questionnaires (to the year 2000) and by the NEA Working Party on Nuclear Fuel Cycle Requirements for the OECD (NEA)/IAEA 1986 report "Nuclear Energy and its Fuel Cycle: Prospects to 2025" [10].

Demand projections for the two strategies up to the year 2025 were made using a number of assumptions such as 0.25% tail assays and a 70% load factor. These projections were extrapolated to arrive at a demand for the period 2025 - 2035. A detailed description of the methodology applied for the projection of uranium demand is given in the Red Book 1986.

The analysis is based on two pure reactor strategies, the low demand case using improved LWRs, and the high demand case using a Pu recycle strategy, with the following characteristics:

Improved LWR: consisting of a 15% improved LWR, operating on the once-through cycle; all LWRs built in the period January 1991 to December 1995 will be of the 15% improved type; after 1995, improved LWRs are installed exclusively (additions and replacements); pre-1991 LWRs are retrofitted by 1993; there will be reprocessing only to provide the plutonium used by FBRs as identified on questionnaire returns and to reprocess all gas-graphite reactor fuel.

Plutonium (Pu) Recycle: consisting of a Pu burning LWR and a 15% improved LWR with U recycle; the introduction of Pu burning LWRs from January 1991 was limited either by the plutonium availability or by the condition that the fraction of plutonium burners shall not exceed 12.5% of the total LWR capacity in the year 1995 and 25% in the year 2000; in the long-term, the plutonium burning capacity may temporarily exceed the 25% fraction but must ultimately attain that value which causes the plutonium stockpile to be consumed by 2030.

In addition to the above two pure reactor strategies, a mixed case was developed using the average of the high (Pu recycling), and low (improved LWR), scenarios. This third reactor strategy was selected as the Base Case for the demand projections.

For the short-term time frame 1985-2000, demand and data were used from the 1986 Red Book questionnaire, which did not provide replies on the reactor strategy used. In practice, however, the demand figures shown in Table 1 for 5 years' intervals, are based on the improved LWR strategy.

Table 1

ANNUAL WOCA SHORT-TERM URANIUM DEMAND (UP TO 2000)

(Rounded to 1000 tonnes U)

YEAR	ANNUAL
1985	39
1990	49
1995	55
2000	62

For the long-term, between 2000 and 2035, the demand projections of the three strategies used in this analysis are summarized as 5 years' intervals in Table 2 and illustrated in Figure 1.

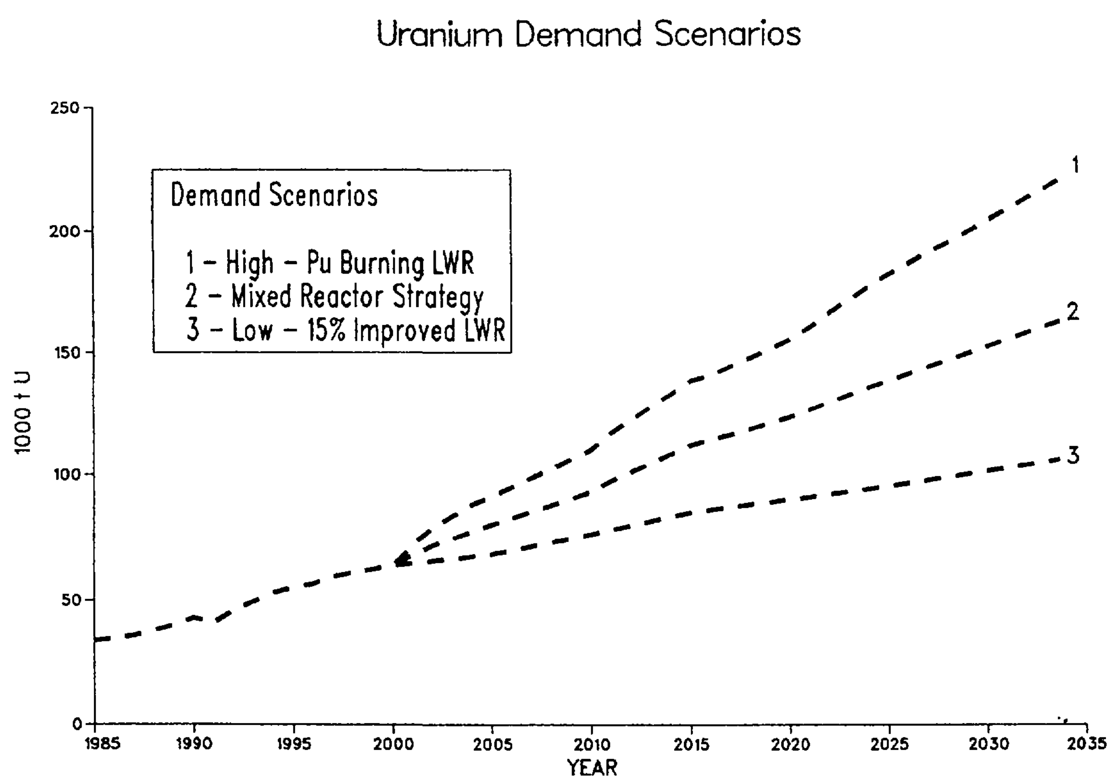

FIGURE 1

Table 2

ANNUAL WOCA LONG-TERM URANIUM DEMAND (2000-2035)

(Rounded to 1000 tonnes U)

YEAR	IMPROVED LWR Low case	Pu RECYCLE High case	MIXED STRATEGY Base case
2000	62	62	62
2005	67	85	76
2010	74	104	89
2015	82	130	106
2020	88	149	118
2025	93	174	134
2030	99	197	148
2035	105	219	162

In addition to these demand curves, however, the uranium stocks were taken into account, as they diminish the actual demand in times of surplus inventory and increase demand when the minimum inventory of 1.5 years' reactor demand assumed has to be built up to the required level.

Annex 1 shows for the three demand scenarios the computation of the "total demand" defined as reactor related demand minus available inventory to be drawn down or plus allowance for a stock to build up as the case may be, the cumulative (running) stock levels and the percentage and stocks of the annual total demand.

6. SUPPLY SCENARIOS

For the short-term, until the year 2000, production capability from existing, commited, planned and prospective production centres, (Case "B" of the Red Book) supported by known (RAR and EAR-I) resources recoverable at costs below $130/kg U plus available inventories were used as supply, and, therefore as shown in Figures 2 - 8 supplies are considered to be the same as production capability. For the long-term (2000-2035), however, uranium supply derived from known and undiscovered (EAR-II and SR) resources is matched to the total demand to be filled, i.e. the supply is "demand fitted" in the analysis.

The scenario used in respect to the inventories currently estimated at 130,000 t U, equivalent to a little more than the next three years' demand, is that they are assumed to be drawn down annually by 5,000 t U, until the global average level of 1.5 years demand is reached, which will then be maintained throughout the period of the analysis.

As regards the resources, the following three different cases are used:

High Case:
RAR + EAR-I and II recoverable at costs up to $130/kg U + high range case SR,

Low Case:
RAR + EAR-I and II recoverable at costs up to $130/kg U + low range case SR,

Base Case:
RAR + EAR-I and II recoverable at costs up to $130/kg U + low range of the most favourable quartile SR.

7. SUPPLY-DEMAND ANALYSES

7.1. Introduction

Using the supply and demand data discussed in the previous chapters, the following seven supply-demand scenarios were simulated with the RAPP 3 computer model (Table 3):

1. Case 1: Low Resources - Low Demand Case: supply from RAR + EAR-I and II, recoverable at costs of $130/kg U or less and low case SR, demand of the low case of the improved LWR strategy.

2. Case 2: Low Resources - High Demand Case: supply from RAR + EAR-I and II, recoverable at costs below $130/kg U and low case SR-demand of the high case of the Pu recycling strategy.

TABLE 3

OVERVIEW OF ANALYSES AND PARAMETERS

		PARAMETERS						
CASE NO.	ANALYSIS	RESOURCES	DEMAND	RESOURCE DEV. RATE FACTOR	LEAD TIMES FACTOR	SUPPLIERS	MARKET SHARE	RESOURCE COST CATEGORY
1	supply-demand	low	low impr. LWR	1	1	all available	30%	$130/kg U
2	supply-demand	low	high Pu recyc.	1	1	all available	30%	$130/kg U
3	supply-demand	high	low impr. LWR	1	1	all available	30%	$130/kg U
4	supply-demand	high	high Pu recyc.	1	1	all available	30%	$130/kg U
5	supply-demand	low	mixed strategy	1	1	all available	30%	$130/kg U
6	supply-demand	high	mixed strategy	1	1	all available	30%	$130/kg U
7	supply-demand	low most favorable quartile	mixed strategy	1	1	all available	30%	$130/kg U
"BASE CASE"		"BASE"	"BASE"					
8	resource categories	base	base	1	1	all available	30%	$130/kg U
9	could-do supply	low	base	1	1	all available	30%	$130/kg U
10	could-do supply	high	base	1	1	all available	30%	$130/kg U
11	could-do supply	base	base	1	1	all available	30%	$130/kg U
12	sensitivity	base	base	2	1	all available	30%	$130/kg U
13	sensitivity	base	base	3	1	all available	30%	$130/kg U
14	sensitivity	base	base	1	2	all available	30%	$130/kg U
15	sensitivity	base	base	1	3	all available	30%	$130/kg U
16	sensitivity	base	base	1	1	elimin. Australia	30%	$130/kg U
17	sensitivity	base	base	1	1	elimin. Canada	30%	$130/kg U
18	sensitivity	base	base	1	1	elimin. S. Africa	30%	$130/kg U
19	sensitivity	base	base	1	1	elimin. USA	30%	$130/kg U
20	sensitivity	base	base	1	1	all available	15%	$130/kg U
21	sensitivity	base	base	1	1	all available	12%	$130/kg U
22	sensitivity	base	base	2	1	all available	30%	(Equiv.)$80/kg U
23	sensitivity	base	base	4	1	all available	30%	(Equiv.)$80/kg U

3. Case 3: High Resources - Low Demand Case: supply from RAR + EAR-I and II recoverable at costs below $130/kg U and high case SR-demand of the low case of the improved LWR strategy.

4. Case 4: High Resources - High Demand Case: supply from RAR and EAR-I and II recoverable at costs below $130/kg U and high case SR-demand of the high case of the Pu recycling strategy.

5. Case 5: Low Resources - Base Demand: supply from RAR and EAR-I and II recoverable at costs below $130/kg U and low case SR-demand of the low bound of the mixed reactor strategy.

6. Case 6: High Resources Base Demand: supply from RAR and EAR-I and II recoverable at costs below $130/kg U and high case SR-demand of low bound of the mixed reactor strategy.

7. Case 7: Base Resource - Base Demand: supply from RAR and EAR-I and II recoverable at costs below $130/kg U and low most favourable quartile SR-demand of low bound of the mixed reactor strategy.

Graphical illustrations of the seven supply-demand scenarios are shown in Figures 2 - 8, and the following discussions are based on these illustrations.

7.2. The Period 1985 - 2000: As already mentioned, the supply curves up to the year 2000 are fitted to the total production capability category "B" of the Red Book nomenclature. This situation is identical for all seven scenarios.

For the period 2000 - 2035, however, for which the supply is fitted to meet the demand, separate analysis for each case will be presented.

As Figures 2 - 8 show the supply situation over the period 1985 to 2000, based on production capability, exceeds demand.

In 1985, the production capability amounts to about 44,500 t U, while demand is 34.000 t U. However, full production will not be achieved, and some of the remaining 5,000 t U, will be supplied from inventories. The production capability of WOCA in 1985 is in 16 countries. Six of them have a combined share of over 85% (Australia, Canada, Namibia, Niger, South Africa and USA), while the remaining 10 countries (Argentina, Belgium, Brazil, France, Gabon, FRG, India, Japan, Portugal and Spain) have a cumulative supply possibility of 14%.

Total production capability is projected to increase and peak around 1990 at about 50,000 t U. The projected supply countries are about the same as in 1985 and the ratio between the significant producers and others remains unchanged. However, it is projected that Brazil will emerge as a supplier of 1,250 t U p.a., equalling about 2% of the total.

In accordance with the definition, production capability is not equivalent to actual production. For example, the 1985 production was about 6,700 t U or 15% below the production capability. This difference is expected to increase and may reach over 20.000 t U in 1995, equivalent to over 30% of the projected total production capability at that time. This excess capacity reflects plants shutdown, plants operating at less than full capacity and the fact that the capability of some plants is less at current prices than at the $130/kg U assumed for the Red Book studies.

7.3. The Period 2000 - 2035

For this period the supply is designed to meet demand ("demand fitted"). The following seven cases (Cases 1-7) are based on different supply and demand assumptions as explained above and summarized in Table 3.

Case 1 which is shown in Figure 2 and Annex 2 summarizes the supply and demand data for the years 2000, 2010, 2020, 2030 and 2035.

Uranium Supply – Demand Scenario
Case 1

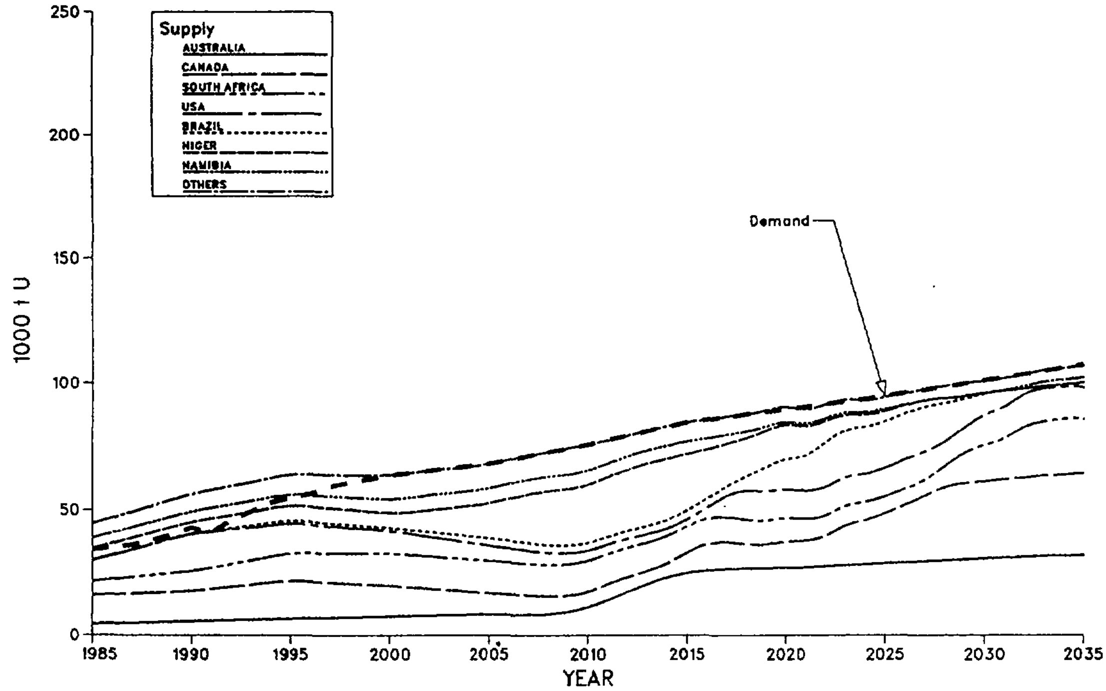

FIGURE 2

Uranium demand for this case grows from 63,500 t in 2000 to 107,500 t U in 2035, or by an average of slightly less than 1.75% per year.

In the year 2000, supplies are modelled to meet the demand of 63,500 t U. As shown in Annex 2, suppliers are divided into two groups, 1) the major suppliers: Australia, Brazil, Canada, Namibia, Niger, South Africa, and the USA, and 2) the other suppliers including Algeria, Argentina, France, Gabon, India, Italy, Portugal, Spain and Turkey. This group is labelled as "others" in Figure 2. The market shares of these groups in the year 2000 is about 85% and 15% respectively.

In 2010, total demand increases to 75,850 t U. The two supplier groups continue to contribute the same share as in the year 2000. The supplies from individual countries, however, increased significantly in the cases of Australia, Brazil, India, and Niger, offsetting decreases mainly by Canada and the USA.

The total demand for the year 2020 is projected to be 89,600 t U. A stronger role of the major suppliers (Australia, Brazil, Canada, Niger, South Africa, USA) is evident. Their share of the total supply grows to 94%, and five suppliers, (Australia, Brazil, Canada, Niger and USA) have a combined market share of 82%. The other three major suppliers, Namibia, Niger and South Africa, decrease their production considerably.

The "others" group include seven countries (Algeria, Argentina, FRG, India, Italy, Spain and Turkey), with a market share of 7%. Among them, FRG, India and Spain, have production of 1,000 t U or more than 1,000 t U each, and two traditional suppliers, Gabon and Portugal cease their role as uranium producers.

Demand in the year 2030 is projected to reach 100,900 t U. Nearly 95% of this demand is supplied by only five countries (Australia, Brazil, Canada, South Africa and the USA), and the remaining 5% is divided among six countries, led by India and Spain.

In 2035, the final year of this projection, total demand amounts to 107,100 t U. The supply situation continues to be similar to 2030, but with a further concentration of supplies. Four countries (Australia, Canada, South Africa and the USA) are the leading producers with a total of 93% of the total demand, and the remaining 7% of the total are supplied by five countries, Namibia and of the "others", Algeria, France, India and Spain.

In summary, the uranium demand for Case 1 is met through the year 2035 mainly by the major suppliers, whose market share increases from 85% in 2000 to 96% in 2035, with a correspondingly declining share of the other suppliers.

Case 2: The supply demand picture is shown in Figure 3 and the supply-demand data at regular intervals (2000-2035) are summarized in Annex 3.

Total demand between 2000 and 2035 increases from 63,500 to 226,500 t U, or by an average increase of slightly over 3.5%, about twice the annual increase of Case 1.

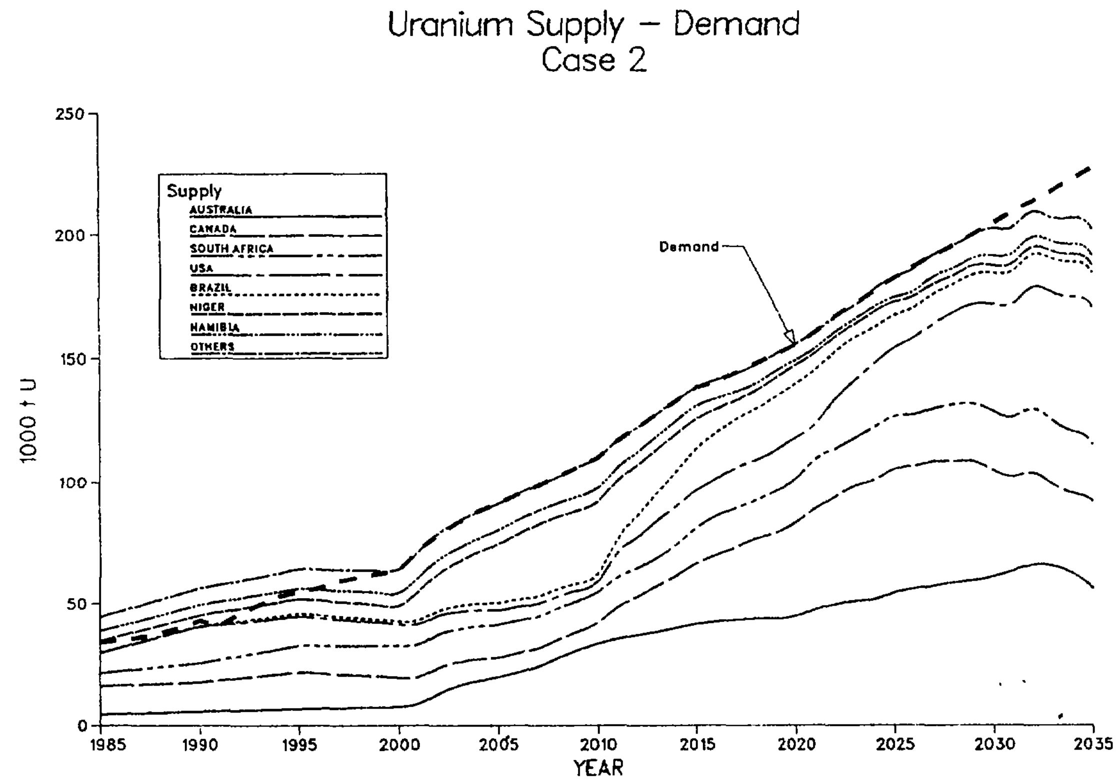

FIGURE 3

In the year 2010, total uranium demand rose to nearly 110,000. The supply to meet this demand is to nearly 90% provided by the major suppliers especially due to large production increase, of 4-5 times, from Australia and Niger. The remaining 10% of the total are supplied by nine countries (Algeria, Argentina, France, FRG, Gabon, India, Portugal, Spain, Turkey), led by France and India.

Through 2020, the demand increased to 155,000 t U, which still can be met by available supplies.

The major suppliers increase their supply to nearly 96% of the total due to significant growth in the production from Australia, Brazil, Canada and the USA. These four countries supply 78% of the total demand. The second supplier group which decreased to seven countries, contribute only 4% of the total market.

In the year 2030, demand rose to about 204,000 t U while total supplies reach only about 202,500 t U, leaving an unfilled demand of 1,500 t U, or equivalent to slightly more than 7% of the total demand.

Through the year 2035, demand further increased to 226,500 t U. Total supply remains in the range of 203,000 t, leaving an unfilled demand of 23,500 t U or over 10% of the total demand of the period 2030-2035. The group of major suppliers continues to have a market share of 95%, although two suppliers (Australia and Canada) decreased their share, offset, however, by increases from Brazil and USA.

The supplies from the "others" are also unchanged. Relatively minor decreases have been compensated by Gabon, which doubled its supply.

The most important result of Case 2 is that supplies fill the high demand only through 2030. The resulting cumulative deficit through 2035 totals about 63,200 t U, or about 5% of the cumulative demand of that period.

Case 3: The supply and data demand for this case are shown in Figure 4 while Annex 4 presents a summary for the years 2000, 2010, 2020, 2030 and 2035.

Uranium Supply – Demand
Case 3

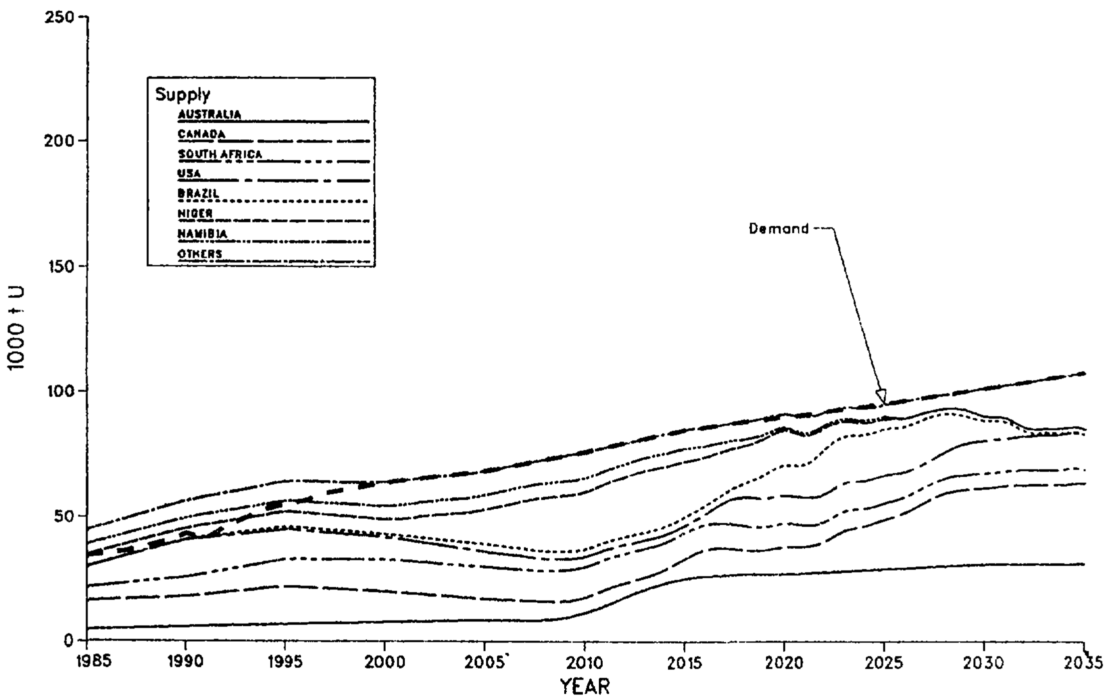

FIGURE 4

The demand for this case is the same as in Case 1, increasing from 63,500 t in 2000 to 107,100 t U in 2035, equivalent to an annual growth of 1.5%.

In 2010, uranium demand reached 75,800 t U and the supplies to meet this demand are mainly provided by the major suppliers, led by Niger. This group contributes a portion of 85% of the total demand, while nine other suppliers (Algeria, Argentina, France, Gabon, India, Italy, Portugal, Spain, Turkey) provide the balance.

In the year 2020, demand amounts to nearly 90,000 t. This demand is met by the two supplier groups: the major suppliers with a share of 95%; and the second group with a share of 5%.

The heavy growth in the major suppliers group is due to large increases from Australia, Brazil, Canada, and the USA, offsetting decreases in supplies from Namibia, Niger and South Africa. In this year, 83% of all the supplies came from only five countries.

Through 2030 uranium demand grows to nearly 101,000 t U, met by available supplies. The major suppliers' share decreased from the 2020 peak to 88%, mainly due to reduced supplies from Brazil, Niger and South Africa and the exhaustion of Namibia resources. Accordingly, the "others" increased their share to 12% of the total supply. This was possible through larger supplies from France and India and additional supplies from the "newcomers" such as Denmark and Pakistan.

In the year 2035, demand has reached over 107,100 t U and is filled by available supplies.

The supply picture, however, has changed, as the majors' share declined to 80% while the "others" took over the balance. The decrease of the supply from the major suppliers stems from Brazil, which ceased supply, leaving five countries with a share of 80%. In the second group, an increase in supplies occurs in the cases of Denmark, France, India, Spain and Sweden, while supplies from Pakistan and Portugal remain unchanged.

Case 4 is shown in Figure 5 and the supply and demand data for the period through 2035 are summarized in Annex 5.

Uranium Supply – Demand
Case 4

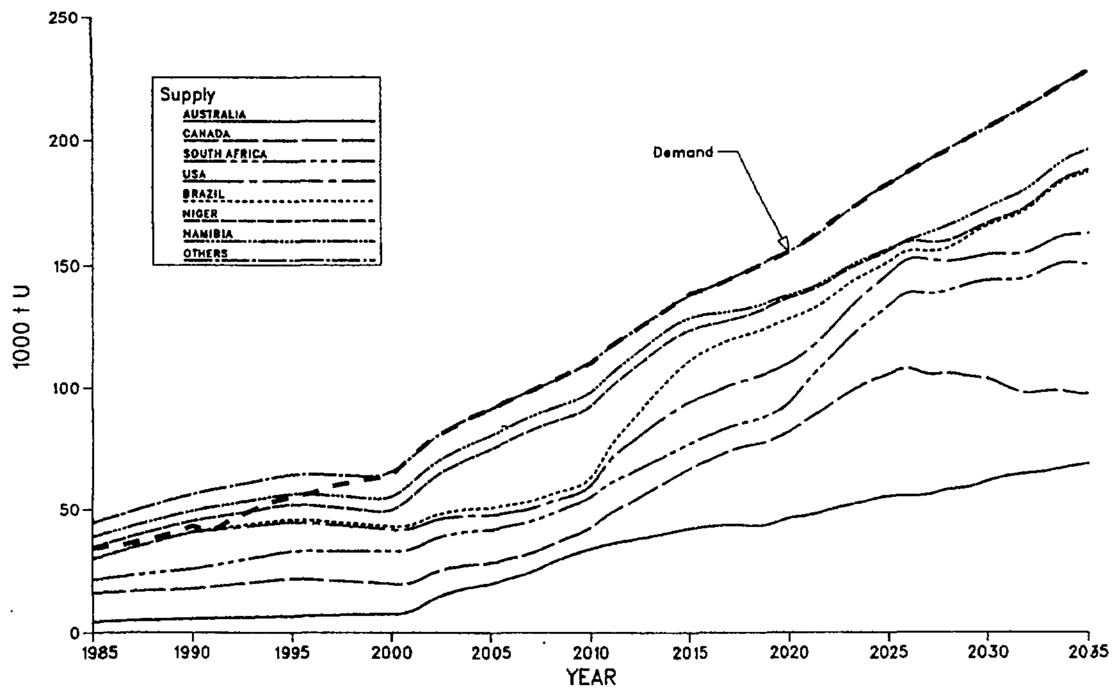

FIGURE 5

Uranium demand for the period 2000 - 2035 increases from 63,500 t in 2000 to 226,500 t U in 2035 as in Case 2 (Table 3).

Between 2000 and 2010, demand is filled by supplies from the major suppliers and the "others", holding a market share of nearly 90% and 10% respectively. Within the major suppliers, Australia and Niger are outstanding with a combined share of more than 50%, and France and India are the main suppliers of the "others" group including nine countries.

In 2020, demand increased to 155,000 t U, supplied in the same ratio 90 : 10 by the groups of major suppliers and "others". Significant increases in supplies occurred in Australia, Brazil, Canada and the USA. Supplies from Niger, which had occupied a prominent role in 2010, decreased.

Demand in 2030 increased to 204,000 t U, is met by the two groups in an unchanged ratio of 90 : 10. Main producers are Australia, Brazil, Canada and South Africa among the major producers, while the "others" are to be led by Spain and India.

The same trend continues in 2035, when demand reaches over 226,000 t U. Major suppliers are Australia, Brazil, Canada and South Africa with a combined share of more than 75%. The "others" group increased to 17 countries, as listed in Annex 5. Main producers within this group are Spain, India, and Mexico.

The main results of Case 4 include, that the high demand growth is met by supplies produced from high resources. The supply situation is stabilized and the majors' share of market range from only 85% to 89%. The balance is supplied a larger number of other countries.

Case 5: This scenario is shown in Figure 6 and the summarized data are included in Annex 6.

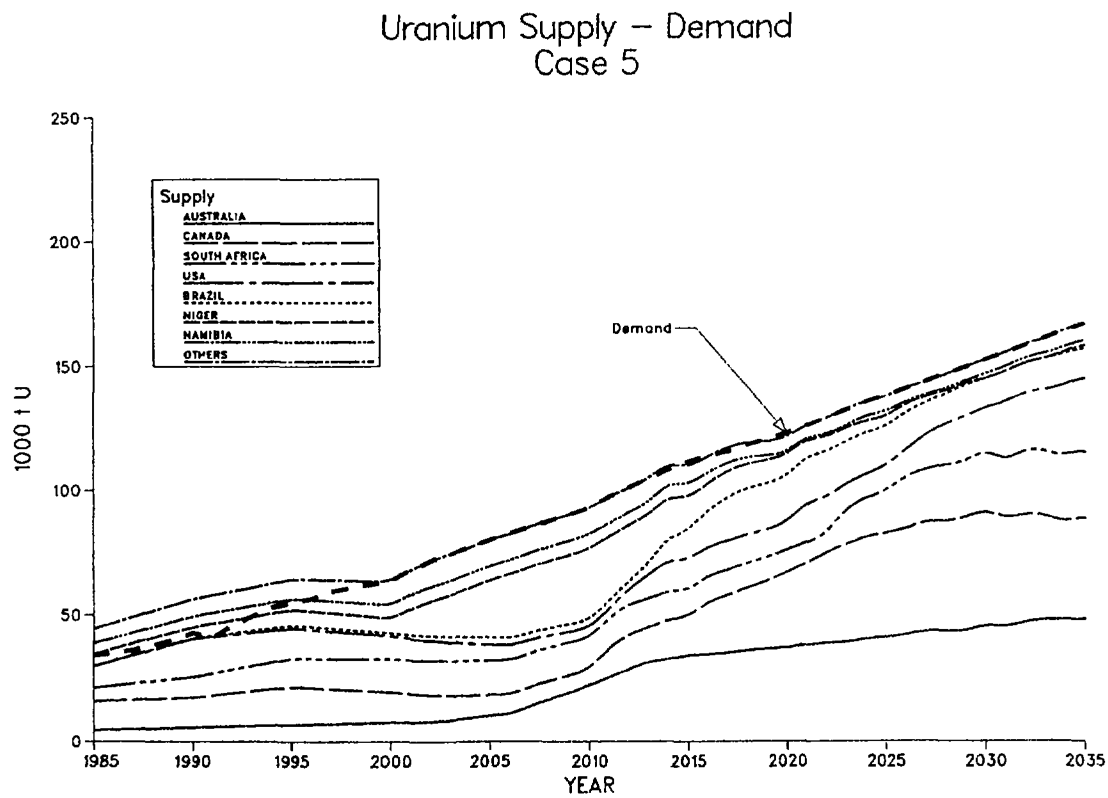

FIGURE 6

Total demand from the mixed reactor strategy (Table 3) increases in the period 2000 to 2035 from 63,500 t to 166,450 t U in 2035, or by an annual average of slightly less than 3%.

Demand in 2010, increased from 63,500 t to 92,650 t U. The supply situation is similar to the one discussed in the previous cases: the major suppliers provide for nearly 89% of the total. Leaders in this group are Niger, Australia and South Africa. These three countries supply more than two thirds of the total demand.

In addition to the group of major suppliers, the "others", including eight countries in 2010, have an aggregated market share of 11%. Significant suppliers in this group are France and India.

Through the year 2020, demand grew to nearly 123,000 t U. Major suppliers provide a larger share than in 2010: 95% compared to 89% in 2010. Countries, which step up their supplies considerably, include Australia, Brazil, Canada, and the USA and force smaller suppliers out of the market: in total the "others" group include now only seven countries, down from eight in 2010.

In 2030, demand reaches over 152,100 t U, which is met largely by the major suppliers which increased their supply to over 96% of the total. Consequently, the "others", in this year including only five supplier countries, reduce their market share to only 4%.

A similar situation occurs in 2035, when the demand of 166,450 t U is met in the same manner as in 2035.

Important results of Case 5 are that the major suppliers continue to dominate the supply field with individual market shares of Australia and Canada being close to the limit of 30% imposed by the model.

Case 6 is shown in Figure 7 and its supply and demand data are summarized in Annex 7.

In the year 2010, the demand of 92,600 t U is met by the major suppliers, which provide for nearly 88% of the total. Niger, Australia and South Africa are the leading producers with a share of nearly 70% of the total. The "others" group, including 9 supplier countries supply about 12%, led by India and Spain.

In 2020, demand increased to 122,800 t U, filled by nearly 95% by the major supplier countries Australia, Brazil and Canada.

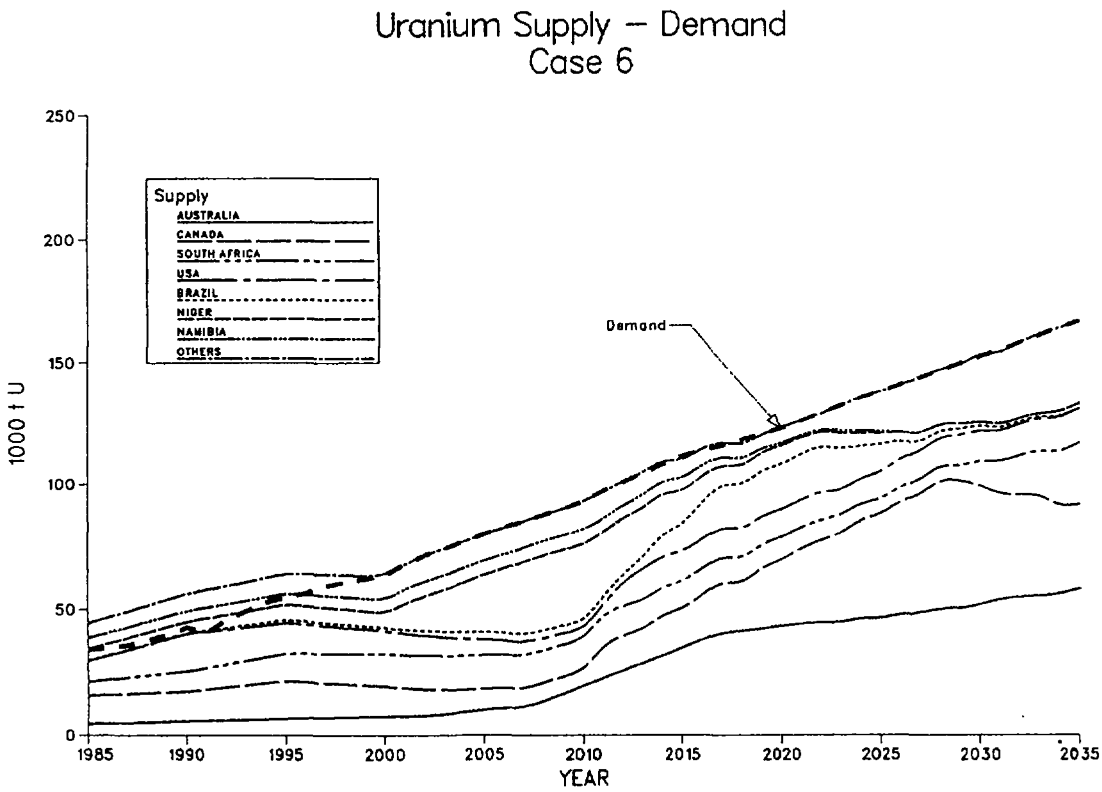

FIGURE 7

In the year 2030, a change in the supply pattern is notable: the demand of over 152,000 t U is filled by the major suppliers, whose share dropped to 82%. The other supplier countries increased their share accordingly with newcomers such as Greece, Mexico, Norway, Pakistan and Zaire, and countries such as Argentina, India, Spain.

In 2035, demand and supplies continue to be in balance. The supply pattern continued the trend outlined above: the market shares of the major suppliers continues to fall, while the "others" increased their supplies. The majors are able to increase supplies, their growth rate, however, is only half of that of demand. This development is offset by the "others", two producer countries of which India and Spain reach significant supply levels of 6,000 and 11,000 t per year respectively.

The supply and demand situation of Case 6 is in general similar to that of the other case. Outstanding, however, is that two countries of the "others" group of suppliers, India and Spain, can provide considerable supplies.

Case 7 is graphically shown in Figure 8 and the data are summarized in Annex 8. This case is considered the more realistic one of all seven scenarios and therefore used as Base Case for the theoretical "could do" supply cases and the sensitivity studies (Table 3).

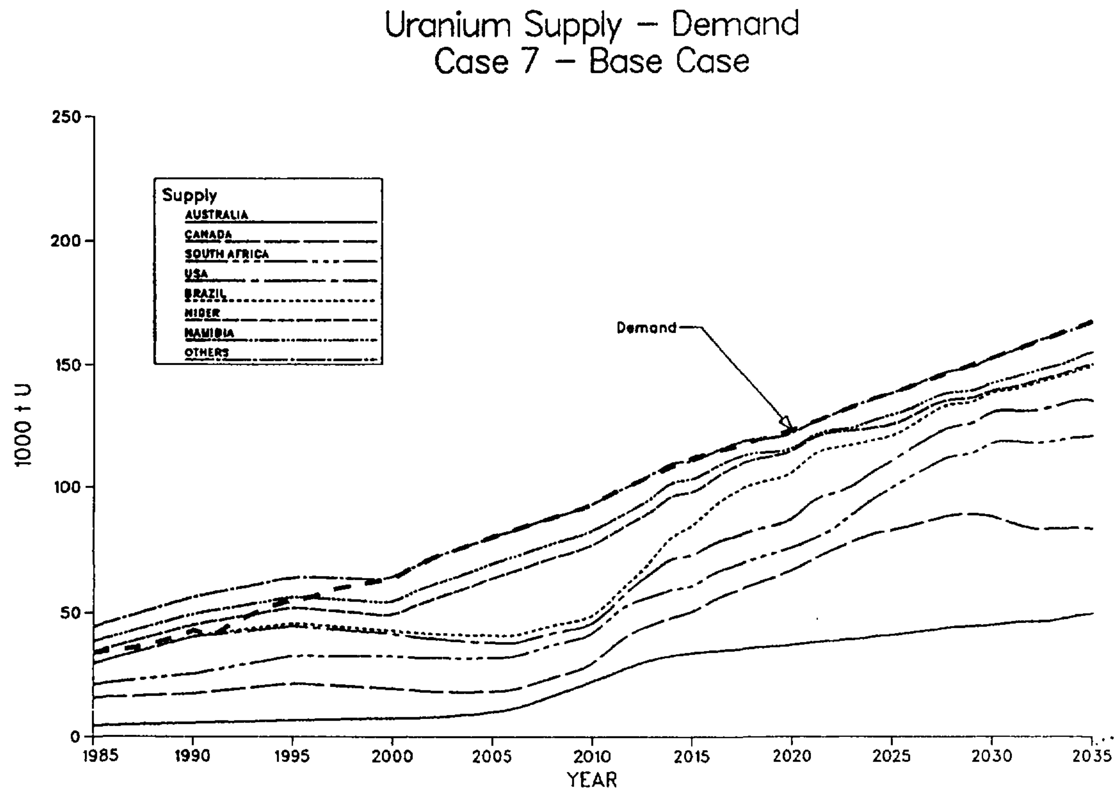

FIGURE 8

<u>In 2010</u>, the ratio of the supply provided by the major producers and the "others" increased to nearly 90 : 10. Main suppliers are Niger and Australia (54%) among the majors and France and India of the second group.

The market share of the two groups in the <u>year 2020</u> changed to a peak of nearly 95 and 5% respectively. Increased supplies came from Australia, Brazil, Canada and the USA.

In the period <u>2030</u> to <u>2035</u> is a slight change in this trend: the major suppliers decrease their share of market slightly to 93%, but five producers supply nearly 90% of the 2035 demand.

The results of the seven supply-demand cases can be summarized as follows:

1. The demand projections of Cases 1, 3, 4, 5, 6 and 7 can be met by supplies from the different resource scenarios.

2. In Case 2, projecting the high demand of the Pu recycling reactor strategy to be filled by low resources, occurs a supply shortage between 2030 and 2035 totalling about 63,000 t or 5% of the cumulative demand of this period.

3. The supplies in all cases are provided by two groups, 1) the major suppliers, Australia, Brazil, Canada, Namibia, Niger, South Africa, USA, with a market share of 80-95%, and 2) the others, including in the case of supplies from low resources Algeria, Argentina, France, FRG, Gabon, India, Italy, Portugal, Spain, Turkey; additional supplier for supplies from high resources countries included Denmark, Greece, Japan, Mexico, Norway, Pakistan, Sweden, UK and Zaire.

8. DISTRIBUTION OF SUPPLIES FOR DEMAND BASE CASE FROM DIFFERENT RESOURCE CATEGORIES

To determine the distribution of the supplies Base Case (Case 7) from the different resource categories (RAR, EAR-I and II, SR), and from production facilities of the different categories (existing, committed, planned and prospective), Case 8 was carried out.

Figure 9 illustrates the supply based on production capability through 2000 and on the fitted demand, through 2035. Total supplies shown consist of three segments, as follows:

A. The lowest segment on Figure 9; committed resources of the RAR and EAR-I categories below $130/kg U to support the production capability of the "B" category fo the Red Book.

B. The middle segment; uncommitted resources in the same resource categories to support projected additional production centres modelled by the RAPP model.

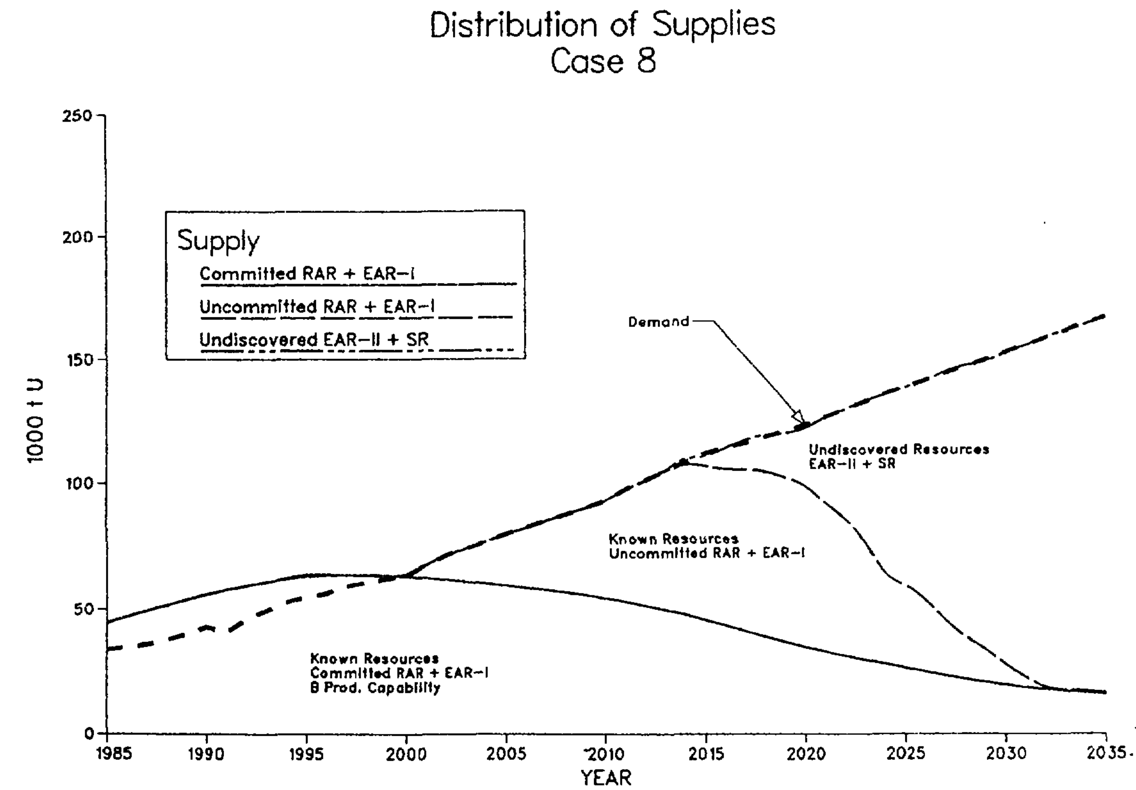

FIGURE 9

C. The upper right hand segment; undiscovered resources (EAR-II) and SR below $130/kg U), to be converted into RAR and EAR-I and used to feed the additional production centres projected by the RAPP model.

Annex 9 provides the data for the three supply classes. Production from committed RAR and EAR-I total about 2.3 million t U, through 2035 for this case, uncommitted RAR and EAR-I total about 1.13 million t U and undiscovered resources about 1.6 million t U.

The following table compares the above production from resources in this case with the Red Book 1986 resource estimates.

In conclusion, the RAR and EAR-I recoverable at costs of below $130/kg U can provide the supplies needed for the scenario of Case 8. Only about 1/6 of EAR-II (-$130/kg U) and the low most favourable quartile SR were needed to meet the Base Case Demand. In fact, the EAR-II (-$130/kg U) alone matches the Base Case Demand.

Table 4

COMPARISON OF RESOURCES PRODUCED IN CASE 8
WITH RED BOOK 1986 ESTIMATES
(Million t U)

TOTAL PRODUCTION BY RESOURCE CATEGORY CASE 8		RESOURCES RED BOOK 1986	
A. From RAR & EAR-I below $130/kg U commited to "B" production capability:	2.3	RAR ($130/kg U):	2.24
B. From RAR & EAR-I below $130/kg U uncommitted to "B" production capability:	1.13	EAR-I (-$130/kg U):	1.30
Total:	3.43	Total:	3.54
C. From EAR-II & SR below $130/kg U undiscovered to support additional productions after conversion		EAR-II ($130/kg U):	1.60
to known resources:	1.60	SR (low m.f.quartile	9.60
Total:	1.60	Total:	11.20

9. THEORETICAL "COULD DO" SUPPLY CASES

These scenarios (Cases 9, 10 and 11) were developed to illustrate the supply situation based on the highest feasible production, subject, however, to the normal constraints of the model. These "could do" cases are not fitted to any demand case, though the results of projections cases are analyzed in relation to the Base Demand Case used in this study, in order to place them into the proper context with a demand scenario. In addition, Cases 9-11 are graphically compared to the High and Low Demand Cases. These studies indicate an upper limit on the supplies that could be developed without regard to demand projection, given the proper economic climate to allow full use of the various $130/kg U resources.

Three "could do" cases (Cases 9, 10 and 11) were projected with the different resource cases: Low Resources, High Resources and the Base Case, low most favourable quartile resources (Table 3).

Figure 10 illustrates these three cases in relation to the demand cases (High Case, Base Case, Low Case) for the period through 2035. Annexes 10-12 provide the supply data from the different suppliers for the years 1990, 2000, 2010, 2020, 2030 and 2035 related to the Base Case Demand.

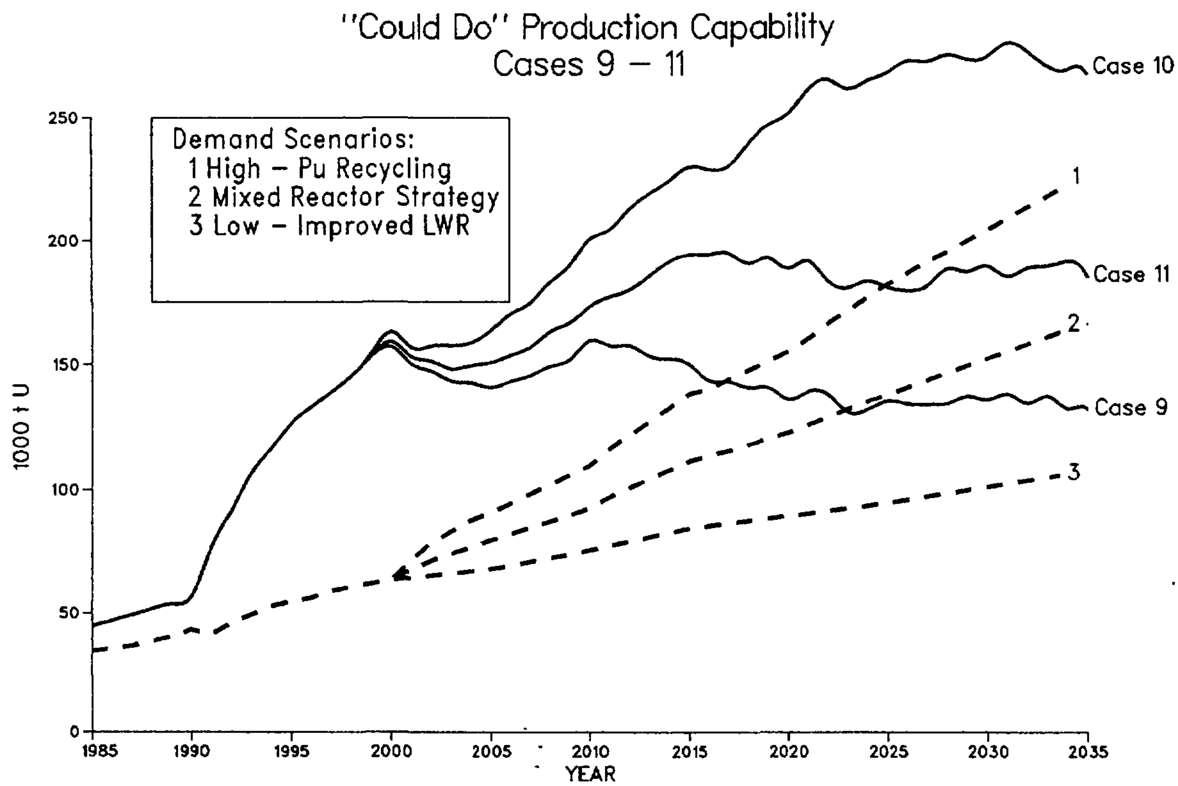

FIGURE 10

The "could do" supply from all cases through 1990 is identical. Total output in 1990 is about 56,000 t U well above the demand of 43,000 t U. Supplier countries include the traditional countries plus Brazil, with a total share of 88%, while the remainder is supplied by the other suppliers, which in 1990 consist of eight countries, led by France and Gabon.

Case 9 (Figure 10, Annex 10) shows total production capability increasing from about 56,200 t U in 1990 to a peak of nearly 160,000 t in 2010, declining then to approximately 134,000 t in 2035. The share of the major group ranges from 88% in 1990 to about 95% in 2020, while the others, consisting of eleven countries produce the balance.

A comparison with the Base Case Demand shows that there is a possible large overcapacity through about 2020 with a peak of nearly 150% of demand in 2000. Beyond 2020 there would be an apparent deficit amounting to 11% of demand in 2030 and 20% in 2035.

As regards the Low and High Demand Cases, Figure 10 shows that Case 9 provides for a continuous oversupply through 2035 for the Low Demand Case, but can fill the High Demand only through about 2017. Case 10 (Figure 10, Annex 11) is based on production from the High Resource Case. Annual production capability ranges from about 56,000 t U in 1990 to a high of over 273,000 t U in 2030 and decreases slightly to 268,000 t U in 2035. Suppliers include the traditional majors with a share decreasing from 92% in 2000 to 78% in 2035 and twenty countries included in "others" with a corresponding market share range. These include a number of new suppliers such as Denmark, Libya, Norway, Pakistan and Zaire.

As Figure 10 and Annex 11 show, Case 10 results in a production capability much in excess of the Base Case Demand. The excess production capacity increases from 30% of demand in 1990 to a maximum of over 150% in 2000 and decreases thereafter to 105% in 2020 and 60% in 2035. A similar situation occurs even for the High Case Demand (Figure 10).

Case 11 shown in Figure 10 and Annex 12 projects future supply from the Base Case (low most favourable quartile) Resources.

The production capability peak is reached in approximately 2030 with nearly 190,00 t U, up from 56,200 t U in 1990. Between 2030 and 2035 a slight decrease occurs to about 186,000 t U. The major suppliers have a market share between 88 and 93%, and the others provide for the remainder, with production from 16 countries.

Compared to the Base Demand Case there would be overcapacity, though smaller than in the Case 10. The production supply peaks at about 2000 with capacity at about 150% of demand and decreases to about 12% above demand in 2035.

In relation to the High Case Demand, Figure 10 indicates that Case 11 can meet this demand until about 2025.

Summary:

1. Cases 10 and 11 based on High Case and the Base Case (low most favourable quartile) Resources (Table 3), could provide a continuous oversupply in relation to the Base Demand Case.

2. Both cases show supply peaks in about 2000 of more than 150% of the demand of that year and decrease through 2035 to 60% above Demand Case 10 and 12% above Demand Case 11 respectively.

3. Case 9 provides oversupplies until about 2020, with a similar peak as in the two previous cases in 2000. An apparent production deficit occurs in the period (2020 - 2035) which amounts to about 11% of demand in 2030 and 20% in 2035.

4. In practice, the apparent deficit will have no impact, as under this scenario large inventories have been built up during the oversupply period through 2020, or alternatively production not needed in the earlier years could be deferred until later.

5. As graphically shown in Figure 10 the resource cases are sufficient to fill much larger demands than needed even for the High Demand Case.

10. SENSITIVITY ANALYSES

To test the reaction of the model and of the conclusions reached to modified input parameters, a number of sensitivity analyses were made using the Case 7 (Base Case Resources and Base Case Demand) supply-demand scenario as baseline. The parameters which were modified include (Table 3):

1. <u>resource development rate</u> by extending the years required to develop the undiscovered uranium resources to reserves.

2. lead times by extending the number of years required to the start of exploration programmes, to first discovery and to production,

3. major uranium supplier countries by eliminating production alternately from Australia, Canada, South Africa and the USA.

4. market share of any major supplier, by lowering the market share any major suplier is allowed to occupy from the 30% used in the Base Case.

5. the resource base through the reduction of resources as would occur with a lower cost category than the Base Case of $130/kg U.

10.1. Resource Development Rate

The Base Case (Case 7) in which a resource development rate (the rate at which Speculative Resources are converted to reserves) of 1 was used, was modified by introducing rates of 2 and 3, which double or triple the resource development of the Base Case. These cases are referred to as Cases 12 and 13 and are shown in Figure 11. Annexes 13 and 14 present the detailed data for 2000, 2010, 2020, 2030 and 2035.

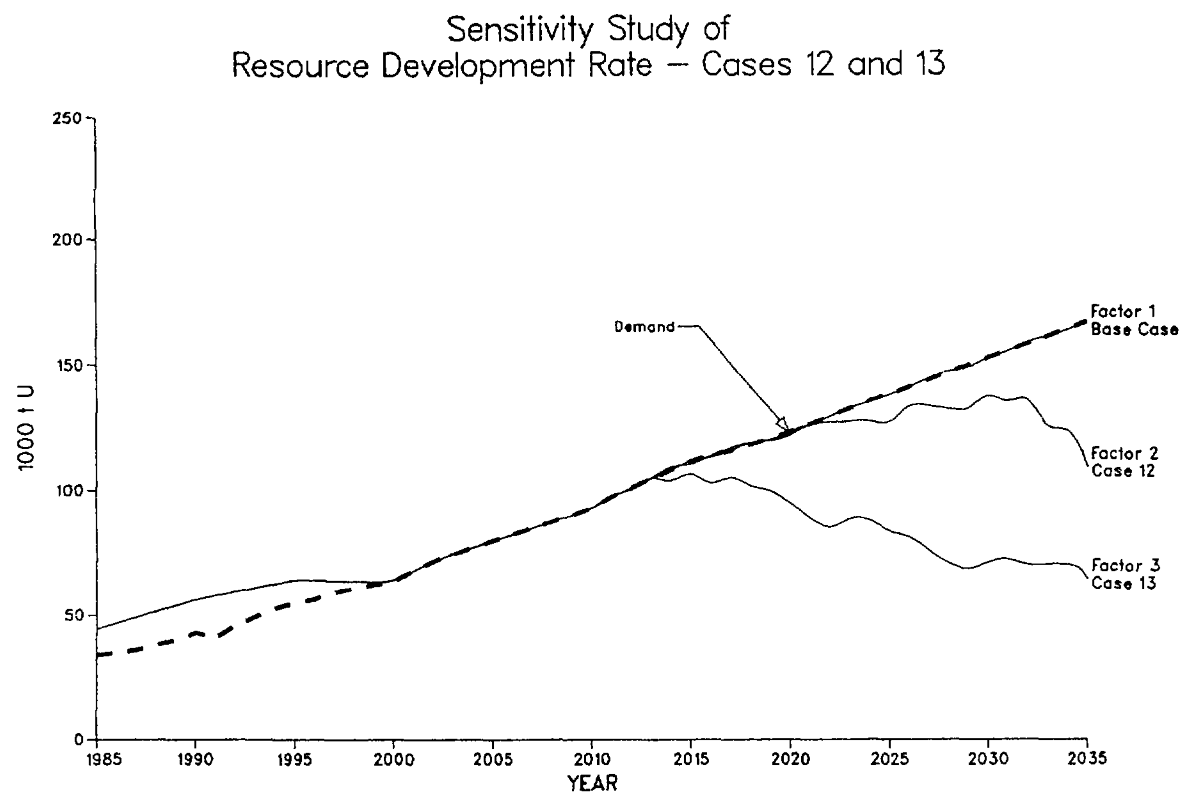

FIGURE 11

Under the assumption that the resource development rate times are extended by the factor 2 (Case 12), the Base Case Demand is filled through 2021 as shown in Figure 10, but would not meet demands afterward. In 2030 the unfilled demand is about 14,300 t U, increasing to nearly 56,000 t U in 2035, equivalent to over 30% of the total demand (Annex 13). The total supply deficit between 2022 and 2035 amounts to 263,000 t U equalling about 8% of the total demand of that period.

Case 13 using factor of 3 shows that demand is filled only through 2013 (Figure 11). In 2020, the unfilled demand is about 24,000 t U (nearly 20% of total demand) in 2035 to over 100,000 t U (60%) as shown in Annex 14. The total supply deficit between 2014 and 2035 reaches more than 1 million t U, equivalent to about 38% of total demand of this period.

Summary:

1. The projection of Case 8 is sensitive to the increases of the resource development rate factor.

2. The effects of a doubling of this factor results in a supply shortfall of about 263,000 t U between 2022 and 2035, or of nearly 20%.

3. A threefold increase of this rate leads to a supply shortage of more than 1 million t U in the period 2014 - 2035, equivalent to about 38% of the total demand of this period.

4. It must be concluded that assumptions about the resource development factor have significant effects on the supply outlook and must be carefully considered. It should be noted that in recent years these rates have tended to increase. The current low level of exploration activity will also extend the time for resource conversion.

10.2. Lead Times

Cases 14 and 15 were run to test the effects of increased lead times, i.e. the time needed to initiate uranium exploration, to the first discovery of uranium mineralization and subsequently to the start of uranium production (Table 3). These cases are again related to the Base Case (Case 7) with the lead time factor 1. In Cases 14 and 15 this factor was 2 and 3 respectively.

Case 14 (Figure 12) shows that the uranium demand through 2035 is filled with supplies despite of the doubled lead times.

Case 15 (Figure 12, Annex 15), however, demand is filled only through about 2014. In the year 2020, the supply gap amounts to about 18,500 t U, equivalent to about 15% of demand. In 2030, it peaks at over 62,000 t U (41% of demand) while in 2035 it decreased to 41,000 t or 25% of the annual demand. Total unfilled demand for the period 2015 - 2035 amounts to some 825,000 t U.

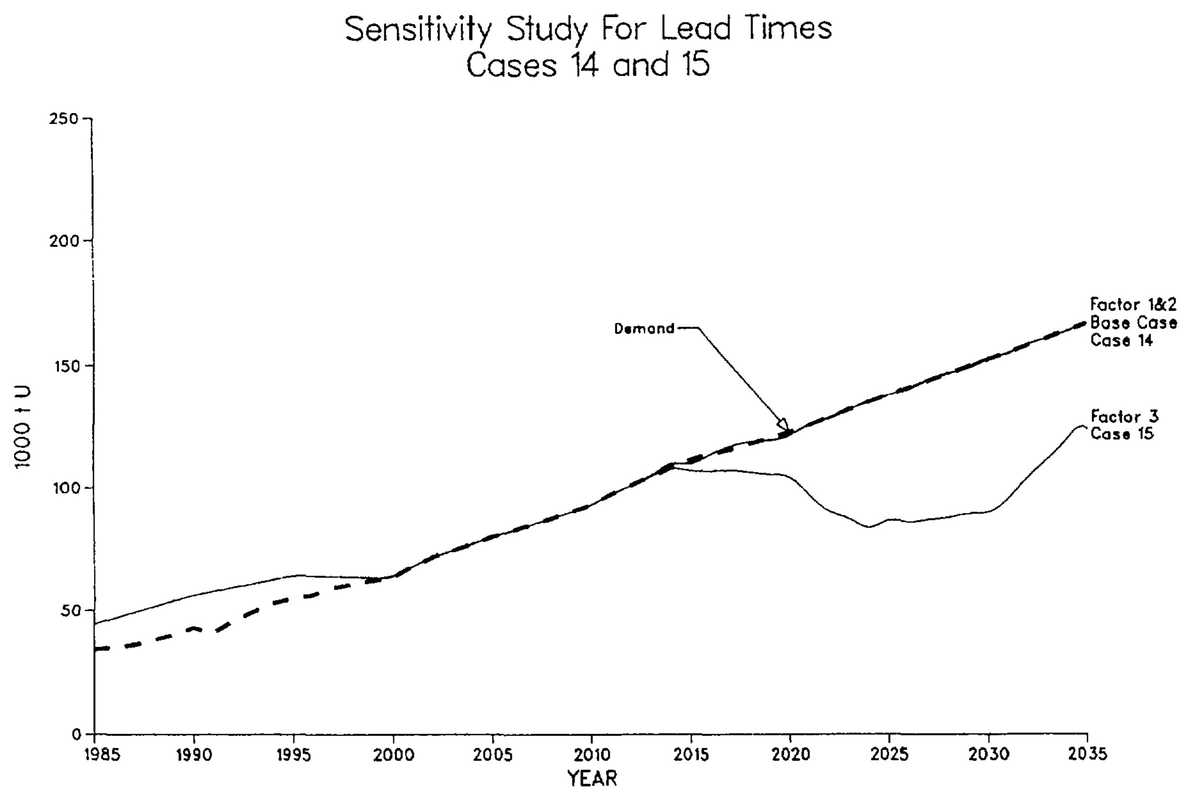

FIGURE 12

Summary:

1. The doubling of total lead times of the Base Case (Case 7) as shown in Case 14 has no effect on the supply within the period through 2035.

2. A threefold increase of the lead times (Case 15), however, shows a significant effect on supply: a shortfall occurs between 2015 and 2035 amounting to some 825,000 t U, or to over 28% of the cumulative demand.

3. The conclusion can be drawn that the increase of the lead times have a lesser effect on the supply projection than the resource development rate factor. The Base Case lead time assumptions would have to increase significantly to affect the findings of this study.

10.3. Major Uranium Supplier Countries

This part of the sensitivity studies reviewed the impact that the elimination of a single major uranium supplier country would have on the supply-demand projection of the Base Case (Table 3).

The Cases 16, 17, 18 and 19, consist of eliminating alternately the four major suppliers, Australia, Canada, South Africa and USA and comparing the remaining supplies to the Base Case Demand.

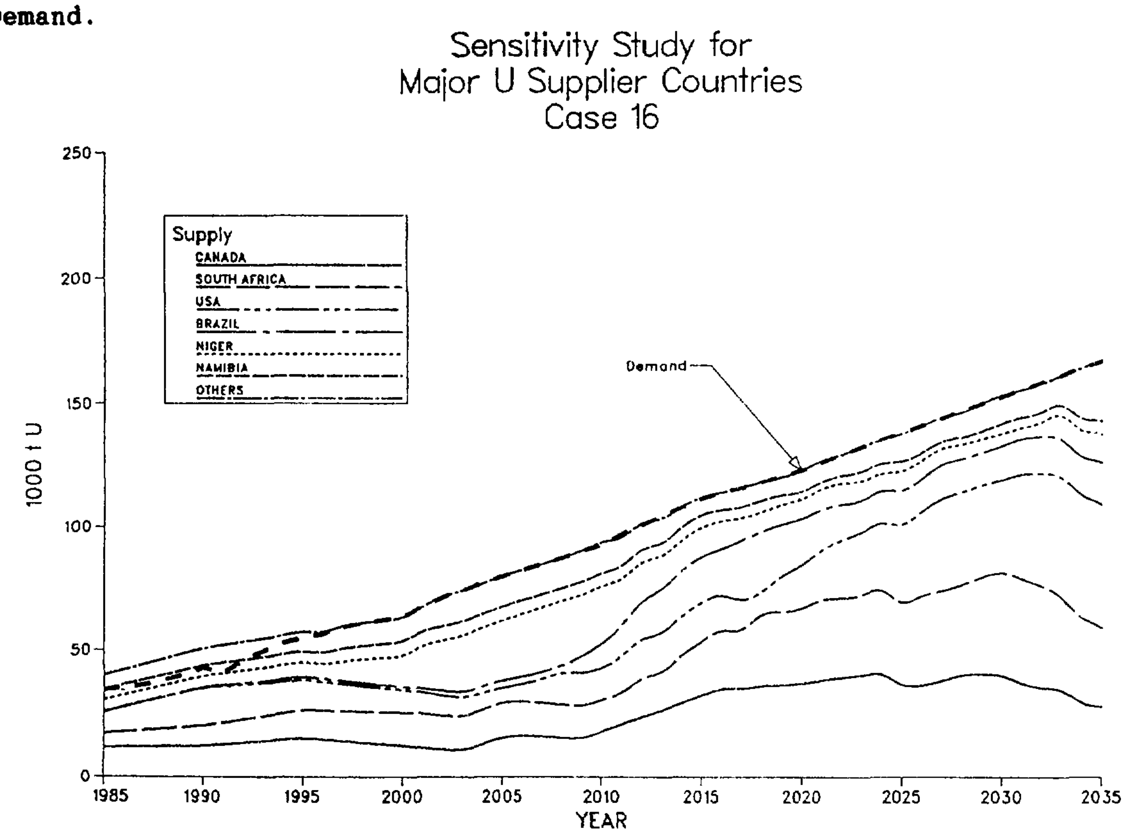

FIGURE 13

Sensitivity Study for
Major U Supplier Countries
Case 17

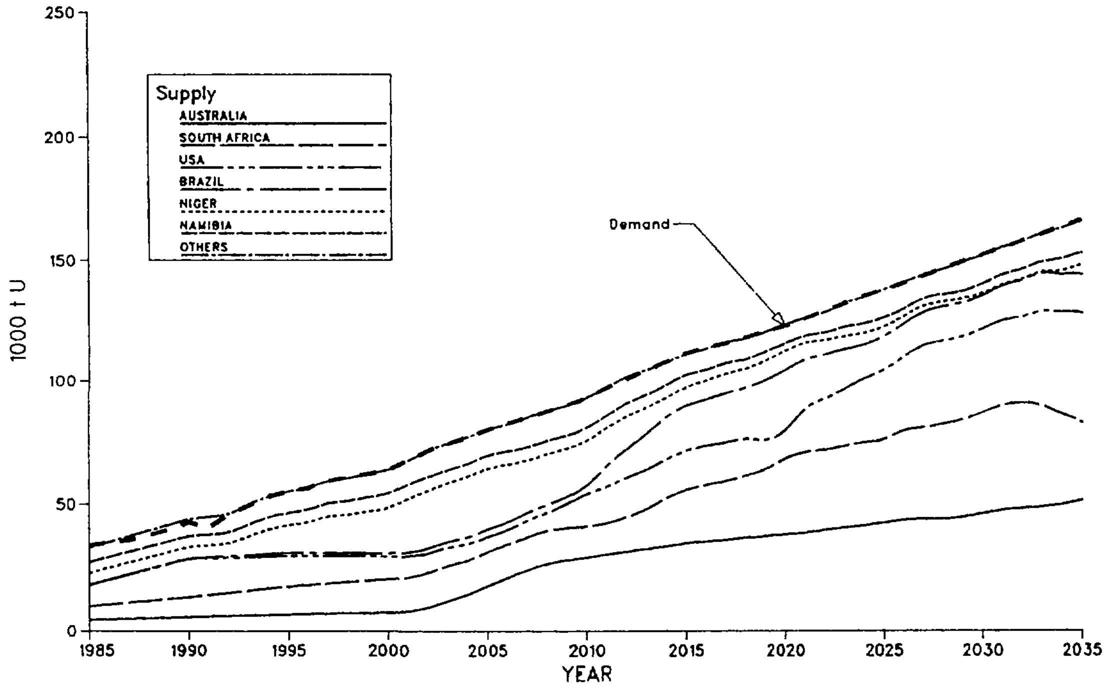

FIGURE 14

Sensitivity Study for
Major U Supplier Countries
Case 18

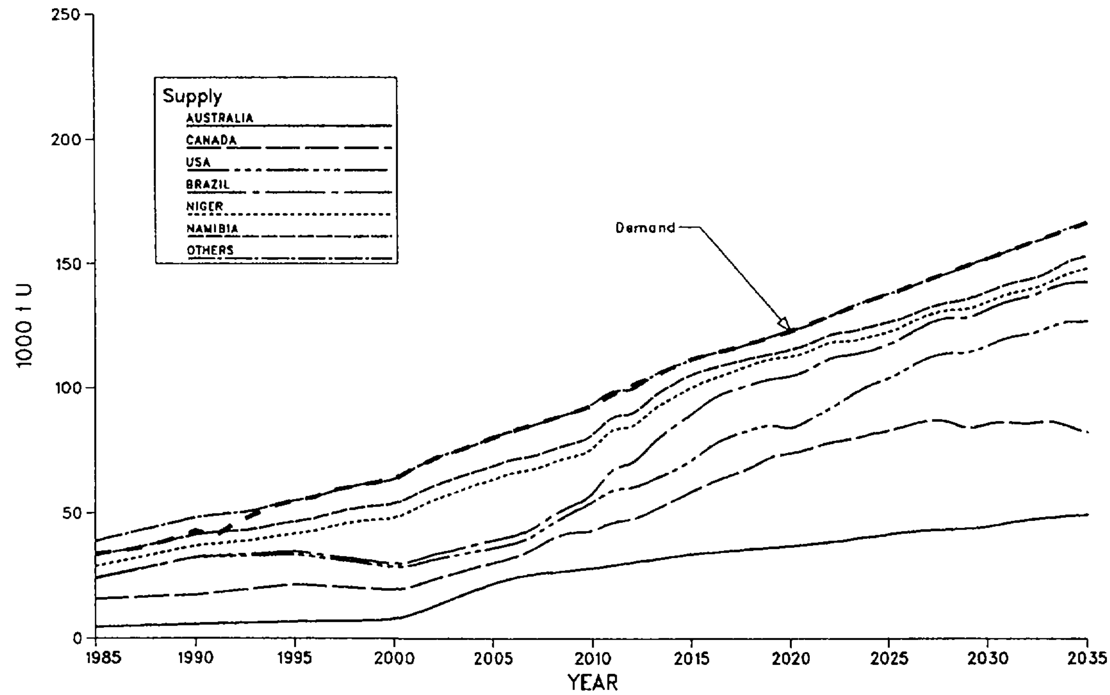

FIGURE 15

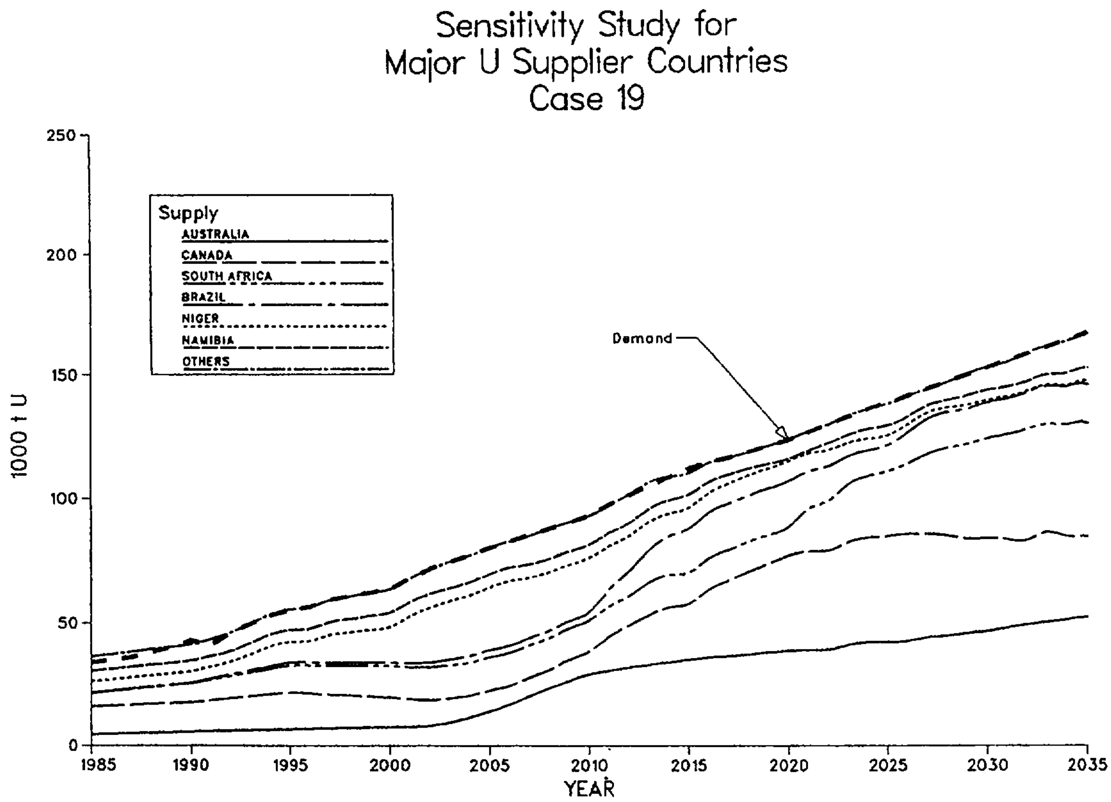

FIGURE 16

Figures 13 - 16 illustrate the supply-demand picture over the period 1985 through 2035. As shown, the lack of the supplies from any of the four major producers does not cause any supply shortages based on the Base Demand Case through 2035. In all four cases, other suppliers are flexible enough to increase their supplies to offset the loss of some supplies of a single major producer.

10.4. Market Share

In the supply-demand scenarios, Cases 1-7, a maximum allowable market share of any supplier country of 30% was used. Sensitivity Cases 20 and 21 were run using maximum market shares of 15 and 12% respectively to test the impact of the modified market share on the supply situation in relation to the demand Base Demand Case (Table 3). These two cases are illustrated in Figures 17 and 18.

As shown in Figure 17 the 15% share of market limit has no impact on the supply of Base Case Demand through 2035. The share of the seven major producers increases from about 87% in 2000 and

Sensitivity of Market Share
Case 20

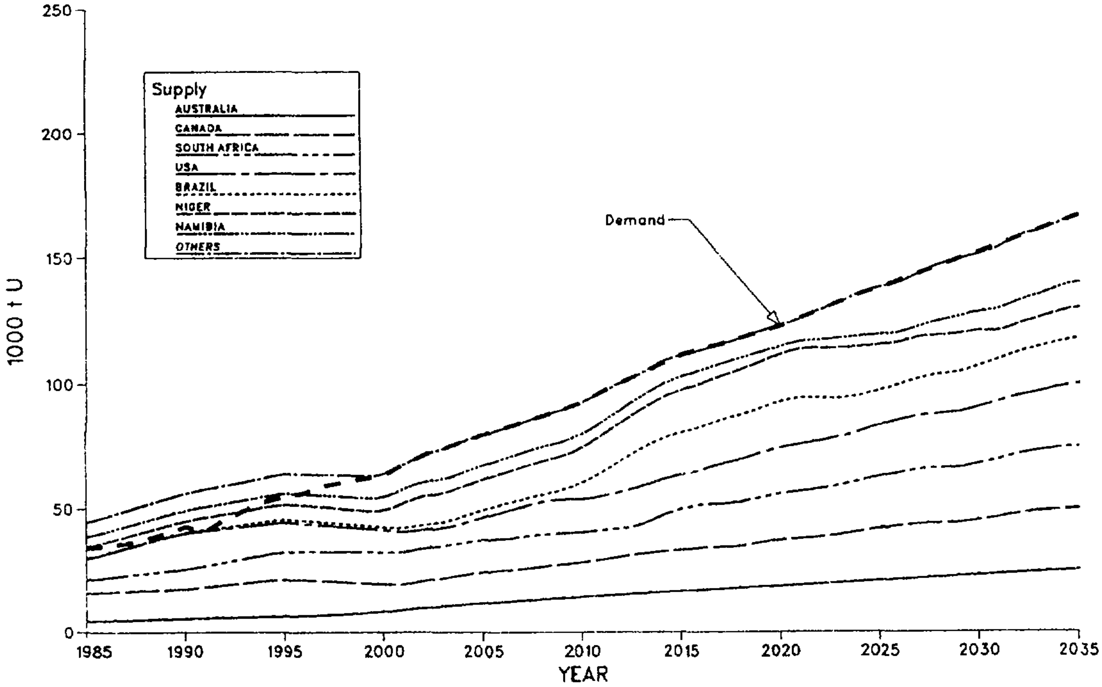

FIGURE 17

Sensitivity of Market Share
Case 21

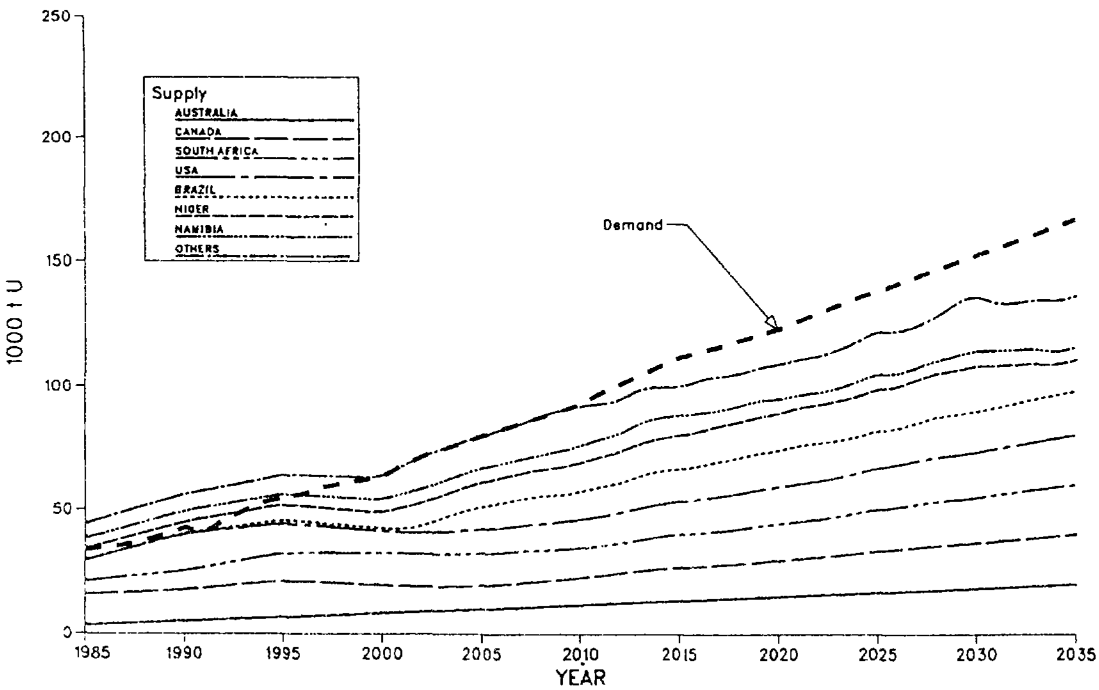

FIGURE 18

reaches a peak in about 2020 with 93% but falls thereafter to 84% through 2035. This means the other suppliers' share decreases from 13% in 2000 to 7% in 2020 and grows to 16% in 2035.

To better determine the point at which a supply deficit would occur, a 12% maximum market share of each supplier was examined in Case 21 (Figure 18). As shown, this scenario meets demand only until 2010. The cumulative supply deficit (2011 - 2035) totals about 400,000 t U, or 12% of the total demand of this period.

Summary

1. With a limitation of the market shares of the individual supplier countries of 15 and 12% production could still meet the projected Base Case Demand through 2035.

2. With the lowering of the maximum market share of any single supplier to 12%, a supply gap occurs between 2011 and 2035, of about 12% of the total demand.

3. The lowest market share for each supplier, at which demand is still filled, lies somewhere between 12 and 15%. As these levels are quite low such types of restrictions are not likely to affect the adequacy on supplies.

10.5. Reduction of the Resource Base through the Decrease of Cost Category

The supply-demand cases as well as the other studies were carried out using resources of the \$130/kg U cost category. As the present market price averages lie well below this point and are likely to be so for some time, a test was made on the sensitivity of a lower cost category on the availability of supplies in the market place (Table 3).

For this study, available low cost resource estimates from the Red Book for the RAR and EAR-I categories recoverable at the cost level \$80/kg U were used. For the undiscovered resources (EAR-II and SR) exist only incomplete information on the lower cost resources category. To approximate a lower base for the undiscovered resources the resource development rate factor was increased to 2 and 4 respectively, assuming that the effect would be that only 50% or 25% of the undiscovered resources would be discovered within the time frame of this projection, and that these portions would in effect approximate the $80/kg U cost category of both EAR-II and SR.

These exercises were carried out as Cases 22 and 23, using the following parameters (Table 3).

A. RAR + EAR-I (-80/kg U)

B. Resource Development Rate of 2 (Case 22) and 4 (Case 23)

C. Base Case Resources (low most favourable quartile SR)

D. Base Demand Case

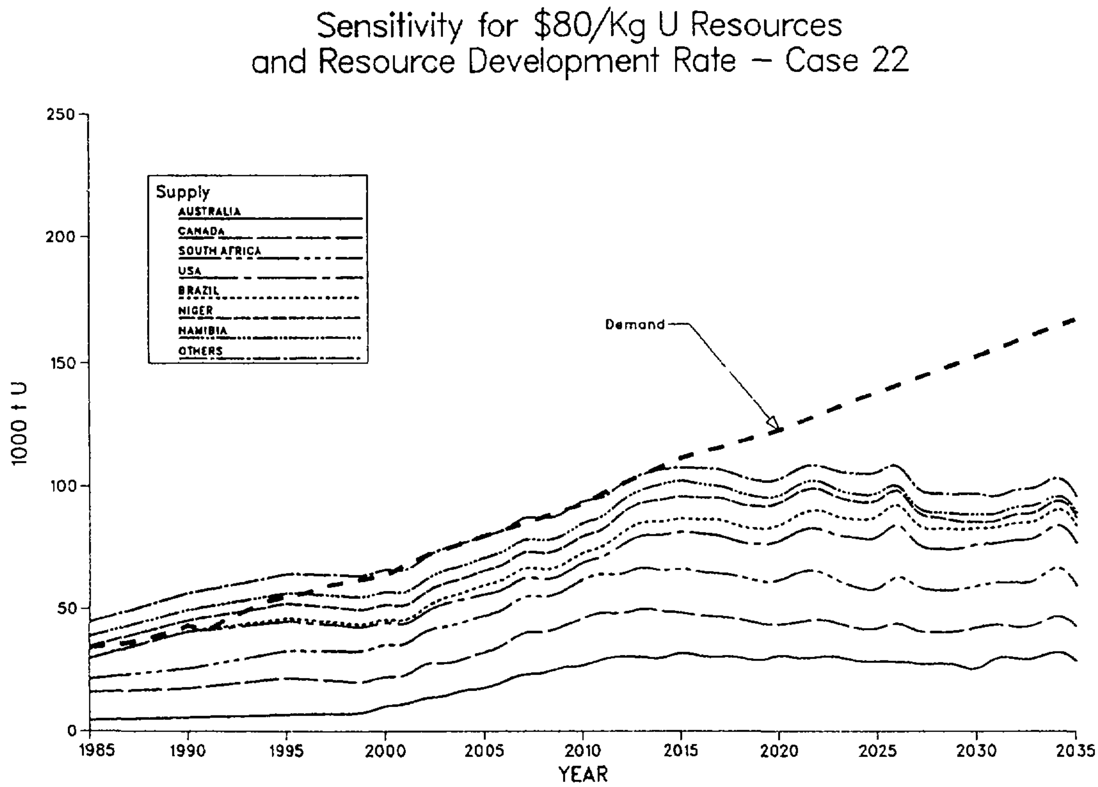

FIGURE 19

Figure 19 illustrates the supply-demand situation through 2035 and Annex 16 summarizes the supply-demand data for the reference years for Case 22. Supplies continue to meet demand through 2013.

Sensitivity for $80/Kg U Resources
and Resource Development Rate – Case 23

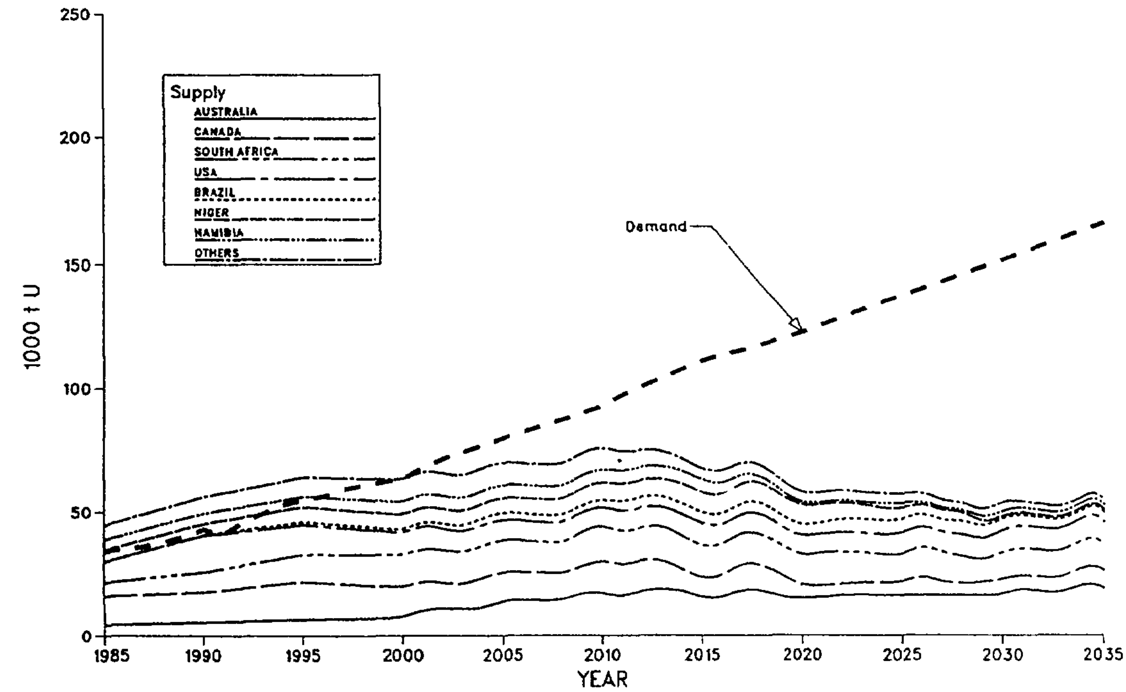

FIGURE 20

The subsequent gap, through 2035, totals about 750,000 t U or 25% of the cumulative demand of the period 2014 through 2035. As seen in Annex 16 supplies from the major supplier countries are reduced when compared to the cases using the $130/kg U resources. Australia's annual production barely exceeding 30,000 t U in 2020 compared to nearly 37,000 t in Case 8.

Case 23 is shown in Figure 20 and Annex 17. Due to the even more limited undiscovered resource base, supplies of both supplier groups decrease significantly in comparison to the Case 22. Supplies are projected to meet the Base Demand only through 1999. Thereafter through 2035 supplies are decreasing and cause a widening supply gap. The total undersupply between 2000 and 2035 amounts to nearly 1.9 million t U, or 45% of the cumulative demand.

Summary:

1. The Cases 22 and 23 shows that the reduction of the resource base to a below $80 cost category is significant: as Case 22 shows (Figure 18), suppliers meet demand until 2013. The supply deficit

between 2014 and 2035 amounts to about 0.75 million t U or 25% of the cumulative demand.

2. In Case 23, supply meets demand only until 1999 and the resulting supply deficit through 2035 totals 1.9 million t U or 45% of the cumulative demand.

3. The findings of these studies are very sensitive to the level of resources assessed. If the current estimates are incorrect - under or over estimated - the conclusions would be significantly different. If prices remain low for an extended time and only low cost resources are of interest for the market place the situation will be significantly different with much less supply available.

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12. GLOSSARY

<u>Geologic Types of Uranium Deposits:</u> The major uranium resources of the world can be assigned on the basis of their geological setting to the following types:

1. Sandstone deposits;
2. Bedded deposits;
3. Vein;
4. Disseminated magmatic, pegmatitic and contact deposits in igneous and metamorphic rocks;
5. Surficial deposits;
6. Quartz-pebble conglomerate deposits;
7. Unconformity-related deposits;
8. Other types of deposits;
9. Phosphate (Primary)

The main features of these deposits are described below:

1. Sandstone deposits

Most of the ore deposits of this type are contained in rocks that were deposited under fluvial or marginal marine conditions. Lacustrine and eolian sandstones are also mineralized, but uranium deposits are much less common in these rocks. The host rocks are almost always medium to coarse grained poorly sorted sandstones containing pyrite and organic matter of plant origin. The sediments are commonly associated with tuffs. Unoxidized deposits of this type consist of pitchblende and coffinite in arkosic and quartzitic sandstones. Upon weathering, secondary minerals such as carnotite, tuyamunite and uranophane are formed.

The Tertiary, Jurassic and Triassic sandstones of the western cordillera of the United States account for most of the uranium production in that country. Cretaceous and Permian sandstones are important host rocks in Argentina. Other important uranium deposits are found in Carboniferous deltaic sandstones in Niger; in Permian lacustrine siltstones in France; and in Permian sandstones of the Alpine region. The deposits in Precambrian marginal marine sandstones in Gabon have also been classified as sandstone deposits by some authors.

2. Bedded deposits

The Proterozoic bedded Olympic Dam U-Cu-Au deposit of Australia is classified under this heading awaiting a type definition of its own.

3. Vein deposits

The vein deposits of uranium are those in which uranium minerals fill cavities such as cracks, fissures, pore spaces, breccias and stockworks. The dimensions of the openings have a wide range, from the massive veins of pitchblende at Jachymov, Skinkolobwe and Port Radium to the narrow pitchblende filled cracks, faults and fissures in some of the ore bodies in Europe, Canada and Australia.

4. Disseminated magmatic, pegmatitic and contact deposits in igneous and metamorphic rocks

The deposits included in this grouping are those associated with granites, magmatities, syenites, pegmatites, carbonatites and volcanic rocks.

The largest known deposit in this grouping is Rössing, in Namibia, which is associated with pegmatitic granite and alaskite.

5. Surficial deposits

Uraniferous surficial deposits may be broadly defined as uraniferous sediments, usually of Tertiary to Recent age which have not been subjected to deep burial and may or may not have been calcified to some degree. The uranium deposits, associated with calcrete, which occur in Australia, Namibia and Somalia in semi-arid areas where water movement is chiefly subterranean, as well as the "young organic-sediment uranium deposits" associated with peat containing formations in North America and Scandinavia are included in this type.

6. Quartz-pebble conglomerate deposits

Known quartz-pebble conglomerate ores are restricted to a specific period of geologic time. They occur in basal Lower Proterozoic beds unconformably situated above Archaean basement rocks composed of granitic and metamorphic strata. Commercial deposits are located in Canada and South Africa, and sub-economic occurrences are reported in Brazil.

7. Unconformity-related deposits

Deposits of the unconformity-related type occur spatially close to major erosional unconformities. Such deposits most commonly developed during a generally worldwide orogenic period about 1,800 - 1,600 my ago. They are represented by the ore bodies at Cluff Lake, Key Lake and Rabbit Lake in northern Saskatchewan, Canada, and those in the Alligator Rivers area in northern Australia.

8. Other types of deposits

Included in this grouping are deposits that cannot readily be classified with the ore types already mentioned. These include uranium deposits which occur in limestone and limestone karst terrain as phosphatized fractions of the limestone. Uranium which occurs at low concentrations in marine phosphorite, bituminous shales and lignites is also included here.

9. Phosphate (Primary)

This type includes for example the Uraniferous Phosphate Province of Itataia, with the Itataia deposit. Uranium mineralization occurs in a brownish-red phosphatic rock, referred to as collophanite, which accounts for more than 80% of the mineralogical content of the host rock.

<u>LWR ("Light Water Reactor")</u>: A nuclear reactor that used water as the primary coolant and moderator. This reactor type includes two types of commercial LWRs: the BWR ("Boiling Water Reactor") and the PWR ("Pressurized Water Reactor").

<u>Most favourable quartile</u>: applied to Speculative Resources, is that 25% portion of the resource range in which it is judged most likely by the estimator that the true resource value lies.

<u>Production Capability</u>: Production Capability refers to an estimate of the maximum level of production that could be practically and realistically achieved under favourable circumstances from the plant and facilities at any of the types of production centres described below, given the nature of the resources tributary to them.

Projections of production capability are supported only by RAR and/or EAR-I recoverable at up to $130/kg U.

The OECD(NEA)/IAEA report "Uranium Resources, Production and Demand", 1986 [9], distinguishes between "Production Capability A and B", and defines them as follows: "A." refers to the production capability from "existed and committed production centres" (see under "Production Centre") and "B." refers to the production capability from "existing, committed, planned and prospective production centres".

<u>Production Centres:</u> A <u>PRODUCTION CENTRE</u>, is a production unit consisting of one or more ore processing plants, one or more associated mines and the resources that are tributary to them. For the purpose of describing production centres, they have been divided into the following four classes;

(i) <u>EXISTING Production Centres</u> are those that currently exist in operational condition and include those plants which are closed down but which could be readily brought back into operation.

(ii) COMMITTED Production Centres are those that are either under construction or are firmly committed for construction.

(iii) PLANNED Production Centres are those that are planned, based on feasibility studies that are either completed or underway, but for which construction commitments have not yet been made. This class also includes those plants that are closed which would require substantial expenditures to bring them back into operation.

(iv) PROSPECTIVE Production Centres are those that could be supported by tributary RAR and EAR-I, i.e. "known resources", but for which construction plans have not yet been made.

Pu: Chemical symbol for Plutonium, a heavy fissionable, radioactive metallic element. It can be produced as a by-product of the fission reaction in a uranium-fueled nuclear reactor and can be recovered for use in advanced reactor types.

Reserves: For the purpose of this report, reserves are mineable resources. The discovery of which has been simulated by the RAPP 3 model. Reserves are equivalent to low cost cost RAR.

Resources: Refer to "Uranium Resource Categories"

Resource Cost Categories: The cost categories used at present are: up to \$80/kg U, \$80 to \$130/kg U and \$130 to \$260/kg U.

For the estimation of production costs assigning resources within these cost categories, the following cost items are included:

- the direct costs of mining, transporting and processing the uranium ore;

- the costs of associated environmental and waste management;

- the costs of maintaining non-operating production units where applicable;

- in the case of ongoing projects, those capital costs which remain unamortized;

- the capital cost of providing new production units where applicable including the cost of financing;

- indirect costs such as office overheads, taxes and royalties where applicable;

- future exploration and development costs wherever required for further ore delineation to the stage where it is ready to be mined.

Sunk costs were not normally taken into consideration.

Uranium Resource Categories: Reasonably Assured Resources (RAR) refers to uranium that occurs in known mineral deposits of such size, grade and configuration that it could be recovered within the given production cost ranges, with currently proven mining and processing technology. Estimates of tonnage and grade are based on specific sample data and measurements of the deposits and on knowledge of deposit characteristics. Reasonably Assured Resources have a high assurance existence.

Estimated Additional Resources - Category I (EAR-I) refers to uranium in addition to RAR that is expected to occur, mostly on the basis of direct geological evidence, in extensions of well-explored deposits, and in deposits in which geological continuity has been established but where specific data and measurements of the deposits and knowledge of the deposits' characteristics are considered to be inadequate to classify the resource as RAR. Such deposits can be delineated and the uranium subsequently recovered, all within the given cost ranges. Estimates of tonnage and grade are based on such sampling as is available and on knowledge of the deposit characteristics as determined in the best known parts of the deposit or in similar deposits. Less reliance can be placed on the estimates in this category than on those for RAR.

Reasonably Assured Resources and Estimated Additional Resources - Category I are also referred to as "known resources".

Estimated Additional Resources - Category II (EAR-II) refers to uranium in addition to EAR-I that is expected to occur in deposits believed to exist in well-defined geological trends or areas of mineralization with known deposits. Such deposits can be discovered, delineated and the uranium subsequently recovered, all within the given cost ranges. Estimates of tonnage and grade are based primarily on knowledge of deposit characteristics in known deposits within the respective trends or areas and on such sampling, geological, geophysical or geochemical evidence as may be available. Less reliance can be placed on the estimates in this category than on those for EAR-I.

Speculative Resources (SR) refers to uranium, in addition to Estimated Additional Resources - Category II, that is thought to exist mostly on the basis of indirect evidence and geological extrapolations, in deposits discoverable with existing exploration techniques. The location of deposits envisaged in this category could generally be specified only as being somewhere within a given region or geological trend. As the term implies, the existence and size of such resources are highly speculative.

Estimated Additional Resources - Category II and Speculative Resources are also referred to as "undiscovered resources".

WOCA: World Outside Centrally Planned Economies Area.

Annex 1

Computation of Reactor-Related Demand

1. Improved LWR Strategy, Low Case Demand (t U)

1985	39000	40000	41000	43000	45000	48000	46000	51000	52000	53000	RCTR DEMAND
	-5000	-5000	-5000	-5000	-5000	-5000	-5000	-5000	-2500	0	TO STOCK
	34000	35000	36000	38000	40000	43000	41000	46000	49500	53000	TOTAL DEMAND
130000	125000	120000	115000	110000	105000	100000	95000	90000	87500	87500	CUMM. STOCK
	321	300	280	256	233	208	207	176	168	165	percent demand

1995	55000	56400	57800	59200	60600	62000	62920	63840	64760	65680	RCTR DEMAND
	0	0	1500	1500	1500	1500	1500	1500	1500	1500	TO STOCK
	55000	56400	59300	60700	62100	63500	64420	65340	66260	67180	TOTAL DEMAND
87500	87500	87500	89000	90500	92000	93500	95000	96500	98000	99500	CUMM. STOCK
	159	155	154	153	152	151	151	151	151	151	percent demand

2005	66600	68000	69400	70800	72200	73600	75340	77080	78820	80560	RCTR DEMAND
	1500	1500	1750	2000	2000	2250	2250	2250	2250	2250	TO STOCK
	68100	69500	71150	72800	74200	75850	77590	79330	81070	82810	TOTAL DEMAND
99500	101000	102500	104250	106250	108250	110500	112750	115000	117250	119500	CUMM.STOCK
	152	151	150	150	150	150	150	149	149	148	percent demand

2015	82300	83360	84420	85480	86540	87600	88680	89760	90840	91920	RCTR DEMAND
	2250	2250	2250	2250	2000	2000	1750	1750	1750	1750	TO STOCK
	84550	85610	86670	87730	88540	89600	90430	91510	92590	93670	TOTAL DEMAND
119500	121750	124000	126250	128500	130500	132500	134250	136000	137750	139500	CUMM. STOCK
	148	149	150	150	151	151	151	152	152	152	percent demand

2025	93000	94240	95480	96720	97960	99200	100440	101680	102920	104160	RCTR DEMAND
	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	TO STOCK
	94750	95990	97230	98470	99710	100950	102190	103430	104670	105910	TOTAL DEMAND
139500	141250	143000	144750	146500	148250	150000	151750	153500	155250	157000	CUMM. STOCK
	152	152	152	151	151	151	151	151	151	151	percent demand

2. Plutonium Recycle Strategy, High Case Demand (tU)

1985	39000	40000	41000	43000	45000	48000	46000	51000	52000	53000	RCTR DEMAND
	-5000	-5000	-5000	-5000	-5000	-5000	-5000	-5000	-2500	0	TO STOCK
	34000	35000	36000	38000	40000	43000	41000	46000	49500	53000	TOTAL DEMAND
130000	125000	120000	115000	110000	105000	100000	95000	90000	87500	87500	CUMM. STOCK
	321	300	280	256	233	208	207	176	168	165	percent demand
1995	55000	56400	57800	59200	60600	62000	66600	71200	75800	80400	RCTR DEMAND
	0	0	1500	1500	1500	1500	5000	7500	7500	7500	TO STOCK
	55000	56400	59300	60700	62100	63500	71600	78700	83300	87900	TOTAL DEMAND
87500	87500	87500	89000	90500	92000	93500	98500	106000	113500	121000	CUMM. STOCK
	159	155	154	153	152	151	148	149	150	150	percent demand
2005	85000	88740	92480	96220	99960	103700	109060	114420	119780	125140	RCTR DEMAND
	6000	6000	6000	6000	6000	6000	7500	7500	7500	7500	TO STOCK
	91000	94740	98480	102220	105960	109700	116560	121920	127280	132640	TOTAL DEMAND
121000	127000	133000	139000	145000	151000	157000	164500	172000	179500	187000	CUMM.STOCK
	149	150	150	151	151	151	151	150	150	149	percent demand
2015	130500	134200	137900	141600	145300	149000	154100	159200	164300	169400	RCTR DEMAND
	7500	6000	6000	6000	6000	6000	6000	7000	7000	7500	TO STOCK
	138000	140200	143900	147600	151300	155000	160100	166200	171300	176900	TOTAL DEMAND
187000	194500	200500	206500	212500	218500	224500	230500	237500	244500	252000	CUMM. STOCK
	149	149	150	150	150	151	150	149	149	149	percent demand
2025	174500	179000	183500	188000	192500	197000	201500	206000	210500	215000	RCTR DEMAND
	7500	7500	7500	7000	7000	7000	7000	7000	7000	7000	TO STOCK
	182000	186500	191000	195000	199500	204000	208500	213000	217500	222000	TOTAL DEMAND
252000	259500	267000	274500	281500	288500	295500	302500	309500	316500	323500	CUMM. STOCK
	149	149	150	150	150	150	150	150	150	150	percent demand

3. Mixed Strategy, Base Case Demand (t U)

1985	39000	40000	41000	43000	45000	48000	46000	51000	52000	53000	RCTR DEMAND
	-5000	-5000	-5000	-5000	-5000	-5000	-5000	-5000	-2500	0	TO STOCK
	34000	35000	36000	38000	40000	43000	41000	46000	49500	53000	TOTAL DEMAND
130000	125000	120000	115000	110000	105000	100000	95000	90000	87500	87500	CUMM. STOCK
	321	300	280	256	233	208	207	176	168	165	percent demand

1995	55000	56400	57800	59200	60600	62000	64760	67520	70280	73040	RCTR DEMAND
	0	0	1500	1500	1500	1500	3000	4000	4000	4000	TO STOCK
	55000	56400	59300	60700	62100	63500	67760	71520	74280	77040	TOTAL DEMAND
87500	87500	87500	89000	90500	92000	93500	96500	100500	104500	108500	CUMM. STOCK
	159	155	154	153	152	151	149	149	149	149	percent demand

2005	75800	78370	80940	83510	86080	88650	92200	95750	99300	102850	RCTR DEMAND
	4000	4000	4000	4000	4000	4000	5000	5000	5000	5000	TO STOCK
	79800	82370	84940	87510	90080	92650	97200	100750	104300	107850	TOTAL DEMAND
108500	112500	116500	120500	124500	128500	132500	137500	142500	147500	152500	CUMM.STOCK
	148	149	149	149	149	149	149	149	149	148	percent demand

2015	106400	108780	111160	113540	115920	118300	121390	124480	127570	130660	RCTR DEMAND
	5000	5000	4500	4500	4500	4500	4500	4500	4500	4500	TO STOCK
	111400	113780	115660	118040	120420	122800	125890	128980	132070	135160	TOTAL DEMAND
152500	157500	162500	167000	171500	176000	180500	185000	189500	194000	198500	CUMM. STOCK
	148	149	150	151	152	153	152	152	152	152	percent demand

2025	133750	136620	139490	142360	145230	148100	150970	153840	156710	159580	RCTR DEMAND
	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	TO STOCK
	137750	140620	143490	146360	149230	152100	154970	157840	160710	163580	TOTAL DEMAND
198500	202500	206500	210500	214500	218500	222500	226500	230500	234500	238500	CUMM. STOCK
	151	151	151	151	150	150	150	150	150	149	percent demand

Annex 2

Summary Table for Case 1

Supply - Demand

Year	2000	2010	2020	2030	2035
Total Demand (t U)	63,500	75,850	89,600	100,950	107,100
Supply (t U)					
a) Major Suppliers					
Australia	7,550	10,400	26,900	30,400	31,900
Brazil	1,250	3,000	12,500	7,500	12,350
Canada	12,100	6,600	11,000	30,500	32,500
Namibia	5,250	5,725	1,000	0	2,000
Niger	6,000	23,000	14,000	200	0
South Africa	13,000	12,500	9,500	15,000	22,000
USA	9,000	4,000	11,000	12,000	12,500
Sub Total a)	54,150	65,220	85,900	95,800	113,250
b) Other Suppliers					
Algeria	1,000	1,000	500	200	500
Argentina	570	650	500	500	0
France	3,900	4,250	0	500	1,000
FRG	0	0	1,000	0	0
Gabon	1,000	1,000	0	0	0
India	1,500	2,500	1,500	1,750	1,150
Italy	238	0	1,500	0	0
Portugal	370	370	0	0	0
Spain	845	845	1,345	1,922	2,085
Turkey	200	200	200	0	0
Sub Total b)	9,623	10,765	6,500	4,872	4,735
Total Supply	63,773	75,985	92,400	100,672	117,985

Annex 3

Summary Table for Case 2

Supply-Demand

YEAR	2000	2010	2020	2030	2035
Total Demand (t U)	63,500	109,700	155,000	204,000	226,500
Supply (t U)					
a) Major Suppliers					
Australia	7,550	33,400	44,400	60,900	56,897
Brazil	1,250	3,000	21,500	12,750	14,000
Canada	12,100	8,600	38,500	43,500	35,500
Namibia	5,250	5,725	2,000	4,000	4,000
Niger	6,000	30,000	7,500	3,000	3,000
South Africa	13,000	12,500	18,000	24,000	24,000
USA	9,000	4,000	17,000	43,000	55,000
Sub Total (t U)	54,150	97,225	118,900	191,150	192,397
b) Other Suppliers					
Algeria	1,000	1,000	500	500	500
Argentina	570	650	500	3,000	3,000
France	3,900	4,200	500	500	500
FRG	0	1,000	500	0	0
Gabon	1,000	1,000	0	1,000	2,000
India	1,500	2,500	2,000	2,750	1,500
Italy	238	0	0	0	0
Libya	0	0	0	1,000	1,000
Portugal	370	370	0	0	0
Spain	845	1,345	2,345	2,422	2,000
Turkey	200	200	200	0	0
Sub Total (t U)	9,623	12,265	6,545	11,172	10,500
Total (t U)	63,773	109,490	125,445	202,322	202,897

Annex 4

Summary Table for Case 3

Supply-Demand

YEAR	2000	2010	2020	2030	2035
Total Demand (t U)	63,500	75,850	89,600	100,950	107,100
Supply (t U)					
a) Major Suppliers					
Australia	7,550	10,400	26,900	30,400	30,900
Brazil	1,250	3,000	12,500	7,500	0
Canada	12,100	6,600	11,000	30,500	32,500
Namibia	5,250	5,725	1,000	0	0
Niger	6,000	23,000	14,000	1,700	2,000
South Africa	13,000	12,500	9,500	6,000	6,000
USA	9,000	4,000	11,000	13,000	14,000
Sub Total (t U)	54,150	65,225	85,900	89,100	85,400
b) Other Suppliers					
Algeria	1,000	1,000	500	0	0
Argentina	570	650	500	500	0
Denmark	0	0	0	500	1,000
France	3,900	3,900	300	1,500	2,000
FRG	0	1,000	0	0	0
Gabon	1,000	1,000	0	0	0
India	1,500	2,500	2,000	5,750	6,000
Italy	238	0	0	0	0
Pakistan	0	0	0	500	500
Portugal	370	370	0	1,500	1,500
Spain	845	845	1,345	422	9,000
Sweden	0	0	0	1,000	1,500
Turkey	200	200	200	0	0
Sub Total (t U)	9,623	11,465	4,845	11,672	21,500
Total (t U)	63,773	76,690	90,745	100,772	106,900

Annex 5

Summary Table for Case 4

Supply-Demand

YEAR	2000	2010	2020	2030	2035
Total Demand (t U)	63,500	109,700	155,000	204,000	226,500
Supply (t U)					
a) Major Suppliers					
Australia	7,550	33,400	46,400	60,900	67,900
Brazil	1,250	3,000	18,500	11,750	24,000
Canada	12,100	8,600	35,000	42,500	28,500
Namibia	5,250	5,725	1,000	6,000	8,000
Niger	6,000	30,000	8,500	1,000	1,000
South Africa	13,000	12,500	11,000	40,000	53,000
USA	9,000	4,000	17,000	10,500	12,500
Sub Total (t U)	54,150	97,225	137,400	172,650	194,900
b) Other Suppliers					
Algeria	1,000	1,000	500	1,000	1,000
Argentina	570	650	1,500	2,500	2,000
Denmark	0	0	0	500	1,000
France	3,900	4,200	1,000	1,000	2,000
FRG	0	1,000	1,000	1,000	1,000
Gabon	1,000	1,000	0	0	0
Greece	0	0	0	500	1,000
India	1,500	2,500	4,500	6,250	5,000
Italy	238	0	0	0	1,000
Japan	0	0	0	0	1,000
Mexico	0	0	500	3,500	4,500
Norway	0	0	500	1,000	500
Pakistan	0	0	0	500	1,000
Portugal	370	370	500	1,500	1,000
Spain	845	1,345	6,845	9,500	5,500
Sweden	0	0	500	500	1,000
Turkey	200	200	200	0	0
United Kingdom	0	0	0	500	1,000
Zaire	0	0	0	1,000	2,000
Sub Total (t U)	9,623	12,265	17,545	30,750	29,500
Total (t U)	63,773	109,490	154,945	203,400	224,400

Annex 6

Summary Table for Case 5

Supply-Demand

YEAR	2000	2010	2020	2030	2035
Total Demand (t U)	63,500	92,650	122,800	152,100	166,450
Supply (t U)					
a) Major Suppliers					
Australia	7,550	22,400	36,900	45,900	47,900
Brazil	1,250	3,000	18,500	11,750	12,000
Canada	12,100	6,600	30,000	45,500	41,000
Namibia	5,250	5,725	1,000	2,000	2,000
Niger	6,000	28,000	9,000	0	1,000
South Africa	13,000	12,500	9,000	24,000	27,000
USA	9,000	4,000	11,000	17,500	29,000
Sub Total (t U)	54,150	82,225	115,400	146,650	159,900
b) Other Suppliers					
Algeria	1,000	1,000	500	500	500
Argentina	570	650	500	0	0
France	3,900	3,900	800	1 500	500
FRG	0	0	1,000	0	0
Gabon	1,000	1,000	0	1,000	2,000
India	1,500	2,500	1,500	1,750	1,000
Italy	238	0	0	0	0
Portugal	370	370	0	0	0
Spain	845	845	1,345	1,900	2,000
Turkey	200	200	200	0	0
Sub Total (t U)	9,623	10,465	5,845	6,650	6,000
Total (t U)	63,773	92,690	121,245	153,300	165,900

Annex 7

Summary Table for Case 6

Supply-Demand

YEAR	2000	2010	2020	2030	2035
Total Demand (t U)	63,500	92,650	122,800	152,100	166,450
Supply (t U)					
a) Major Suppliers					
Australia	7,550	19,900	43,400	51,900	57,900
Brazil	1,250	3,000	18,500	2,250	0
Canada	12,100	6,600	26,000	47,500	33,500
Namibia	5,250	5,725	1,000	0	0
Niger	6,000	30,000	7,500	1,500	2,000
South Africa	13,000	12,500	9,000	10,000	25,000
USA	9,000	4,000	11,000	12,500	14,500
Sub Total (t U)	54,150	81,725	116,400	125,650	132,900
b) Other Suppliers					
Algeria	1,000	1,000	500	1,000	1,000
Argentina	570	650	500	1,500	2,000
Denmark	0	0	500	500	500
France	3,900	4,200	1,000	1,500	1,000
FRG	0	500	500	1,000	1,500
Gabon	1,000	1,000	0	0	0
Greece	0	0	0	500	1,000
India	1,500	2,500	1,500	5,750	6,000
Italy	238	0	0	0	0
Mexico	0	0	0	1,500	2,000
Norway	0	0	0	1,000	1,000
Pakistan	0	0	0	500	1,000
Portugal	370	370	0	1,500	1,500
Spain	845	845	1,345	9,500	11,000
Sweden	0	0	500	1,000	1,000
Turkey	200	200	200	0	0
United Kingdom	0	0	0	500	1,000
Zaire	0	0	0	1,000	2,000
Sub Total (t U)	9,623	11,465	6,045	28,250	33,500
Total (t U)	63,773	93,190	122,445	153,900	166,400

Annex 8

Summary Table for Case 7 ("Base" Case)

Demand-Supply

YEAR	2000	2010	2020	2030	2035
Total Demand (t U)	63,500	92,650	122,800	152,100	166,450
Supply (t U)					
a) Major Suppliers					
Australia	7,550	22,400	36,900	43,900	48,900
Brazil	1,250	3,000	18,500	7,750	14,000
Canada	12,100	6,600	29,500	44,000	34,000
Namibia	5,250	5,725	1,000	3,000	5,000
Niger	6,000	28,000	9,000	1,000	1,000
South Africa	13,000	12,500	9,000	30,000	37,000
USA	9,000	4,000	11,000	12,500	15,000
Sub Total (t U)	54,150	82,225	114,900	142,650	154,900
b) Other Suppliers					
Algeria	1,000	1,000	500	500	1,000
Argentina	570	650	500	1,000	1,000
France	3,900	3,900	1,300	1,500	500
FRG	0	0	1,000	0	0
Gabon	1,000	1,000	0	0	500
Greece	0	0	0	0	500
India	1,500	2,500	1,500	2,750	3,000
Italy	238	0	0	0	0
Mexico	0	0	0	1,500	1 ,500
Norway	0	0	0	5000	500
Portugal	370	370	0	500	1,000
Spain	845	845	1,345	1,900	2,000
Sweden	0	0	0	500	500
Turkey	200	200	200	0	0
United Kingdom	0	0	0	500	500
Sub Total (t U)	9,623	10,465	6,345	11,150	13,000
Total (t U)	63,773	92,690	121,245	153,800	167,900

Annex 9

Summary Table for Case 8

Distribution of Supplies

YEAR	COMMITTED RES (t U)	UNCOMMITTED RES (t U)	UNDISCOVERED RES (t U)	TOTAL RES (t U)
1985	44519	0	0	44519
1986	16859	0	0	46859
1987	49198	0	0	49198
1988	51537	0	0	51537
1989	53876	0	0	53876
1990	56215	0	0	56215
1991	57737	0	0	57737
1992	59259	0	0	59259
1993	60781	0	0	60781
1994	62303	0	0	62303
1995	64063	0	0	64063
1996	63873	0	0	63873
1997	63723	0	0	63723
1998	63573	0	0	63573
1999	63423	0	0	63423
2000	63273	500	0	63773
2001	62429	5475	0	67904
2002	61585	9975	0	71560
2003	60741	13475	0	74216
2004	59897	16975	0	76872
2005	59053	20975	0	80028
2006	58095	23975	0	82070
2007	57375	27475	0	84850
2008	56655	30975	0	87630
2009	55935	33975	0	89910
2010	55215	37475	0	92690
2011	53065	44300	0	97365
2012	51285	49300	0	100585
2013	49505	54800	0	104305
2014	47725	59650	3000	110375
2015	45945	60300	3000	109245
2016	43545	61300	9000	113845
2017	41145	63800	12000	116945
2018	38745	65300	15000	119045
2019	36345	65100	18000	119445
2020	33945	64800	22500	121245
2021	32605	58500	35000	126105
2022	31265	54500	43000	128765
2023	29925	46500	56000	132425
2024	28585	33750	72500	134835
2025	27245	32500	78000	137745
2026	24860	28500	87000	140360
2027	23476	21700	99000	144176
2028	22091	16700	108500	147291
2029	20707	13500	113500	147707
2030	19322	8500	125000	152822
2031	18738	4500	131000	154238
2032	18153	500	140000	158653
2033	17569	500	142500	160569
2034	16985	500	145500	162985
2035	16400	500	150000	166900
Total Res. (t U)	2300368	1131050	1609000	5040418

Annex 10

Summary Table for Case 9

"Could Do" Supply

YEAR	1990	2000	2010	2020	2030	2035
Total Demand (t U)	43,000	63,500	92,650	122,800	152,100	166,450
Supply (t U)						
a) Major Suppliers						
Australia	5,600	35,050	60,900	36,900	35,400	33,400
Brazil	150	16,250	5,000	8,500	11,750	12,000
Canada	12,000	23,600	34,600	27,500	26,000	26,000
Namibia	4,250	5,725	5,250	3,000	3,000	3,000
Niger	4,600	29,000	7,500	8,000	2,000	2,000
South Africa	8,000	13,500	17,000	20,000	18,000	19,000
USA	14,900	21,500	20,500	24,500	29,000	29,000
Sub Total (t U)	49,500	144,625	150,750	128,400	125,150	124,400
b) Other Suppliers						
Algeria	0	1,000	500	500	500	500
Argentina	520	1,070	650	1,000	2,000	2,000
France	3,900	4,200	3,900	500	500	500
FRG	40	1,000	0	0	0	0
Gabon	1,000	1,000	1,000	1,000	1,000	1,000
India	200	2,500	1,500	2,000	2,750	2,000
Italy	0	238	0	0	0	0
Libya	0	0	0	0	1,000	1,000
Portugal	270	370	0	0	0	500
Spain	585	1,345	1,345	1,845	2,400	2,000
Turkey	200	200	200	200	0	0
Sub Total (t U)	6,715	12,923	9,095	7,045	10,150	9,500
Total (t U)	56,215	157,548	159,845	135,445	135,300	133,900

Summary Table for Case 10

Supply Case

YEAR	1990	2000	2010	2020	2030	2035
Total Demand (t U)	43,000	63,500	92,650	122,800	152,100	166,450
Supply (t U)						
a) Major Suppliers						
Australia	5,600	35,050	58,900	83,900	80,400	66,400
Brazil	150	16,250	8,000	16,500	21,750	22,000
Canada	12,000	26,100	36,100	28,000	30,500	27,000
Namibia	4,250	5,725	8,250	7,000	8,000	10,000
Niger	4,600	29,000	12,000	15,000	9,000	10,000
South Africa	8,000	15,500	26,000	32,000	32,000	33,000
USA	14,900	22,500	27,500	32,500	39,500	41,000
Sub Total (t U)	49,500	150,125	176,750	214,900	221,150	209,400
b) Other Suppliers						
Algeria	0	1,000	500	500	1,000	1,000
Argentina	520	1,070	5,150	7,000	10,000	11,000
Denmark	0	0	0	500	500	500
France	3,900	4,200	4,400	2,000	2,000	1,000
FRG	40	1,000	0	500	500	1,000
Gabon	1,000	1,000	2,000	2,000	2,000	2,000
Greece	0	0	0	500	500	500
India	200	2,500	5,000	9,000	9,750	10,000
Italy	0	238	0	0	1,000	1,000
Japan	0	0	0	0	1,000	1,000
Libya	0	0	0	1,000	2,000	1,000
Mexico	0	0	0	2,500	5,500	6,500
Norway	0	0	0	500	1,000	500
Pakistan	0	0	0	0	2,500	6,000
Portugal	270	370	870	500	1,000	1,000
Spain	585	1,845	5,845	8,845	9,900	10,000
Sweden	0	0	0	500	500	1,000
Turkey	200	200	200	200	0	0
United Kingdom	0	0	0	0	500	1,000
Zaire	0	0	0	0	1,000	3,000
Sub Total (t U)	6,715	13,423	23,965	36,045	52,150	59,000
Total (t U)	56,215	163,548	200,715	250,945	273,300	268,400

Annex 12

Summary Table for Case 11

"Could Do" Supply

YEAR	1990	2000	2010	2020	2030	2035
Total Demand (t U)	43,000	63,500	92,650	122,800	152,100	166,450
Supply (t U)						
a) Major Suppliers						
Australia	5,600	35,050	58,900	68,900	48,400	48,400
Brazil	150	16,250	6,000	10,500	14,750	15,000
Canada	12,000	23,600	34,600	27,500	30,500	26,500
Namibia	4,250	5,725	7,250	5,000	6,000	5,000
Niger	4,600	29,000	9,500	11,500	6,000	6,500
South Africa	8,000	15,500	23,000	26,000	31,000	31,000
USA	14,900	21,500	21,500	25,500	31,500	34,000
Sub Total (t U)	49,500	146,625	160,750	174,900	168,150	166,400
b) Other Suppliers						
Algeria	0	1,000	500	500	500	1,000
Argentina	520	1,070	2,650	4,500	5,500	4,500
France	3,900	4,200	4,400	1,000	2,000	1,500
FRG	40	1,000	0	0	0	0
Gabon	1,000	1,000	1,000	1,000	1,000	2,000
Greece	0	0	0	0	0	500
India	200	2,500	2,000	3,500	5,250	3,000
Italy	0	238	0	0	0	0
Libya	0	0	0	0	1,000	1,000
Mexico	0	0	0	0	2,500	2,500
Norway	0	0	0	0	0	500
Portugal	270	370	370	500	500	500
Spain	585	1,345	1,345	1,845	2,400	2,000
Sweden	0	0	0	0	500	500
Turkey	200	200	200	200	0	0
United Kingdom	0	0	0	0	500	500
Sub Total (t U)	6,715	12,923	12,465	13,045	21,650	20,000
Total (t U)	56,215	159,548	173,215	187,945	189,800	186,400

Summary Table for Case 12

Sensitivity Study of Resource Development Rate

(2x Base Case)

YEAR	2000	2010	2020	2030	2035
Total Demand (t U)	63,500	92,650	122,800	152,100	166,450
Production (t U)					
a) Major Suppliers					
Australia	7,550	27,900	34,400	43,400	35,400
Brazil	1,250	3,000	14,000	7,750	8,000
Canada	12,100	10,600	24,000	18,500	15,000
Namibia	5,250	5,250	2,000	4,000	2,000
Niger	6,500	18,000	8,000	4,500	4,500
South Africa	13,000	12,000	18,000	23,000	17,000
USA	9,000	6,000	18,000	27,000	20,500
Sub Total (t U)	54,650	82,750	118,400	128,150	102,400
b) Other Suppliers					
Algeria	500	500	500	0	500
Argentina	570	650	0	4,500	4,500
France	3,900	3,900	500	500	0
FRG	0	500	0	0	0
Gabon	1,000	1,000	0	1,000	1,000
India	1,500	2,000	2,000	2,750	1,500
Italy	238	0	0	0	0
Portugal	370	370	0	0	500
Spain	845	845	1,345	900	500
Turkey	200	200	200	0	0
Sub Total (t U)	9,123	9,965	4,545	9,650	8,500
Total (t U)	63,773	92,715	122,945	137,800	110,900

Summary Table for Case 13

Sensitivity Study for Resource Development Rate

(3x Base Case)

YEAR	2000	2010	2020	2030	2035
Total Demand (t U)	63,500	92,650	122,800	152,100	166,450
Supply (t U)					
a) Major Suppliers					
Australia	7,550	25,400	35,400	20,400	20,400
Brazil	1,250	8,000	5,800	5,750	5,000
Canada	12,100	12,100	12,000	10,500	8,500
Namibia	5,250	5,250	2,000	1,000	1,000
Niger	6,500	14,000	8,000	2,000	2,000
South Africa	13,000	12,000	15,000	17,000	12,000
USA	9,000	7,000	12,500	10,500	12,500
Sub Total (t U)	54,650	83,750	90,700	67,150	61,400
b) Other suppliers					
Algeria	500	500	500	0	0
Argentina	570	650	1,000	1,000	2,000
France	3,900	3,900	3,900	0	0
FRG	0	0	0	0	0
Gabon	1,000	1,000	0	0	1,000
India	1,500	1,500	1,500	1,250	500
Italy	238	0	0	0	0
Portugal	370	370	0	0	0
Spain	845	845	845	845	1,345
Turkey	200	200	200	0	0
Sub Total (t U)	9,123	8,965	7,945	3,095	4,845
Total (t U)	63,773	92,715	98,645	70,245	66,245

Annex 15

Summary Table for Case 15

Sensitivity Study for Lead Times

(3x Base Case)

YEAR	2000	2010	2020	2030	2035
Total Demand (t U)	63,500	92,650	122,800	152,100	166,450
Supply (t U)					
a) Major Suppliers					
Australia	7,550	22,400	42,400	39,400	50,900
Brazil	1,250	3,000	18,500	1,750	2,000
Canada	12,100	6,600	8,000	18,000	29,000
Namibia	5,250	5,725	1,000	0	0
Niger	6,000	28,000	9,000	0	1,000
South Africa	13,000	12,500	9,000	14,000	18,000
USA	9,000	4,000	11,000	14,000	21,000
Sub Total (t U)	54,150	82,225	98,900	87,150	121,900
b) Other Suppliers					
Algeria	500	1,000	500	0	0
Argentina	570	650	500	1,000	2,000
France	3,900	3,900	300	0	500
FRG	0	0	1,000	0	0
Gabon	1,000	1,000	0	0	0
India	1,500	2,500	1,500	750	500
Italy	238	0	0	0	0
Portugal	370	370	0	0	0
Spain	845	845	1,345	400	500
Turkey	200	200	200	0	0
Sub Total (t U)	9,123	10,465	5,345	2,150	3,500
Total (t U)	63,273	92,690	104,245	89,300	125,400

Annex 16

Summary Table for Case 22

Sensitivity Study for $80/kg U Known Resources
and Extended Resource Development Rate
(2x Base Case) for Undiscovered Resources

YEAR	2000	2010	2020	2030	2035
Total Demand (t U)	63,500	92,650	122,800	152,100	166,450
Supply (t U)					
a) Major Suppliers					
Australia	10,550	26,400	31,400	24,400	29,400
Brazil	1,250	4,000	6,500	6,750	7,000
Canada	12,100	19,600	12,000	17,500	14,000
Namibia	5,250	5,250	3,000	3,000	2,000
Niger	6,000	7,000	9,000	2,500	3,500
South Africa	13,000	16,000	18,000	17,000	17,000
USA	9,000	7,000	16,000	17,000	17,500
Sub Total (t U)	57,150	85,250	95,900	88,150	90,400
b) Other Suppliers					
Algeria	500	500	500	0	500
Argentina	570	650	2,000	3,500	2,500
France	3,900	3,900	500	500	0
Gabon	1,000	1,000	0	1,000	1,000
India	1,500	1,500	2,000	2,700	1,500
Italy	238	0	0	0	0
Portugal	370	370	0	0	500
Spain	845	845	1,345	900	500
Turkey	200	200	200	0	0
Sub Total (t U)	9,123	8,965	6,545	8,650	6,500
Total (t U)	66,273	94,215	102,445	96,800	96,900

Annex 17

Summary Table for Case 23

Sensitivity Study for $80/kg U Known Resources

and Extended Resource Development Rate

(4x Base Case) for Undiscovered Resources

YEAR	2000	2010	2020	2030	2035
Total Demand (t U)	63,500	92,650	122,800	152,100	166,450
Supply (t U)					
a) Major Suppliers					
Australia	7,550	17,400	15,400	16,400	20,400
Brazil	1,250	3,000	4,500	4,750	4,000
Canada	12,100	13,100	5,000	6,500	7,000
Namibia	5,250	5,250	1,000	2,000	2,000
Niger	6,000	7,000	8,000	1,000	1,000
South Africa	13,000	14,000	12,000	11,000	11,000
USA	9,000	7,500	8,000	9,000	9,500
Sub Total (t U)	54,150	67,250	53,900	50,650	54,900
b) Other suppliers					
Algeria	500	500	500	0	0
Argentina	570	650	1,000	2,000	1,000
France	3,900	3,900	0	0	0
Gabon	1,000	1,000	0	0	0
India	1,500	1,500	1,500	1,250	500
Italy	238	0	0	0	0
Portugal	370	370	0	0	0
Spain	845	845	845	400	500
Turkey	200	200	200	0	0
Sub Total (t U)	9,123	8,965	4,045	3,650	2,000
Total (t U)	63,273	76,215	57,945	54,300	56,900