System-Level Logistics Modeling of DPC Direct Disposal – 15511

Elena Kalinina* and Ernest* Hardin
*Sandia National Laboratories, Albuquerque, New Mexico, USA

ABSTRACT

The U.S. Department of Energy (DOE), Office of Used Nuclear Fuel Disposition, has been conducting a study of the technical feasibility of direct disposal of existing dual-purpose canisters (DPCs) loaded with commercial spent nuclear fuel (SNF). The system-level logistical modeling described here is a part of this study with the primary goals to project the inventory of DPCs in the future and to understand the timing of DPC disposal constrained by thermal power limits for disposal and other key parameters of the waste management system. The logistics simulations also allow for estimating fuel age at emplacement, an important consideration if storage time is limited. This analysis evaluated the effects on DPC direct disposal from uncertainty in repository emplacement power limits, the repository start date, and whether or when the nuclear industry could transition to loading SNF into the smaller capacity multi-purpose canisters (MPCs). MPCs implemented at a future date would likely contain the youngest fuel with highest burnup, but smaller MPCs would cool to the emplacement power limits relatively quickly. The results of this analysis demonstrate that DPC direct disposal could be complete by about 2070 to 2170 depending on the repository emplacement power limit. These completion dates can be expedited by approximately 10 to 40 years in some scenarios through the transition to MPCs. The greatest average SNF age at emplacement is 88 years in the scenarios with the smallest repository thermal power limit in which no transition to MPCs is considered. Transition to MPCs could decrease the average age at emplacement, to as low as 42 years in some scenarios.

INTRODUCTION

Loading of DPCs in the US first started around 1995 when the wet storage facilities (pools) at a few reactor sites approached their maximum capacities and dry storage became essential for continuing reactor operation. Later in the absence of a geologic repository for permanent disposal of SNF, dry storage was implemented at more power plants to mitigate pool capacity limitations. The dry storage facilities were originally licensed for 20 years with provision for 20- or 40-year extensions as defined in NUREG-1927 [Ref. 1]. Presently, most nuclear power plants have at-reactor dry storage facilities. Of the 71,000 MTU of SNF which was generated as of the end of 2013, 22,000 MTU was in dry storage in 1,850 canisters or casks. The majority of these are DPCs designed for storage and transportation. The remaining SNF is either in storage-only (sealed) canisters or in bare-fuel (bolted) casks. If current fuel management practices continue, half of the SNF in the US will be in dry storage by approximately 2030.

Currently, the Nuclear Regulatory Commission (NRC) has approved 29 DPC designs and 5 storage-only casks. The canister (cask) capacities range from 7 to 37 assemblies for PWR fuel and 52 to 89 assemblies for BWR fuel. Under the terms of existing contracts between the DOE and the nuclear utilities, selection of dry storage systems is at the utility's discretion. As a result, multiple designs have been and continue to be used. Vendors have introduced larger-capacity canisters as more cost-effective solutions, which have been readily adopted. Along with a trend toward higher fuel burnup, these practices have increased DPC heat output.

At present there are significant uncertainties with respect to future SNF management practices. Direct disposal of DPCs, if shown to be feasible, could provide a number of benefits such as reducing complexity of the waste management system, lower cost, less low-level radioactive waste, and possibly lower worker dose. Otherwise, the DPCs will have to be cut open and the SNF repackaged for permanent disposal. This would require, at a minimum, a repackaging facility and a low level radioactive waste facility.

Preliminary results from the study of DPC direct disposal feasibility [Ref. 2] demonstrated how geologic host media constrain the peak temperature, and thus the duration of decay storage needed. Thermal constraints on disposal are represented in the logistical analyses reported here using waste package emplacement power limits, which are based on heat transfer analysis for generic host media [Ref. 2].

This study analyzes DPC direct disposal using a logistical model that includes SNF selection and loading into DPCs at power plants, transportation to and decay storage at an interim storage facility, and disposal at a repository. Thermal constraints are studied using two assumed DPC loading strategies: 1) power plants continue to load the same types of DPCs they currently use, through cessation of reactor operation and decommissioning; and 2) at some future date power plants that still have uncanistered SNF switch to loading smaller, purpose-designed multi-purpose canisters (MPCs). The MPC definition used here is the same as that used internationally: a sealed canister intended for storage, transport, and disposal.

The study considers repository opening dates that are early, as-planned, and late, to represent uncertainty in the timing of disposal implementation. The planned start date is based on *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste* [Ref. 3]. According to this strategy a pilot interim storage facility will be available in 2021, a larger interim storage facility will be available in 2025, and a repository will be available in 2048. These facilities are represented in the model as a single facility for interim storage, and a single repository for the full inventory of commercial SNF. The early and late repository openings dates are 2036 and 2060, respectively. The study compares the duration of operation and the needed capacity for an interim storage facility, in scenarios that range from direct disposal of all SNF in DPCs, to repackaging of DPCs produced before transition to MPCs.

METHOD

Logistical simulations were performed using the computer code TSL-CALVIN [Ref. 4]. The simulator includes an extensive database of information on each nuclear reactor (shutdown or operating) in the US. Tabulated data include: power plant ownership (utility), SNF location, SNF type, and pool capacity; historic discharge data (discharge date, number of assemblies, enrichment, and burnup); estimates of future discharges based on reactor operating license extension and future burnup assumptions; and the types of dry storage canisters used at the different locations. The study assumed 20-year license extension for all operating reactors and no new builds. The total projected inventory of commercial SNF is ~139,000 MTU.

TSL-CALVIN provides a few thermal management capabilities. First, the heat output is recalculated each time a canister needs to be checked against a specified power limit for storage, transportation, or disposal. TSL-CALVIN calculates the heat output for an assembly by interpolating (or extrapolating) the data in its database that describe heat output for BWR and PWR fuel (zirconium-alloy or stainless-steel clad) as a function of burnup, enrichment, and age. Second, TSL-CALVIN allows for linking the repository emplacement thermal power limit to SNF shipments from power plants or from an interim storage facility. These features were used to determine the decay times needed for direct disposal of DPCs under the different scenarios.

Each simulation in TSL-CALVIN starts from the date of the first fuel discharge (1968). TSL-CALVIN tracks the pool capacity at each reactor site. When the maximum capacity is reached, TSL-CALVIN attempts to select SNF (at least 5 years old) from the pool and load it into the dry canister type for that site. The canister is loaded if the fuel thermal output does not exceed the power limit for storage. Accordingly, the present-day state of the waste management system is calculated rather than specified. This initial state is an approximation (within 5%) of the actual present-day SNF inventory in pools and dry storage.

The future state of the waste management system is calculated based on the parameters that define the scenarios. These parameters include dates when an interim storage facility (if included) and a repository begin accepting SNF, and the location of a repackaging facility (i.e., at the interim storage facility or the repository) if such a facility is needed. Other defining parameters include annual SNF acceptance rates for facilities (can be time-dependent), fuel selection method, whether an interim storage facility is used, repository operational parameters, interim storage and repackaging unit costs, fuel blending options (if blending of different SNF assemblies is used with repackaging to meet thermal limits), and repository emplacement power limits. Parameters also describe the types of canisters to be used at power plants and the date of a switch to new MPCs.

TSL-CALVIN begins by simulating fuel discharges and tracking the inventory in pools and transfers to dry storage. Starting with the year of first acceptance at an interim storage facility or repository, the code selects fuel from among the appropriate reactor sites (using a selection algorithm), that meets site-specific transportation thermal limits. If the shipment is directly to a repository, the fuel is also selected to meet the emplacement power limit. Further calculations depend on where the SNF is transported (interim storage or repository), when and where repackaging takes place, and other factors as determined by the scenario. For each year, TSL-CALVIN calculates the SNF inventory at every facility. To perform these calculations, TSL-CALVIN tracks the properties (age, burnup, and enrichment) of each SNF assembly and its current location in the system. In addition, it calculates the capital and operational costs for the interim storage and repackaging facilities.

As summarized above TSL-CALVIN has the capabilities needed for logistical simulation of DPC direct disposal and MPC packaging and disposal. The outputs provide a detailed temporal description of the state of the waste management system. With post-processing, this information is used to address the questions of a primary interest for the study:

- The amount of SNF in DPCs and MPCs that is available each year for disposal.
- The repository annual acceptance rate, constrained by decay storage and the maximum facility rate.
- The maximum capacity and operating duration of an interim storage facility.
- Fuel age and burnup at emplacement.

SIMULATIONS

DPC **Direct Disposal Scenarios**

The TSL-CALVIN simulations were set up to model the conditions described below. Note that this analysis assumed that all DPCs are transportable and disposable (for scenarios involving direct disposal).

- SNF at the reactor sites is loaded into the site-specific DPCs or into smaller MPCs depending on the loading strategy considered in the scenario.
- If the power plants switch to loading MPCs, it occurs 5 years prior to the repository starting date.
- MPC sizes are limited to 4 PWR or 9 BWR assemblies.
- DPCs and MPCs (as applicable) are transported to an interim storage facility that becomes available in 2025.
- DPCs and MPCs (as applicable) are stored at the interim storage facility at least until the year when a repository becomes available.
- Starting with the first year of repository operations, the DPCs and MPCs (as applicable) are transported from interim storage to a repository if they are cool enough to meet the specified repository emplacement power limit, and the repository acceptance rate limit is met.
- DPCs and MPCs (as applicable) are disposed of at the repository as soon as they arrive.
- The interim storage facility remains operational until the last SNF is transported to the repository.

Two waste acceptance rates for interim storage are considered: 3,000 MTU/year and 4,500 MTU/year. The repository waste acceptance rates are set equal to the interim storage acceptance rates. However, for the repository these are maximum acceptance rates, and the actual rate is calculated rather than specified and reflects the availability of SNF that meets the emplacement power limit. Major scenario defining parameters are the repository emplacement power limit, the repository starting date, and the fuel loading strategy (DPCs only or DPCs switching to MPCs). These variables were selected to represent major uncertainties that may impact direct disposal of DPCs. Further discussion of the scenarios is provided below.

TABLE I. Description of scenarios considered in the system-level analysis.

Scenario		**Repository Starting Date**	**Emplacement Power Limit (kW)**	**SNF Loading Strategy**
Direct Disposal of DPCs	**Full Repackaging Alternative**			
Scenario 1	Scenario I-a (3,000 MTU/yr) Scenario I-b (4,500 MTU/yr)	2036	6	DPCs-Only
Scenario 2				DPCs and MPCs
Scenario 3			10	DPCs-Only
Scenario 4				DPCs and MPCs
Scenario 5			18	DPCs-Only
Scenario 6				DPCs and MPCs
Scenario 7	Scenario II-a (3,000 MTU/yr) Scenario II-b (4,500 MTU/yr)	2048	6	DPCs-Only
Scenario 8				DPCs and MPCs
Scenario 9			10	DPCs-Only
Scenario 10				DPCs and MPCs
Scenario 11			18	DPCs-Only
Scenario 12				DPCs and MPCs
Scenario 13	Scenario III-a (3,000 MTU/yr) Scenario III-b (4,500 MTU/yr)	2060	6	DPCs-Only
Scenario 14				DPCs and MPCs
Scenario 15			10	DPCs-Only
Scenario 16				DPCs and MPCs
Scenario 17			18	DPCs-Only
Scenario 18				DPCs and MPCs

In the absence of a repository site, the geologic disposal host medium is the biggest unknown factor affecting disposal requirements. To represent this uncertainty the following emplacement power limits were considered: 6 kW; 10 kW; and 18 kW. The 6 kW limit is adequate for argillaceous (clay-rich) sedimentary media (with extended repository ventilation) assuming a nominal 100°C host rock temperature limit. The 10 kW limit is appropriate for packages of any size emplaced in salt with a 200°C peak salt temperature limit [Ref. 2]. The 18 kW limit was used for Yucca Mountain and may be applicable to any similar concept involving open emplacement in unsaturated, unbackfilled hard rock [Ref. 2].

The repository starting date is another uncertain parameter. Although the strategy [Ref. 3] plans for a repository opening in 2048, a number of uncertain factors may impact this date. To address this uncertainty, repository starting dates of 2036, 2048, and 2060 were considered. The 2036 early start might be possible with successful siting and an aggressive development schedule. The 2060 opening date represents a late start due to unplanned difficulties.

The MPCs are introduced into this analysis to evaluate if any improvement in disposability of DPCs (e.g., disposal schedule) can be achieved if the utilities switch to MPCs in the future. It is assumed that the disposal environment will be understood so that MPCs can be designed, licensed and implemented 5 years before repository opening. Small MPCs are considered to ensure that cooling time for MPCs is minimal (potential effect on DPC disposal is maximum) in this analysis.

A total of 18 scenarios represent emplacement power limits, repository starting dates, and fuel loading strategies (Table 1). A TSL-CALVIN simulation was performed for each scenario.

Repackaging Scenarios

Scenarios involving full repackaging of all DPCs (into purpose-designed disposal canisters) provide a good reference for assessing DPC direct disposal. Repackaging minimizes the interim storage facility operational duration and capacity because it minimizes the decay storage duration needed for disposal. The repackaging scenarios presented here assume that all SNF at the reactor sites is loaded into site-specific DPCs and transported to the interim storage facility starting in 2025. The SNF is then repackaged at an interim storage facility into canisters purpose-designed for disposal. These disposal canisters are then transported to the repository starting the year when it becomes available. The interim storage waste acceptance rate is set equal to the repository maximum waste acceptance rate. For consistency with the direct disposal of DPCs scenarios, two waste acceptance rates were considered: 3,000 MTU/year and 4,500 MTU/year. The TSL-CALVIN simulator is not needed for the repackaging scenarios presented here because they can be computed directly from the acceptance rates.

Because repackaging can comply with any disposal requirements, the repository emplacement power limit has no effect on the repackaging scenarios. A switch from DPCs to MPCs at the reactor sites is not considered because it does not affect the repackaging scenario logistics and the costs are not considered in this analysis. Consequently, the only variable in the repackaging scenarios is the repository starting date. These starting dates are the same as in the direct disposal of DPCs scenarios: 2036, 2048, and 2060.

The combinations of the repository starting dates and waste acceptance rates result in six different full repackaging scenarios (Table I). Note that in the DPC direct disposal scenarios the waste acceptance rate is not a parameter. The waste acceptance rate is calculated based on the availability of the DPCs that meet the repository emplacement power limit.

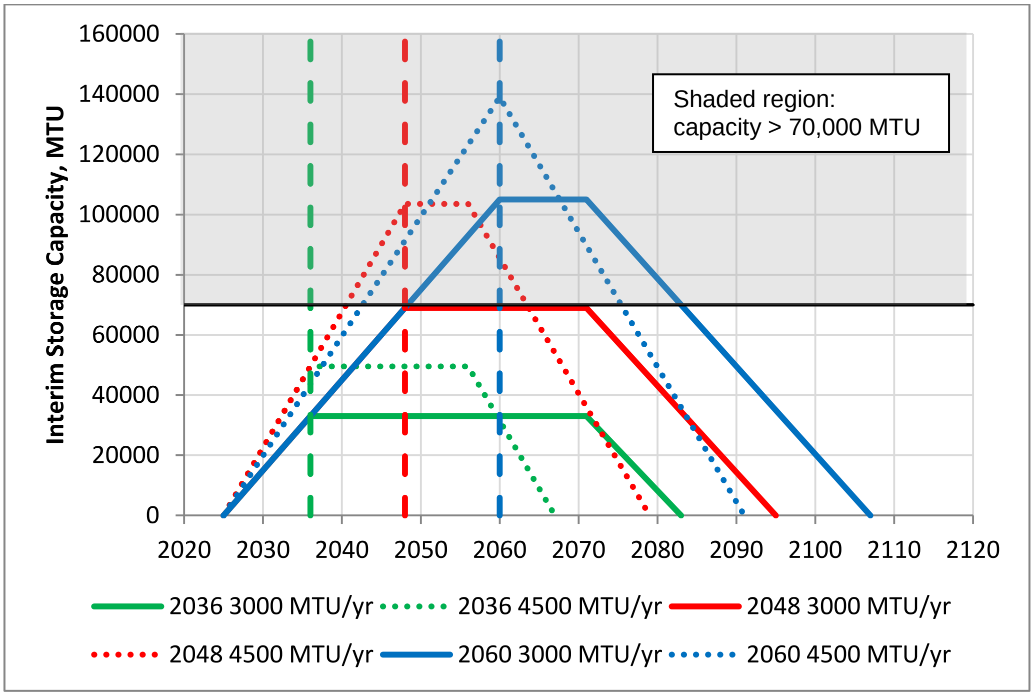
RESULTS

Repackaging Scenario Results

The repackaging scenario results for the interim storage facility are shown in Figure 1. As the scenarios are defined, the interim storage capacity reaches a maximum value at the repository starting date and maintains that capacity until not enough SNF remains at the power plants. From then on the capacity decreases linearly until all SNF is transported to the repository.

The maximum interim storage capacity depends on both the repository starting date and the waste acceptance rate. The minimum storage capacity needed is 33,000 MTU for the case of early repository start and waste acceptance rate 3,000 MTU/yr. Much greater storage capacity is needed for repackaging scenarios with waste acceptance rate of 4,500 MTU/yr, because SNF will be shipped from the power plants much more rapidly. Such scenarios are probably unlikely. A more realistic case is the planned repository start date and a waste acceptance rate of 3,000 MTU/yr.

Note that the interim storage facility operational duration depends only on the waste acceptance rate, for repackaging scenarios as defined. The duration is 47 years with an acceptance rate of 3,000 MTU/year and 31 years with 4,500 MTU/year.



NOTE: The vertical dashed lines show three different repository starting dates - 2036, 2048, and 2060.

Fig. 1. Interim Storage Capacity as a Function of the Repository Starting Date and Waste Acceptance Rate in the Repackaging Scenarios.

DPC Direct Disposal Scenario Results

The cumulative amounts of SNF that are cool enough to meet the repository emplacement power limits in the direct disposal of DPCs scenarios are shown in Figure 2 (6 kW), Figure 3 (10 kW), and Figure 4 (18 kW) for the different repository opening dates: 2036, 2048, and 2060. The dashed vertical lines in these figures show the time of completion of the corresponding repackaging scenarios for the 3,000 MTU/year waste acceptance rate.

Figures 2 through 4 demonstrate the importance of the repository emplacement power limits for DPC direct disposal. The year at which 98% of the total inventory can be emplaced is 2162 for the 6 kW limit, 2112 for the 10 kW limit, and 2074 for the 18 kW limit. All of the 18 kW scenarios can be completed at the same time as the corresponding repackaging scenarios.

The fuel loading strategy (with or without MPCs) is important for the 6 kW and 10 kW scenarios with early or planned repository start dates. Switching to MPCs increases the amount of SNF available for earlier disposal, especially for the 6 kW scenarios. If the repository is delayed until 2060, switching to MPCs has no impact on the SNF availability for disposal regardless of the repository emplacement power limit.

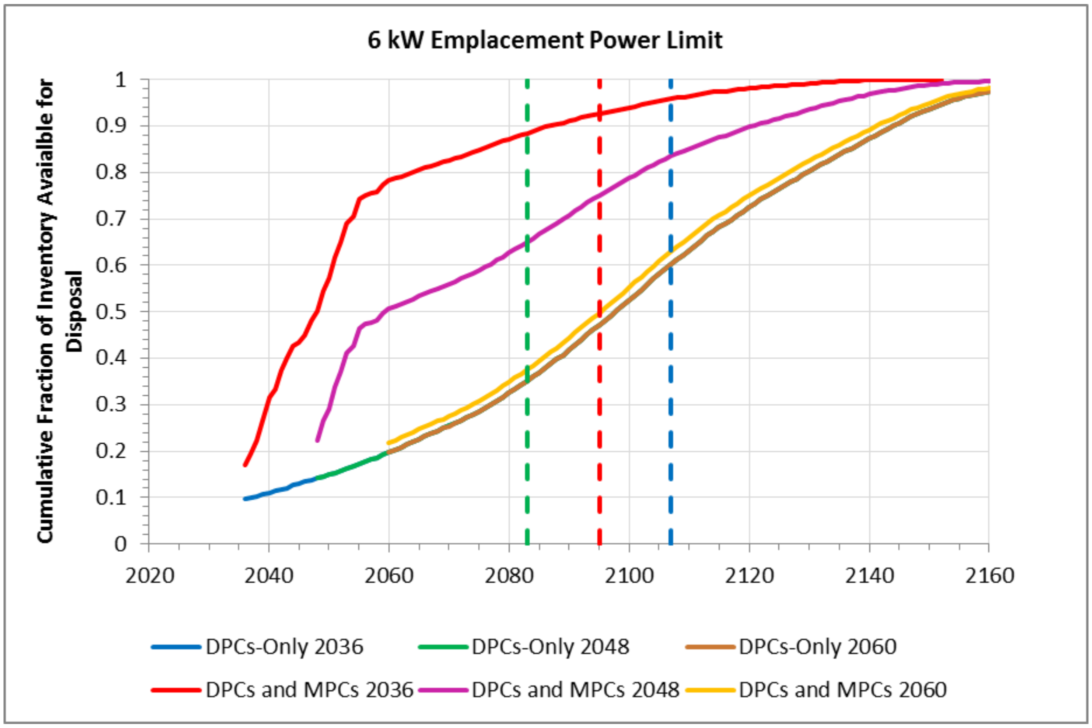


Fig. 2. Cumulative Inventory Available for Disposal in a Repository with 6 kW Constraint.

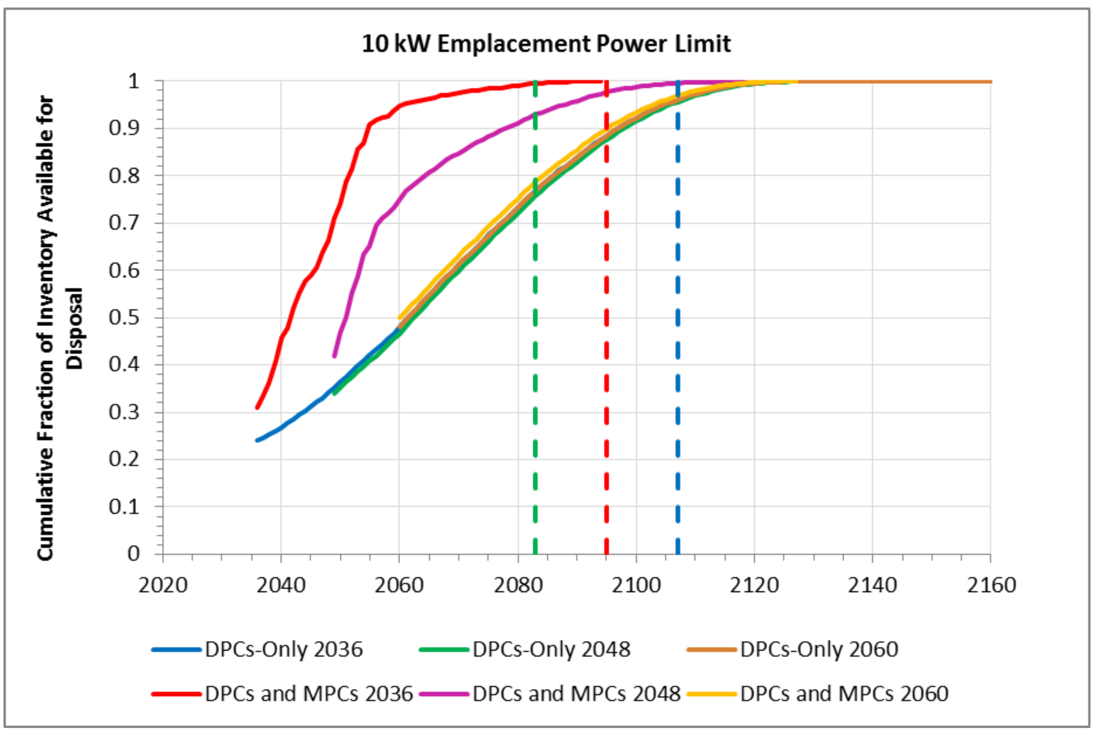


Fig. 3. Cumulative Inventory Available for Disposal in a Repository with 10 kW Constraint.

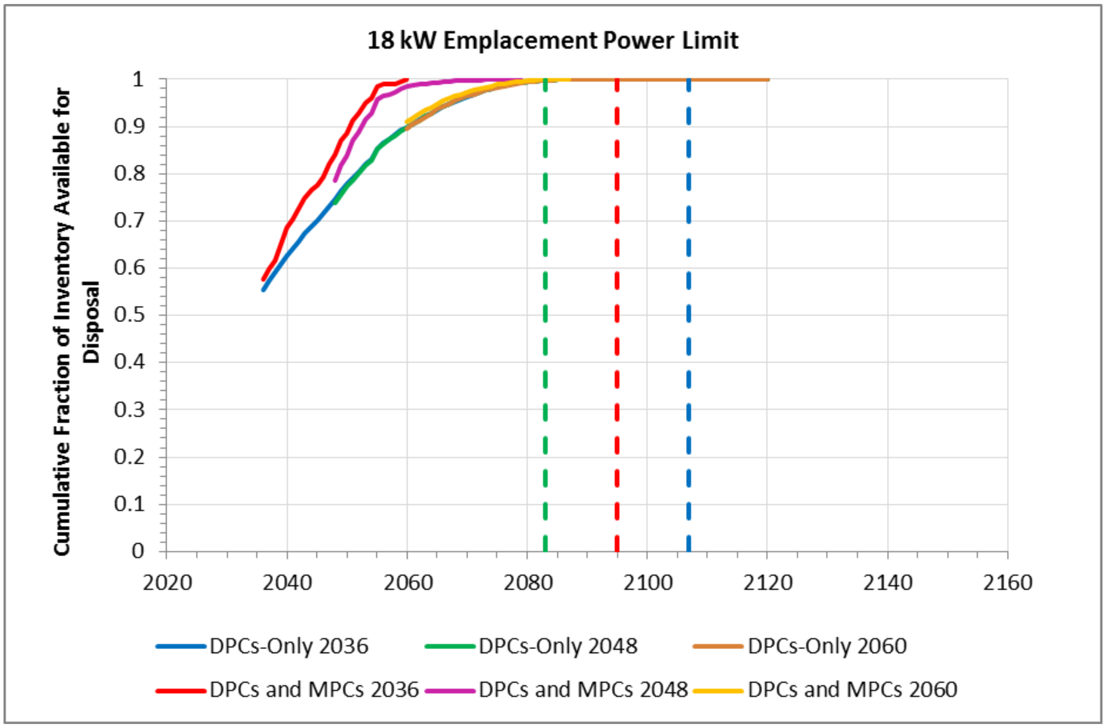


Fig. 4. Cumulative Inventory Available for Disposal in a Repository with 18 kW Constraint.

For a specified emplacement power limit, the availability of SNF in DPCs for direct disposal ("DPCs only") is insensitive to the repository starting dates (lowermost curve in Figures 2 through 4). However, the repository starting date affects the amounts of the SNF in the DPC-only scenarios that can be disposed of by the time of completion of the corresponding repackaging scenario. For example, if the repository starting date is 2036 and the emplacement power limit is 6 kW, by the time the repackaging is completed (2083) only 36% of the total SNF inventory is cool enough to be emplaced. If the repository starting date is 2060, by the time the repackaging is completed 62% of the total SNF inventory is cool enough to be emplaced under the same thermal power limit constraint.

The actual repository acceptance rates calculated assuming the maximum repository acceptance rate of 3,000 MTU/year are shown in Figures 5 through 7, for the different repository starting dates for the scenarios with 6 kW and 10 kW emplacement power limits. The scenarios with the 18 kW emplacement power limit are not shown because in these scenarios the actual repository acceptance rates can be maintained at the maximum rate during all (or majority) of the operational period.

The scenarios with 6 kW and 10 kW emplacement power limits are impacted by the repository starting date and the fuel loading strategy. Introducing MPCs in early and planned repository scenarios allows for maintaining maximum repository acceptance rates over significantly longer period of time (Figures 5 and 6). Implementing MPCs in the late repository scenarios has no impact on the repository acceptance rates.

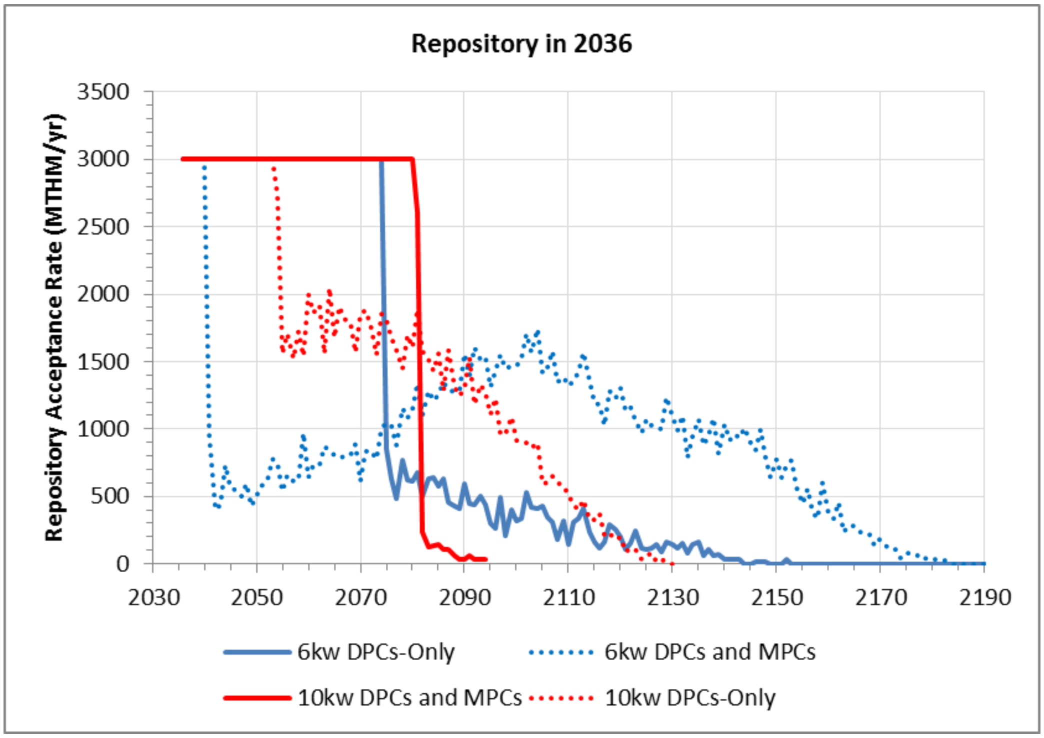


Fig. 5. Annual Repository Acceptance Rate for a Repository in 2036.

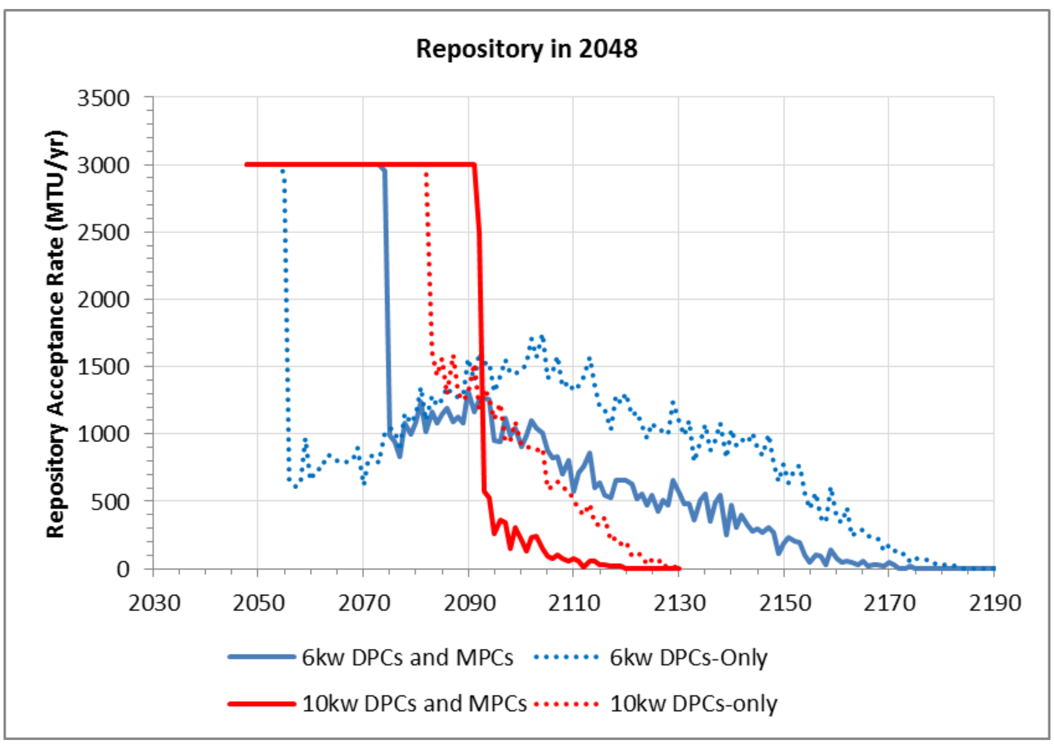


Fig. 6. Annual Repository Acceptance Rate for a Repository in 2048.

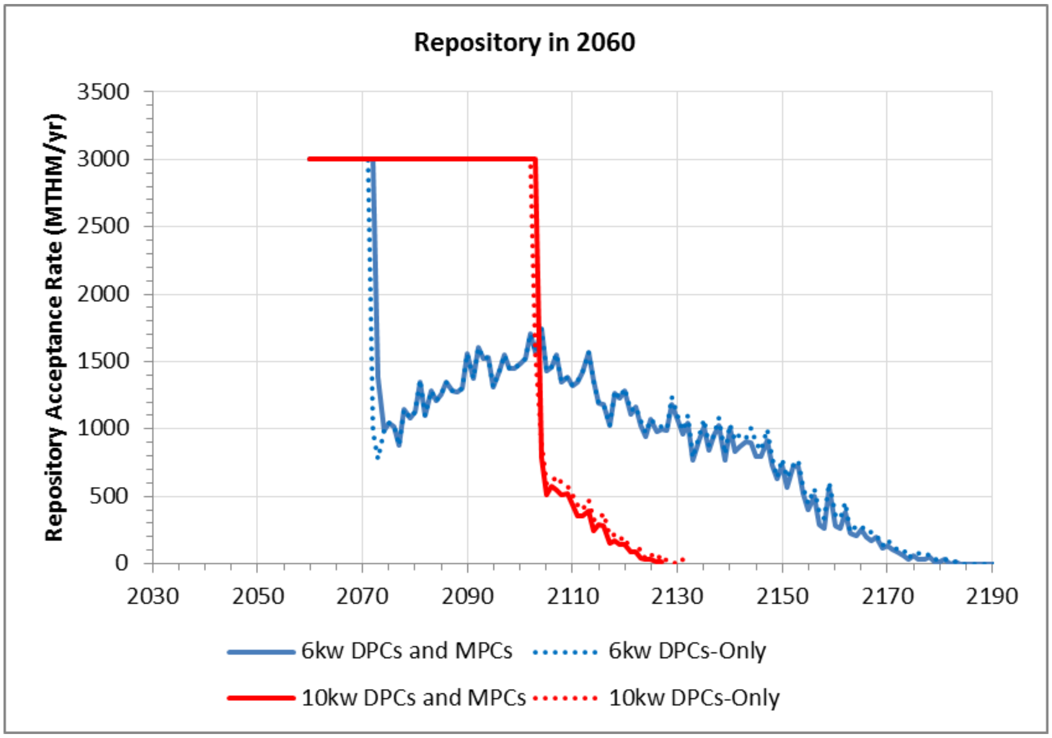


Fig. 7. Annual Repository Acceptance Rate for a Repository in 2060.

Fuel Age at Emplacement

Average fuel age at emplacement (averaged per metric ton) is shown in Figure 8 for the different repository emplacement power limits and fuel loading strategies, as a function of the repository starting date. By implementing MPCs in the scenarios with the 6 kW repository emplacement power limit and repository starting dates 2036 and 2048, the average fuel age at emplacement can be significantly reduced (by 20 to 30 years). The scenarios with the 10 kW emplacement power limit and repository starting date of 2036 and 2048 are only slightly affected by introducing MPCs. The average fuel age at emplacement in the scenarios with the 18 kW emplacement power limit is unaffected by introducing MPCs. The average fuel age at emplacement in the scenarios with the repository starting date in 2060 is not affected by introducing MPCs. For the repository start in 2048, the average fuel age at emplacement is 58 to 62 years in the scenarios in which MPCs are implemented and 61 to 84 years in the scenarios with DPCs only.

Figures 9 and 10 show the differences between the inventory in DPCs and inventory in MPCs for the 6 kW repository emplacement power limit scenario and repository in 2036. This scenario was selected because it demonstrates the greatest potential benefits from introducing MPCs. The differences in the inventory properties are shown with regard to the age at emplacement (Figure 9) and burnup (Figure 10). In this scenario, 40% of the total inventory is disposed of in DPCs and 60% is disposed of in MPCs. The majority of fuel in MPCs is 30 years old or younger. The fuel in DPCs is 50 years old or older. The burnup of the fuel in MPCs is 45 GWD/MTU or higher. The burnup of the fuel in DPCs is 35 to 45 GWD/MTU or lower.

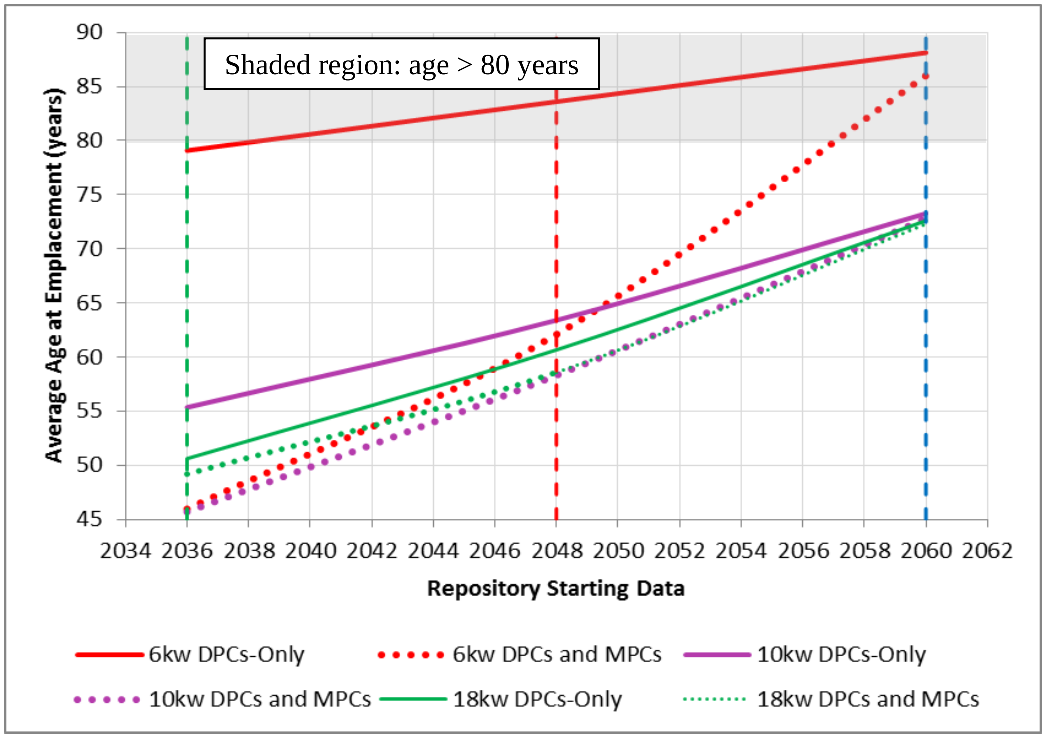


Fig. 8. Average Fuel Age at Emplacement as a Function of Repository Starting Date.

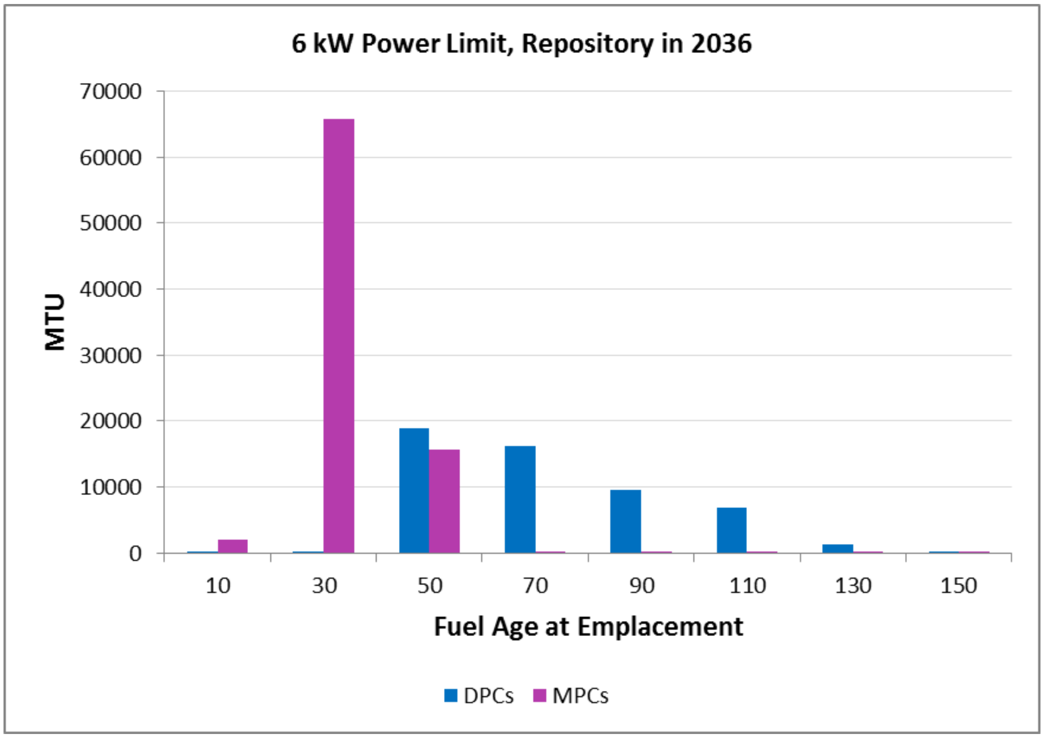


Fig. 9. Fuel Age at Emplacement Distribution Between DPCs and MPCs.

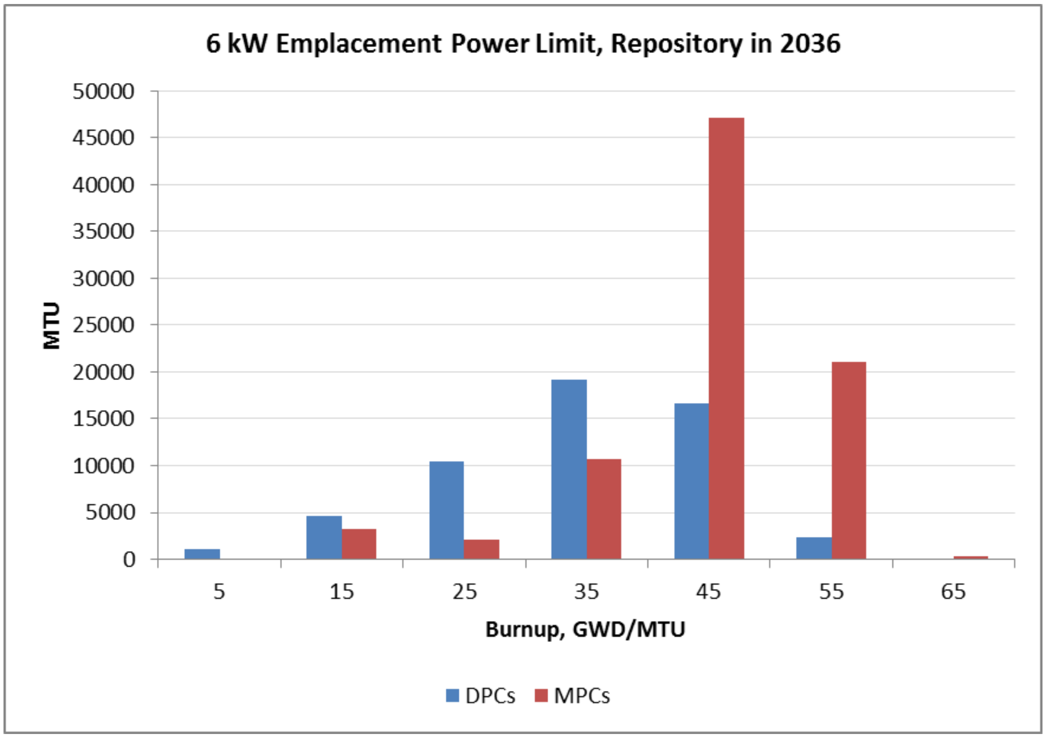


Fig. 10. Fuel Burnup Distribution Between DPCs and MPCs.

Comparison of DPC Direct Disposal with Repackaging Scenarios

The DPC direct disposal scenarios are compared to the corresponding repackaging scenarios in Table II. The comparison is based on the additional operating duration and capacity required at an interim storage facility, for DPC direct disposal vs. repackaging, with a waste acceptance rate of 3,000 MTU/yr. Note that the last year of the operations is the year when 98% of the total inventory is transported to the repository.

Only three of the 18 DPC direct disposal scenarios require additional interim storage capacity compared to the corresponding repackaging scenarios, with the 3,000 MTU/yr waste acceptance rate. These scenarios are the ones with lower emplacement power limits (6 kW and to some extent 10 kW) and earlier repository starting dates (2036 and 2048). The storage capacity during the interim storage operational period is shown for these scenarios in Figure 9. By introducing MPCs, the need for additional interim storage capacity is virtually eliminated.

Additional operating duration is needed for scenarios with the 6 kW emplacement power limit (ranging from 55 to 79 years; switching MPCs reduces this range to 36 to 53 years). The additional operating duration time is also needed for the 10 kW emplacement power limit for DPC-only scenarios with repository starting date in 2036 and 2048. Additional operating duration for an interim storage facility is not needed for the 18 kW scenarios.

TABLE II. Direct disposal of DPCs compared to repackaging scenarios.

Repository Start Date	Emplacement Power Limit (kW)	Fuel Loading Strategy	Maximum Capacity (MTU)	Last Year of Operation	Additional Capacity (MTU)	Additional Operation (years)
2036	6	DPC only	102,701	2162	**69,701**	**79**
	6	DPCs and MPCs	33,000	2119	0	**36**
	10	DPC only	53,245	2112	**20,245**	**29**
	10	DPCs and MPCs	33,000	2083	0	0
	18	DPC only	33,000	2083	0	0
	18	DPCs and MPCs	33,000	2083	0	0
2048	6	DPC only	102,701	2162	**33,701**	**67**
	6	DPCs and MPCs	69,000	2145	0	**50**
	10	DPC only	69,000	2112	0	**17**
	10	DPCs and MPCs	69,000	2095	0	0
	18	DPC only	69,000	2095	0	0
	18	DPCs and MPCs	69,000	2095	0	0
2060	6	DPC only	105,000	2162	0	**55**
	6	DPCs and MPCs	105,000	2160	0	**53**
	10	DPC only	105,000	2112	0	5
	10	DPCs and MPCs	105,000	2110	0	3
	18	DPC only	105,000	2107	0	0
	18	DPCs and MPCs	105,000	2107	0	0

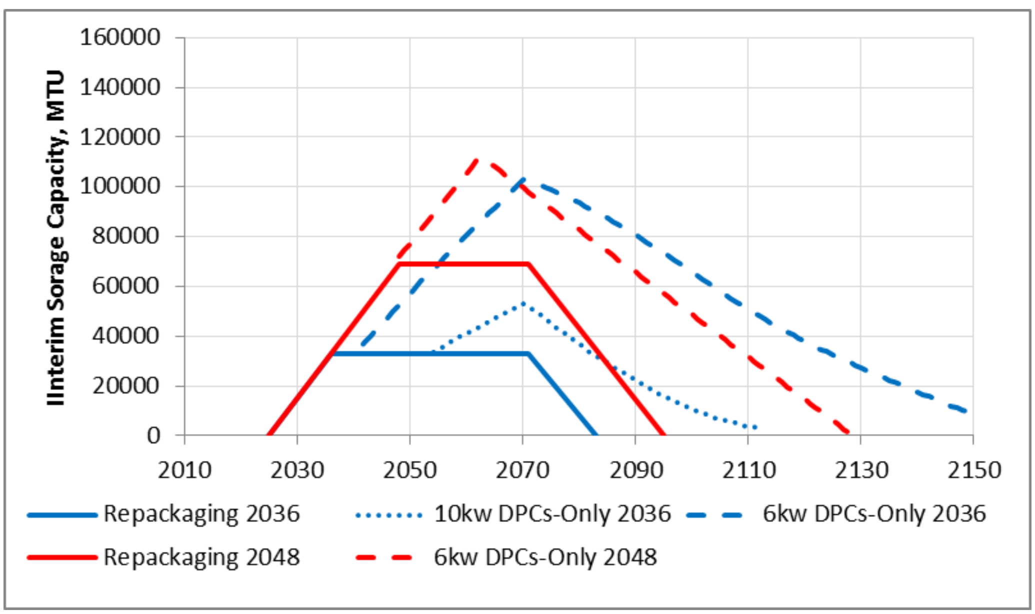


Fig. 11. Storage Capacity in the Scenarios Requiring Additional Storage Compared to Repackaging Scenarios.

CONCLUSIONS

The conclusions of this analysis apply to the logistics of DPC direct disposal along with switching to MPCs, and any other potential constraints or limitations are not considered.

In the scenarios with a repository emplacement power limit of 18 kW (e.g., for an open disposal mode in unsaturated hard rock, without backfilling) additional cooling time or interim storage capacity would not be needed for DPC direct disposal, compared to the corresponding repackaging scenarios. The waste acceptance rate could be maintained at 3,000 MTU/yr throughout repository operations regardless of the repository starting date. This is because the 18 kW emplacement power limit is high enough to accommodate thermal output from existing DPCs.

In scenarios with a repository emplacement power limit of 10 kW (e.g., salt repository) and repository starting dates in 2036 and 2048, some additional cooling time and interim storage capacity would be needed for DPC direct disposal compared to the corresponding repackaging scenarios. The waste acceptance rate could be maintained at 3,000 MTU/yr only during the first 19 to 35 years of repository operations, after which the rate would decline. If dry-canister loading at the power plants switches from DPCs to MPCs, no additional storage capacity would be needed, and little or no additional cooling time would be needed, with waste acceptance rate of 3,000 MTU/yr.

In the scenarios with a repository emplacement power limit of 6 kW (e.g., argillaceous sedimentary media) significant additional cooling time and interim storage capacity would be needed for DPC direct disposal compared to the repackaging scenarios (except for the late repository start in 2060). The waste acceptance rate would be less than 3,000 MTU/yr during most of the repository operations. The schedule could be improved to some extent by switching to MPCs. For the scenarios with MPCs no additional storage capacity would be needed, and less cooling time, with waste acceptance rate of 3,000 MTU/yr.

The greatest potential benefits from implementing MPCs on cooling time, interim storage capacity, repository waste acceptance rate, and fuel age at emplacement are associated with the smallest power limit and the earliest repository start date. For a repository start date of 2060, transition to MPCs would make little difference regardless of the emplacement thermal power limit.

In general, MPCs would be used for 30 years or younger, higher burnup fuel. Even in the most limiting scenario with the 6 kW emplacement power limit, 60% of the total SNF inventory could be disposed of in MPCs with minimal cooling time, while 40% of the inventory could be disposed of in DPCs for 50 years of older fuel with longer, but reasonable cooling time.

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