Estimated natural uranium requirements to the year 2000

by L.L. Bennett*

The future requirements for natural uranium are mainly dependent on the future growth of nuclear energy generation and the types of reactors operated to provide that energy. These topics were examined extensively by the International Nuclear Fuel Cycle Evaluation (INFCE). The resulting projections of nuclear power plant capacity and estimated requirements for natural uranium, other nuclear raw materials and fuel cycle services were presented in the final report of INFCE [1]. This topic is under continuing examination by the IAEA together with the OECD Nuclear Energy Agency (NEA). An updated version of an earlier NEA report [2] on this subject is planned for publication by NEA in late 1981 or early 1982.

However, the projections from INFCE are the most recent results published by an international body, and can therefore be taken as the most authoritive estimates presently available. The INFCE results have been reviewed in the light of latest trends in national nuclear power capacity figures, and a sub-set of the INFCE results are used as the basis for the demand estimates presented in this article. The principal criteria involved in the selection of this sub-set are the nuclear power growth estimates and the reactor and fuel cycle strategies. These criteria are discussed in the following sections.

In the INFCE final report it was emphasized that a high degree of uncertainty is involved in forecasting the growth of an energy source. It was further recognized that all long-term growth projections (and the estimated fuel cycle requirements) are subject to frequent and substantial change, and that the actual amount of nuclear capacity installed in future years could be outside the range indicated in the INFCE projections. Due to this high degree of uncertainty, the IAEA continuously reviews the nuclear power programmes of its Member States.

For a variety of reasons, the nuclear power programmes in a number of Agency Member States have been revised downward since the INFCE projections were made. The latest Agency estimates [3] of nuclear capacity up to 2000 are shown in the figure in comparison with the INFCE projections. This comparison indicates that the INFCE low-growth projection can be considered approximately a "mid-range" value between the high and low limits of the latest Agency estimates. Therefore, the estimates presented in this article are taken from the INFCE results based on calculations for the low nuclear growth projections.

Reactor strategies

Up to the year 2000, INFCE developed projections (see Table 1) of the capacities of each type of reactor expected to be in service in the world outside the centrally planned economy areas (WOCA). For this period, the dominant reactor type is expected to be the light-water reactor (LWR), supplemented by a significant share (up to 10% of total capacity) of heavy-water reactors (HWR), and relatively small amounts of gas-cooled reactors (GCR) and fast breeder reactors (FBR). The INFCE "reactor mix" was assumed to be a still valid representation of reactor strategies up to 2000.
As noted above, the low-growth figures from Table 1 were used as the basis for the uranium demand estimates in this article.

The operating performance of reactors can have a significant effect on the demands for uranium. The INFCE studies considered two variations in reactor performance during the pre-2000 period:

- Upper uranium demand. All reactors built up to 2000 are assumed to use current (unimproved) technology.
- Lower uranium demand. An improved-technology LWR having about 15% reduction in natural uranium demand is introduced in 1990, with retrofitting of this improvement into pre-1990 LWRs by 2000.

Fuel cycle strategies

The INFCE studies examined pre-2000 fuel cycle strategies including both a no-reprocessing strategy and a reprocessing/recycle strategy in which plutonium recycle in

Table 1. INFCE projections of nuclear capacities in WOCA by reactor type for the period up to 2000 (GWe)

Reactor type	1980	1985	1990	1995	2000
LWR	126-141	214-242	329-410	479-684	718-1041
HWR	8	15- 16	26- 29	44- 56	74- 101
GCR	10	12	14	15	20- 27
FBR	0.5	2	5- 7	12- 16	22- 38
Total	144-159	243-272	374-460	550-771	834-1207

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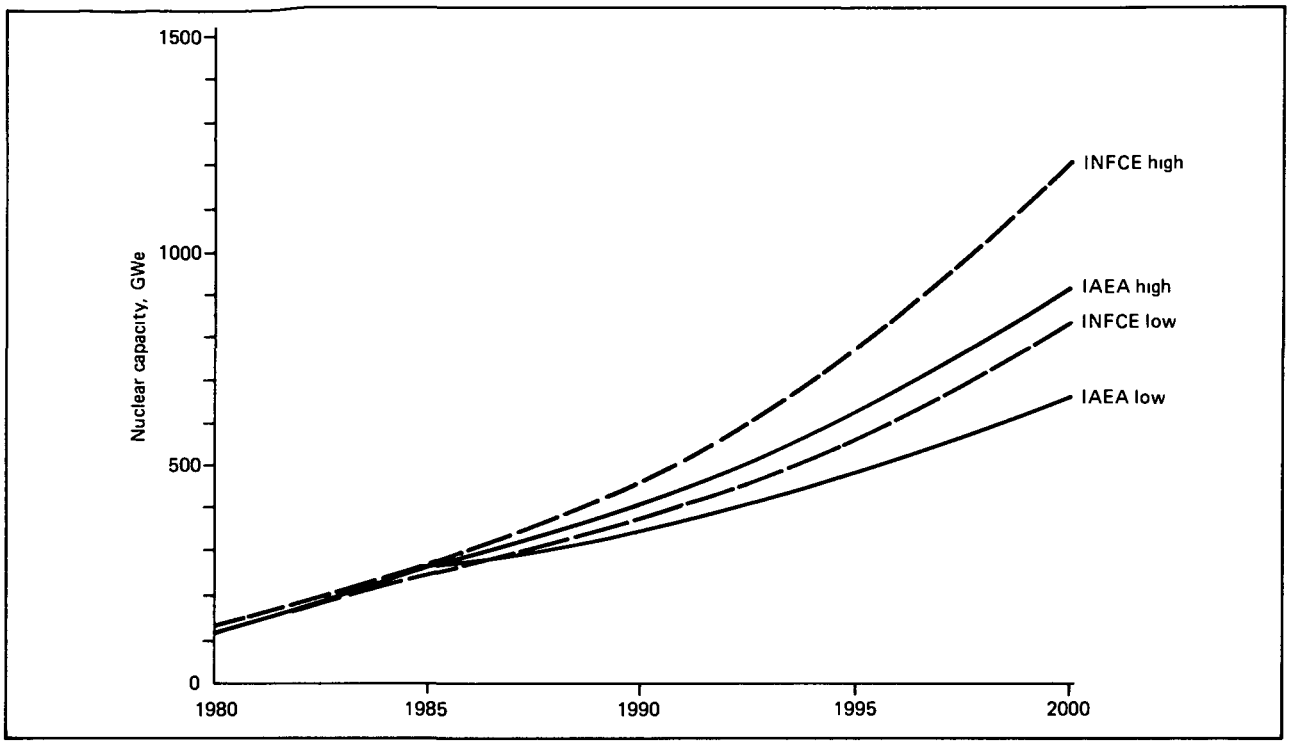

Comparison of INFCE and latest IAEA projections of nuclear power plant capacity in the world outside the centrally planned economy areas (WOCA).

Table 2. Estimates of annual and cumulative natural uranium requirements for reference case (INFCE low-growth, once-through strategy)

	1980	1985	1990	1995	2000
Annual requirements (thousand tU/yr)	29	44	65	89-97	120-136
Cumulative requirements from 1978 (million tU)	0.10	0.29	0.57	0 95-0 98	1 50-1 59

LWRs would be initiated in 1990. However, spent fuel reprocessing is expected to be rather limited up to 2000, and it is not certain that the recovered uranium would be returned at once to the uranium enrichment plants or whether the plutonium would be recycled in LWRs or "saved" for future use in FBRs. Therefore, the potential reduction in needs for natural uranium, due to reprocessing and uranium and plutonium recycle, has been neglected in the natural uranium demand estimates presented here. This assumption corresponds to the "LWR Once-Through" strategies examined by INFCE.

Table 3. Sensitivity of estimated annual uranium requirements to nuclear power growth (thousand tU/yr)

	1980	1985	1990	1995	2000
Reference case INFCE low nuclear growth	29	44	65	89- 97	120-136
Alternative case INFCE high nuclear growth	33	54	88	127-138	175-200

Natural uranium demand

Using the above criteria, the INFCE estimates of annual and cumulative natural uranium requirements in WOCA for low-growth strategies Lla and Llb (see [1] p. 62–63, for definition) are presented in Table 2. This shows that the annual uranium requirements could reach 120–136 thousand tU/yr in the year 2000, with cumulative consumption up to the year 2000 reaching 1.50–1.59 million tU. The estimated lifetime uranium requirements of all reactors projected by INFCE for WOCA up to 2000 were estimated to be 2.9–3.4 million tU, for the low-growth projection.

Although the current IAEA estimates of nuclear power growth up to 2000 tend to agree with the INFCE low-growth projections, it is not possible to rule out the high-growth projection. The estimated annual natural uranium demands for the high-growth case (INFCE strategies Hla and Hlb, see Ref. [1]) are shown in Table 3 in comparison with the reference case (low-growth) demands.

References

[1] *Fuel and heavy water availability* Report of INFCE Working Group 1, IAEA, Vienna (1980)
[2] *Nuclear fuel cycle requirements and supply considerations through the long term* Report by an expert group of the OECD Nuclear Energy Agency, Paris, (1978).
[3] IAEA annual report 1980, in preparation.