US Spent (Used) Fuel Status, Management and Likely Directions- 12522

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ABSTRACT

As of 2010, the US has accumulated 65,200 MTU (42,300 MTU of PWR's;23,000 MTU of BWR's) of spent (irradiated or used) fuel from 104 operating commercial nuclear power plants situated at 65 sites in 31 States and from previously shutdown commercial nuclear power plants [1]. Further, the Department of Energy (DOE) has responsibility for an additional 2458 MTU of DOE-owned defense and non defense spent fuel from naval nuclear power reactors, various non-commercial test reactors and reactor demonstrations [2]. The US has no centralized large spent fuel storage facility for either commercial spent fuel or DOE-owned spent fuel. The 65,200 MTU of US spent fuel is being safely stored by US utilities at numerous reactor sites in (wet) pools or (dry) metal or concrete casks. As of November 2010, the US had 63 "independent spent fuel storage installations" (or ISFSI's) licensed by the US Nuclear Regulatory Commission located at 57 sites in 33 states. Over 1400 casks loaded with spent fuel for dry storage are at these licensed ISFSI's; 47 sites are located at commercial reactor sites and 10 are located 'away' from a reactor (AFR's) site [3]. DOE's small fraction of a 2458 MTU spent fuel inventory, which is not commercial spent fuel, is with the exception of 2 MTU, being stored at 4 sites in 4 States. The decades old US policy of a "once through" fuel cycle with no recycle of spent fuel was set into a state of "mass confusion or disruption" when the new US President Obama's administration started in early 2010 stopping the only US geologic disposal repository at the Yucca Mountain site in the State of Nevada from being developed and licensed. The practical result is that US nuclear power plant operators will have to continue to be responsible for managing and storing their own spent fuel for an indefinite period of time at many different sites in order to continue to generate electricity because there is no current US government plan, schedule or policy for taking possession of accumulated spent fuel from the utilities. There are technical solutions for continuing the safe storage of spent fuel for 100 years or more and these solutions will be implemented by the US utilities that need to keep their nuclear power plants operating while the unknown political events are played out to establish future US policy decisions that can remain in place long enough regarding accumulated spent fuel inventories to implement any new US spent fuel centralized storage or disposition policy by the US government.

INTRODUCTION

The decade's old US policy of a "once through" fuel cycle with no recycle of spent fuel was set into a state of "mass confusion or disruption" when the new US President Obama's administration started in early 2010 stopping the only US geologic disposal repository at the Yucca Mountain site in the State of Nevada from being further developed and licensed. The permanent shutdown of all Yucca Mountain project activities was targeted to be completed by September 30, 2011 of fiscal year 2011. These Obama administration actions removed the only known pathway for implementation of the US "once through" fuel cycle for moving the accumulated US spent fuel inventories from utilities into geologic disposal once the Yucca Mountain site licensing and construction were completed. No alternative disposition pathway, or even a schedule, for spent fuel disposition has yet been offered by the Obama administration. However a "Blue Ribbon Commission" of 15 experts was established January 29, 2010 by the Obama administration to conduct a comprehensive review of new options for managing the back end of the nuclear fuel cycle and spent fuel and is to recommend in a final report new options for further consideration by January 2012 [4]. The Commission was directed in their charter to not consider the Yucca Mountain site as any alternative option. The practical result is that US nuclear power plant operators will have to continue to be responsible for managing and storing their own spent fuel for an indefinite period of time at many different sites in order to continue to generate electricity because there are no current US government plans, schedules or policy for accumulated spent fuel which currently totals 65,200 MTU of commercial spent fuel and 2458 MTU of DOE-owned spent fuel. Continuing to store spent fuel by the utilities is necessary despite contracts prescribed be the Nuclear Waste Policy Act (NWPA) of 1982 (Public Law 97-425) and its amendments signed with the DOE over a decade ago that required DOE to start by 1998 taking possession of the spent fuel from utilities at the utilities sites in return for advance payments of $0.001 per kilowatt hour of electricity generated (10CFR961.5). As of December 2010, $17.9 billion has been collected from the utilities by the US government into a 'nuclear waste fund' ($34B has been accumulated if interest is included and ~24B$ remains in the fund at the end of 2011) on behalf of DOE for final spent fuel disposition [5]. However no spent fuel has yet been taken by DOE from the utilities in violation of the signed contracts as required by 10CFR961.5 during the thirteen years of valid contracts. The Yucca Mountain site development and licensing activities had used about 10B$ from the nuclear waste fund prior to the Obama administration's abandonment the Yucca Mountain disposition pathway. All of the Yucca Mountain site and licensing work during several decades is now basically decades of lost efforts and expended costs ,~10B$, with no end product or result. Spent fuel will have to be continued to be stored by utilities until a new spent fuel disposition pathway and policy is defined and implemented.

METHOD

Published literature was reviewed and summarized to establish the magnitude of the US accumulated spent fuel inventories and the current generation rates of new spent fuel, as well as how and where the spent fuel inventories are being stored. These are important facts required to understand the magnitude of the issue caused by stopping of the spent fuel disposition pathway for geologic disposal, and the US once through spent fuel cycle policy, by the Obama administration with no alternative pathway offered.

RESULTS

A review of the current (through 2010) and projected (through 2050) US inventories is summarized by Fig. 1 from Kessler [1]. As of 2010, the US utilities have accumulated ~65,200 MTU of spent fuel. This inventory at the end of 2010 consisted of 42,300 MTU

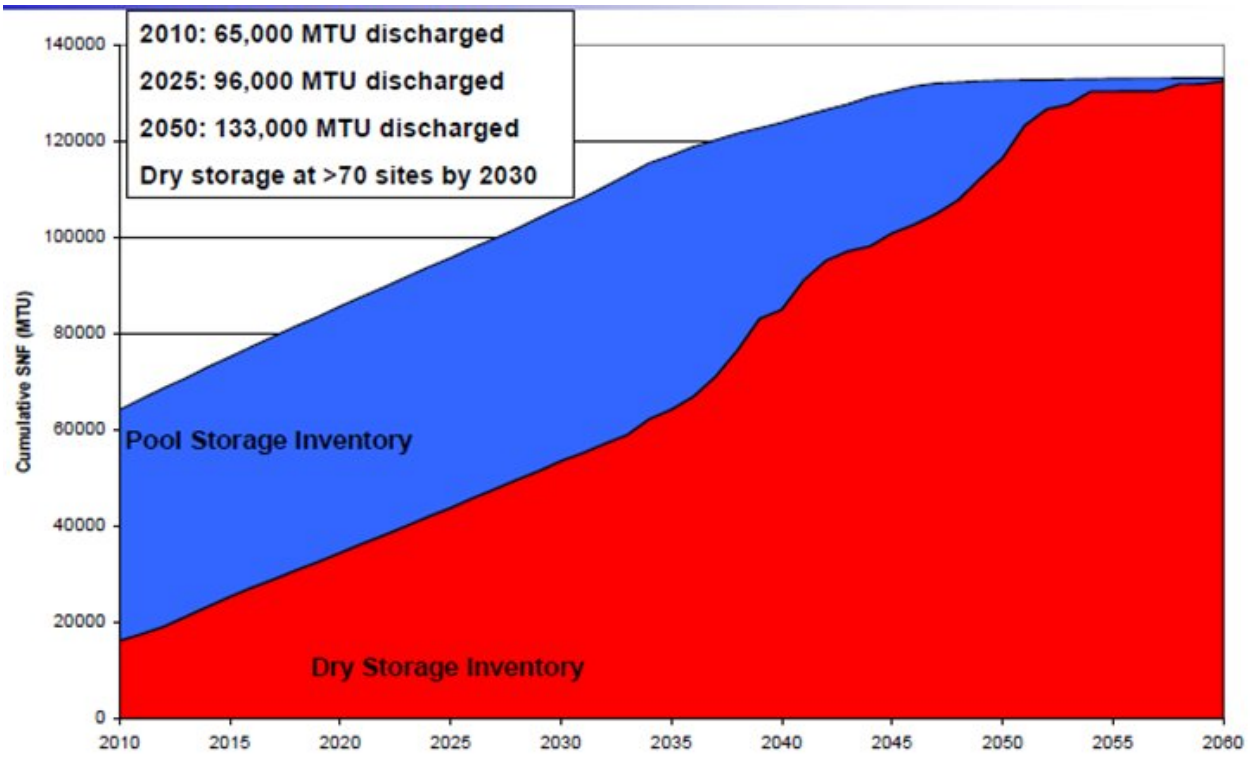

Fig 1. Current and projected US commercial spent fuel inventories for 2010 to 2060 [1].

of PWR's and 23,000 MTU of BWR's of spent (or used) fuel from 104 operating commercial nuclear power plants situated at 65 sites in 31 States and from previously shutdown commercial nuclear power plants. Spent fuel is today being generated at the rate of 2000 to 2400 MTU per year. The projections to 2025 and 2050 make the critical assumption that there are no new nuclear reactors started up that are not now operating and licensed and that all existing reactors will continue to operate until the end of their

60 year design life extensions which are either in already in progress or approved by the US NRC. The projected US spent fuel inventory will be 96,000 MTU by 2030 and 133,000 MTU of spent fuel by 2050. If there are any new reactors started-up in the US which seems inevitable during the next 40 years, the projected inventories will increase beyond these estimates [1].

Approximately 24% of the spent fuel in Fig. 1 has been put into dry storage while 76% remains in wet storage pools, mainly at existing nuclear reactor sites. Alvarez [6] summarized the various US spent fuel wet and dry storage modes and his results have been plotted in Fig. 2. Illinois and South Carolina are the states with the largest inventories of spent fuel, with South Carolina being the State with the most spent fuel

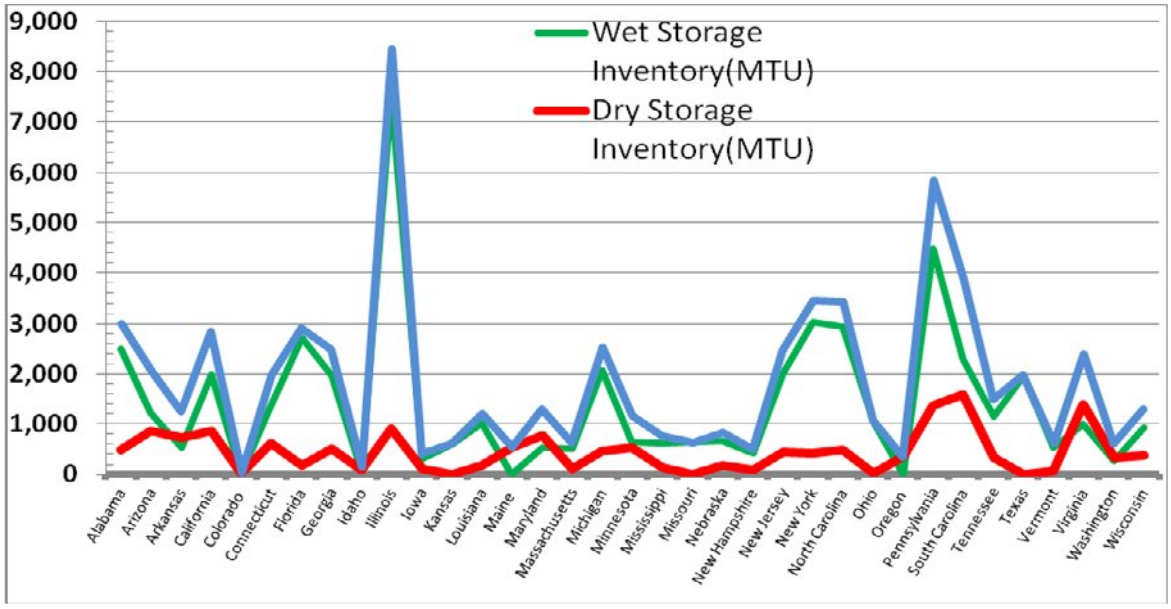

Fig 2. Approximately 24% of the US spent fuel inventory is in dry storage at reactor sites in 35 states [6].

inventory in dry storage. It is reasonable to assume that the dry storage inventories will increase with time because new storage capacities that are added will be dry storage; the further aging of spent fuel inventories facilitates the use of dry storage methods.

The NRC web site [3] reports there are 63 licensed dry storage facilities for spent fuel in 33 states at 57 sites; 48 of these licensed storage facilities are at one of the operating reactor sites. Fifteen of these are licensed separate from the operating reactor license although 7 are located at, or adjacent to, a reactor site and 8 are not at a reactor site [3]. The dry storage methods use either some type of vertically placed above-ground concrete or steel structures (casks) on a concrete pad or sealed canisters that are placed horizontally in above- ground concrete bunkers that provide shielding and

structural isolation. Over 1400 casks are loaded with spent fuel for dry storage at these licensed 'ISFSF's [3].

Carter et. al. [7] provided a further characterization of the 65,200 MTU accumulated inventories. There is approximately twice as much (by mass) PWR spent fuel inventory as there is BWR spent fuel. The average age of all the accumulated commercial spent fuel is ~15 years old. The average burnup is 39,600 MWd/MTU for PWR's and 33,300 MWd/MTU for BWR's; the residual U-235 enrichments are about 3.7% and 3.1%, respectively. His data show the range of the burnups going to as high as ~60,000 to 65,000 MWd/MTU but this is currently a small amount (<1%). However the goal of nuclear plant operators and fuel fabricators is to increase the burnups as much as materials and licensed designs can allow so that 65,000 MWd/MTU and above are much larger percentages. These data of [7] are summarized in Fig 3.

Total Number of Assemblies[b]			Total Initial Uranium (MTU)[a]			Average Enrichment		Average Burnup (MWd/MTU)[c]		Average Age (Yr)		Total Radioactivity (Ci)	
PWR	BWR	Totals	PWR	BWR	Totals	PWR	BWR	PWR	BWR	PWR	BWR	PWR	BWR
97,400	128,600	226,000	42,300	23,000	65,200	3.74	3.12	39,600	33,300	14.9	15.4	16 billion	7 billion
a the estimated fuel discharged has been rounded to the nearest 100 MTU, totals may not appear to sum correctly													
b the number of assemblies has been rounded to the nearest 200, totals may not appear to sum correctly													
c the burn-up has been rounded to the next 100 MWd/MT													

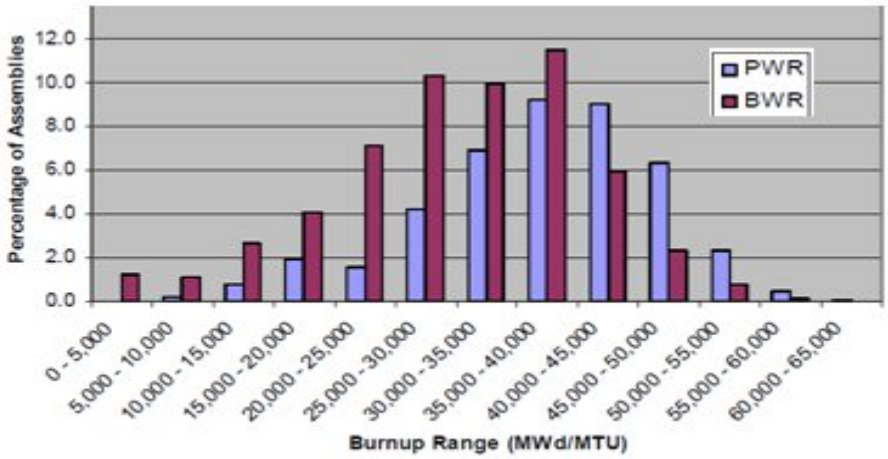

Fig. 3 Select properties and distributions of current US commercial spent fuel inventory at end of 2010 [7].

In addition to the commercial inventory of accumulated spent fuel, the Department of Energy (DOE) has an additional 2458 MTU of spent fuel from naval nuclear power and various non-commercial test reactors and demonstrations, called DOE-owned spent fuel. DOE's small 2458 MTU spent fuel inventory, is not commercial spent fuel, and is with the exception of 2 MTU being stored at 4 sites in 4 States [2]. The sites are at the Savannah River Laboratory (~29 MTU), Hanford (~2129 MTU), Idaho National

Laboratory sites (~282 MT) and Fort St Vrain Colorado (~15 MT). This fuel consists of materials from defense production reactors and R&D reactors and from non-defense reactors used in the Shippingport, Peach Bottom and Fort St Vrain demonstration projects. Three Mile Island debris and both domestic and foreign research reactors are in this 2458 MTU total inventory of DOE-owned spent fuel. The 15 MTU stored at the Fort St Vrain site is managed by DOE but the facility is licensed by the NRC [2].

DISCUSSION

The decades old US policy of a “once through” fuel cycle with no recycle of spent fuel was set into a state of “mass confusion or disruption” when the new US President Obama’s administration started in early 2010 the termination of the only US geologic disposal repository at the Yucca Mountain site in the State of Nevada from being developed and licensed. The permanent shutdown of all Yucca Mountain project was targeted to be completed by September 30, 2011 and has been essentially completed. These Obama administration actions removed the only known single pathway for implementation of the US “once through” fuel cycle for moving the US spent fuel inventories into geologic disposal once the Yucca Mountain site licensing was completed. No alternative disposition pathway, or schedule, for spent fuel disposition has been offered by the Obama administration, although a “Blue Ribbon Commission” of 15 experts was established January 29, 2010 to conduct a comprehensive review of new options for managing the back end of the nuclear fuel cycle and spent fuel and is to recommend in a final report new options for consideration by January 2012 [4]. They were directed by the Obama administration to not consider or to assess the Yucca Mountain site in their activities. They produced a draft report in July 2011 which had very general recommendations and no specifics regarding future spent fuel storage or geologic disposal in the US [4]. Clearly multiple decades will be required to develop and site any new disposition pathway facility for accumulated spent fuel.

The practical result is that US nuclear power plant operators will have to continue to be responsible for managing and storing their own spent fuel for an indefinite period of time at many different sites in order to continue to generate electricity because there is no current US government plan, schedule or policy for accumulated spent fuel. It seems unlikely that the Blue Ribbon Commission final report due in January 2012 will provide any specific disposition pathways for accumulated future spent fuel and future administrations and Congresses will have to address this situation.

The requirement for utilities to store onsite their spent fuel is necessary despite contracts signed with utilities and the DOE over a decade ago requiring DOE to start by 1998 taking back the spent fuel from utilities in return for payments of $0.001 per kilowatt hour of electricity generated as was specified in the NWPA of 1982 and its amendments. As of December 2010, $17.9 billion has been collected from the utilities

by the US government ($34B has been accumulated if interest is included and $10B has been paid out for Yucca Mountain related activities, leaving a balance of ~$24B in the fund) on behalf of DOE but no spent fuel has been taken by DOE from the utilities in violation of the contracts [5].

Because of the valid signed contracts with DOE, utilities have filed multiple lawsuits to recover their unplanned costs require to keep storing safely the spent fuel on their sites. As of June 2010, 72 lawsuits have been filed by utilities against DOE for missing their 1998 contractual deadline to take back spent fuel. Approximately $2 billion has been paid from current judgments and settlements with estimates that DOE's liability could reach $13 billion for future lawsuit settlements by 2020. If there is no take back of spent fuel by DOE after 2020, additional costs of DOE contract liability could increase an additional $0.5 billion per year [8]. It seems unlikely that any new centralized storage facility could be sited, licensed, constructed and operated by 2020 for the US government which could accommodate spent fuel from utilities based on past experience for siting such faculties in the US and associated licensing issues, even if a new centralized spent fuel storage facility is a Blue Ribbon Commission final report recommendation. Certainly, there will be no US geologic disposal facility to well beyond 2020 or any credible other pathway to implement a once through spent fuel disposal policy.

Another issue of delaying take back by DOE of spent fuel once a reactor shuts down and is decommissioned is the continued spent fuel storage and security costs at the reactor site. Hamel et. al. [9] reported that currently 2813 MTU of the 65,200 MTU of accumulated spent fuel is in) storage at 9 sites in 8 states at 10 shutdown commercial reactors. This is referred to as 'stranded' storage because the reactors are shutdown and the only site activities required are the spent fuel storage which costs money to the owners or utilities. They estimated such additional storage and security costs approach $8 million per year of storage per shut down reactor site [9].

It should be noted that these estimated $2B to $13B of lawsuits costs or liability for the spent fuel storage costs paid by the US government to utilities due to US government or DOE delays is above and beyond the $10B 'lost' due to the Obama administration's decision to terminate the Yucca mountain repository site development and licensing. This was a costly decision using rate payers or tax payers funds that could approach $23B that were not based on technical or scientific merits, but only a political decision. What does seem certain is that the utilities will have to continue to safely store spent fuel at multiple sites within the US for an indeterminate time period. There are technical solutions for continuing the safe storage of spent fuel for 100 years or more, and these solutions are being implemented by the US utilities that need to keep their nuclear power plants operating and must therefore have some methods to store discharged spent fuel until the US government takes it away as prescribed in the NWPA of 1982

and its amendments. It remains unknown how future political events or decisions will be played out to establish any future US policy directions that can remain in place long enough regarding accumulated spent fuel inventories to allow implementation of ultimate spent fuel disposition in the US. The road for accumulated spent fuel disposition in the US is totally unknown at this point in time as is any implementation schedule involving the US government future policy decisions.

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