SPENT FUEL STORAGE REQUIREMENTS

R. A. Libby and B. M. Cole
Pacific Northwest Laboratory[a]
Richland, WA 99352

ABSTRACT

Long before a permanent nuclear waste disposal system is available in the United States, several of the operating commercial nuclear power plants will exhaust their existing spent fuel storage capabilities. Studies to define the magnitude of this interim problem were conducted by the Department of Energy through the Commercial Spent Fuel Management (CSFM) Program at the Pacific Northwest Laboratory. Based on information supplied by the nuclear utilities, these studies indicate that if new storage concepts are not available by 1986 some reactors could encroach on their storage pool's full core reserve (FCR), and ultimately, be forced to shut down.

Spent fuel storage capacities at some commercial nuclear power plants are inadequate to handle the projected near-term (1985-1997) spent fuel discharges. Due to the potential development of promising new storage concepts (i.e., dry storage and rod consolidation) it is extremely difficult to ascertain the exact extent of the storage needs. However, bounding conditions can be imposed that allow problem definition. These bounding conditions range from utilizing the current licensed techniques for increasing storage capacity (reracking and transshipment) to implementation of dry storage and/or rod consolidation technologies. This paper will assess the impact that currently licensed storage technologies will have on the timing of the requirements.

The data for these analyses came from the Spent Fuel Data Base maintained by the CSFM Program. This data base consists of data voluntarily supplied by the nuclear utilities to the program through an annual series of data verification forms. The baseline storage requirements derived from this data base were reported in the annually updated Spent Fuel Storage Requirements report [1] issued by the DOE Richland Operations Office in May, 1984. This report shows the spent fuel inventories as of December, 1983 and projected discharges, inventories, and storage requirements through 1993.

The data base used to prepare the Spent Fuel Storage Requirements report has since been modified to track Energy Information Administration (EIA) projections for installed nuclear capacity and annual electrical generation. These EIA forecasts [2] are official DOE projections and form the basis for all Office of Civilian Radioactive Waste Management (OCRWM) program logistics scenarios. Due to EIA assumptions regarding reactor startup dates and reduced plant capacity factors, the modified data base reflects reduced quantities of fuel being discharged compared with the utility data. This has the effect of delaying and reducing the predicted storage requirements with respect to the utility data used in the report.

The two cases that form the basis for the analyses are the Maximum At-Reactor (AR) storage capacity case and the Maximum-at-Reactor Storage with Transshipment (AR-T) Case. The AR case was developed to correspond with conditions that either currently exist or are judged most likely to occur.

The AR case assumes that FCR will be maintained for all reactors. A single FCR is assumed to be maintained for all units at multiple-unit reactor stations employing either a single common spent fuel storage pool, or separate pools with interconnections allowing spent fuel transfer between them. Multiple units on a single site with individual, unconnected pools are assumed to maintain FCR for each unit (except for Southern California Edison, which intends to maintain only a single FCR at the three San Onofre units). Reactors that need to ship fuel to maintain FCR, but have a capacity increase scheduled within two years following loss of FCR, are assumed to operate without FCR until that capacity increase takes place.

All licensable actions to increase storage capacity at reactor sites are assumed to be taken. Thus, if a utility indicates that the maximum pool capacity is larger than that currently licensed, the larger pool capacity is used. Utilities are assumed to increase their spent fuel storage pool capacities to the maximum extent possible using currently licensed technology (reracking). The maximum storage pool capacity assumed may not be the actual maximum pool capacity. Additional technical evaluations or institutional considerations may either increase or decrease the actual licensable capacity compared with the assumed values. It is also assumed that offsite transshipment of spent fuel will not take place except in those cases currently licensed by the NRC. Onsite transfers will occur as planned and additional onsite transfers will

(a) In support of the United States Department of Energy under Contract DE-AC06-76RLO 1830.

occur, if necessary, at reactor sites where such transfers have taken place in the past.

The AR-T case retains the same assumptions as the AR case with the exception that transshipment of spent fuel within a utility system is assumed. Reactors requiring additional storage are assumed to ship fuel to any reactor of the same type (i.e., PWR to PWR or BWR to BWR) operated by the same utility system as needed to meet storage requirements.

The total projected cumulative spent fuel discharges from all reactors are shown in Fig. 1 and are listed in Table I. These projections are shown beginning in 1983 and extending through 2020. The inventory of discharged spent fuel is projected to increase from approximately 10,000 Metric Tons Initial Heavy Metal (MTIHM) to over 100,000 MTIHM by the year 2020. Note that generic reactors are added to the system after the year 2000 to account for projected increases in the installed nuclear power capacity. Projected reactor-by-reactor spent fuel discharges are shown in Reactor-Specific Spent Fuel Discharge Projections: 1984 to 2020[3].

Tables II-V show the annual and cumulative projected additional storage capacity requirements in both assemblies and metric tons for these two cases. Both the requirements from the utility data (as reported in the Spent Fuel Storage Requirements report)[1] and from the utility data modified to track the EIA Middle-Case projections for installed nuclear capacity and energy generation are shown. Requirements through 1997 are indicated, after which time the first repository system is scheduled to begin operation. Figure 2 shows the cumulative additional storage requirements. It is evident that transshipment within a utility system can reduce cumulative additional storage requirements in the next decade to less than half the value without such transshipments. Transshipment does not affect long-term requirements significantly, however, since eventually all utility storage space will be filled. If EIA projections on reactor startup dates and capacity factors are correct, storage requirements are reduced to approximately 70% of the requirements based on unmodified utility data.

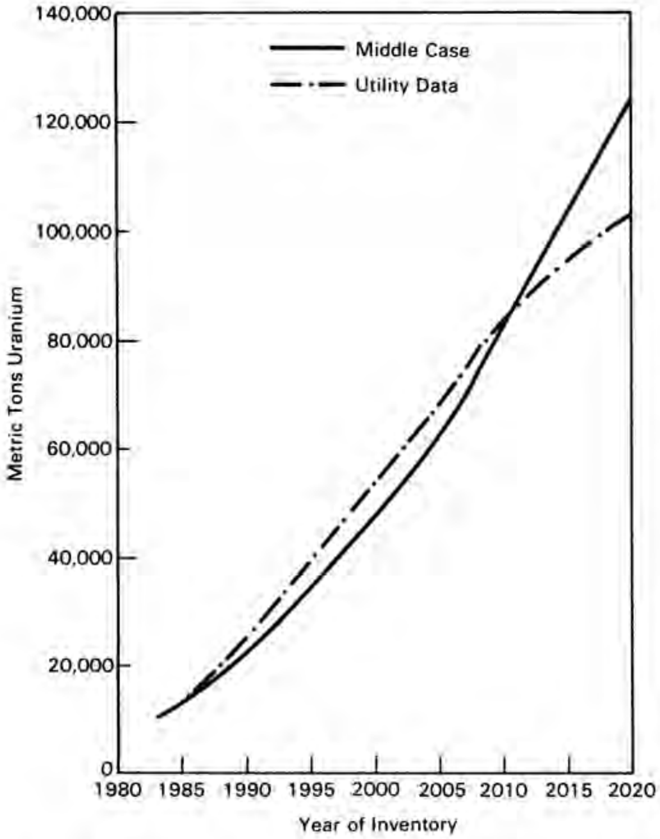

Fig. 1. Projected cumulative spent fuel inventory.

TABLE I

Cumulative Spent Fuel Discharges (MTIHM)

Year	Utility Data	Modified Data
1983	10142	10142
1984	11425	11307
1985	13185	12769
1986	15210	14297
1987	17483	16027
1988	20209	18089
1989	22677	20204
1990	25403	22354
1991	28189	24602
1992	30915	26923
1993	33853	29317
1994	36761	31945
1995	39554	34443
1996	42517	37087
1997	45467	39804
1998	48219	42403
1999	51149	45113
2000	54074	47916
2001	56663	50463
2002	59684	53463
2003	62629	56438
2004	65545	59478
2005	68452	62917
2006	71576	66145
2007	74697	69995
2008	78275	74004
2009	80935	78852
2010	83578	83059
2011	85846	87325
2012	88189	91430
2013	90274	95223
2014	92625	99560
2015	94651	103456
2016	96647	107419
2017	98428	111690
2018	100013	115928
2019	101557	120190
2020	103140	124672

TABLE II

Annual Spent Fuel Storage Requirements - Assemblies

	Maximum AR Capacity Case		Maximum AR Plus Transshipment Case	
Year	Utility Data	Modified Data	Utility Data	Modified Data
1984	0	0	0	0
1985	3	0	0	0
1986	66	50	0	0
1987	294	125	132	49
1988	341	279	0	0
1989	564	467	205	172
1990	1556	685	326	41
1991	2208	1584	912	400
1992	1475	1145	1181	776
1993	2367	1842	1289	809
1994	3045	2389	1736	1352
1995	2535	1726	2349	1508
1996	4867	2929	4231	1793
1997	4247	3037	4828	2480

TABLE III

Cumulative Spent Fuel Storage Requirements - Assemblies

	Maximum AR Capacity Case		Maximum AR Plus Transshipment Case	
Year	Utility Data	Modified Data	Utility Data	Modified Data
1984	0	0	0	0
1985	3	0	0	0
1986	69	50	0	0
1987	363	175	132	49
1988	704	454	132	49
1989	1268	921	337	221
1990	2824	1606	663	262
1991	5032	3190	1575	662
1992	6507	4335	2756	1438
1993	8874	6177	4045	2247
1994	11919	8566	5781	3599
1995	14454	10292	8130	5107
1996	19321	13221	12361	6900
1997	23568	16258	17189	9380

TABLE IV

Annual Spent Fuel Storage Requirements - MTIHM

	Maximum AR Capacity Case		Maximum AR Plus Transshipment Case	
Year	Utility Data	Modified Data	Utility Data	Modified Data
1984	0	0	0	0
1985	1	0	0	0
1986	27	20	0	0
1987	90	40	23	9
1988	147	120	0	0
1989	194	159	37	30
1990	434	225	86	16
1991	536	405	222	91
1992	431	343	295	177
1993	612	465	384	221
1994	804	591	486	358
1995	810	518	697	420
1996	1276	810	1067	529
1997	1251	886	1236	742

TABLE V

Cumulative Spent Fuel Storage Requirements - MTIHM

	Maximum AR Capacity Case		Maximum AR Plus Transshipment Case	
Year	Utility Data	Modified Data	Utility Data	Modified Data
1984	0	0	0	0
1985	1	0	0	0
1986	28	20	0	0
1987	119	60	23	9
1988	266	180	23	9
1989	459	339	61	39
1990	893	564	147	55
1991	1429	969	369	147
1992	1861	1311	664	324
1993	2472	1776	1047	546
1994	3276	2368	1534	903
1995	4086	2886	2231	1323
1996	5362	3696	3298	1852
1997	6613	4582	4533	2594

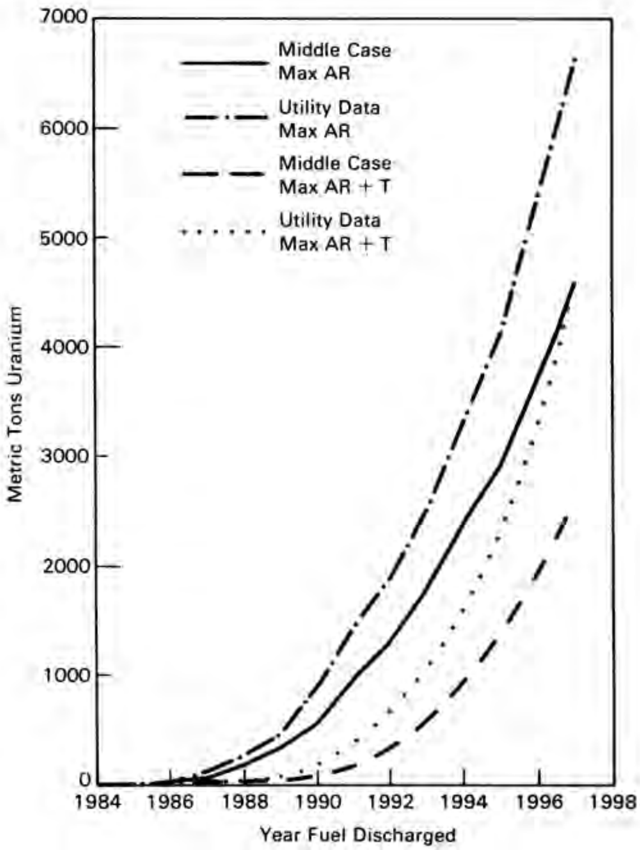

Fig. 2. Projected cumulative additional spent fuel storage requirements.

It is anticipated that these additional storage capacity needs will be met through three primary methods. The first method is reracking existing pools to obtain additional storage space. Although the projected requirements reported here are based on what the utilities believed to be the maximum capacity of the pools, additional studies or new rack design concepts may enable expansion of existing basins. The second method likely to enable additional storage within existing pools is the concept of rod consolidation, in which fuel assemblies are disassembled and the fuel pins are packed tightly together. This concept could double the capacity of some pools. The third storage method, which could see wide-spread use, is dry storage. This concept, whether in the form of casks, vaults, or silos is likely to be applicable to nearly all reactor sites.

REFERENCES

1. Spent Fuel Storage Requirements: An Update of DOE/RL-83-1. DOE/RL-84-1, U.S. Department of Energy, Richland Operations Office, Richland, Washington (1984).

2. Gielecki, M., et al. Commercial Nuclear Power 1984: Prospects for the United States and the World. DOE/EIA-0438 (84), Energy Information Administration, Washington D.C. (1984).

3. Heeb, C. M., et al. Reactor-Specific Spent Fuel Discharge Projections: 1984 to 2020. PNL-5396, Pacific Northwest Laboratory, Richland, Washington (1985).