SAND2015-4538PE

Used Fuel Disposition Campaign

System-Level Logistics for DPC Disposal

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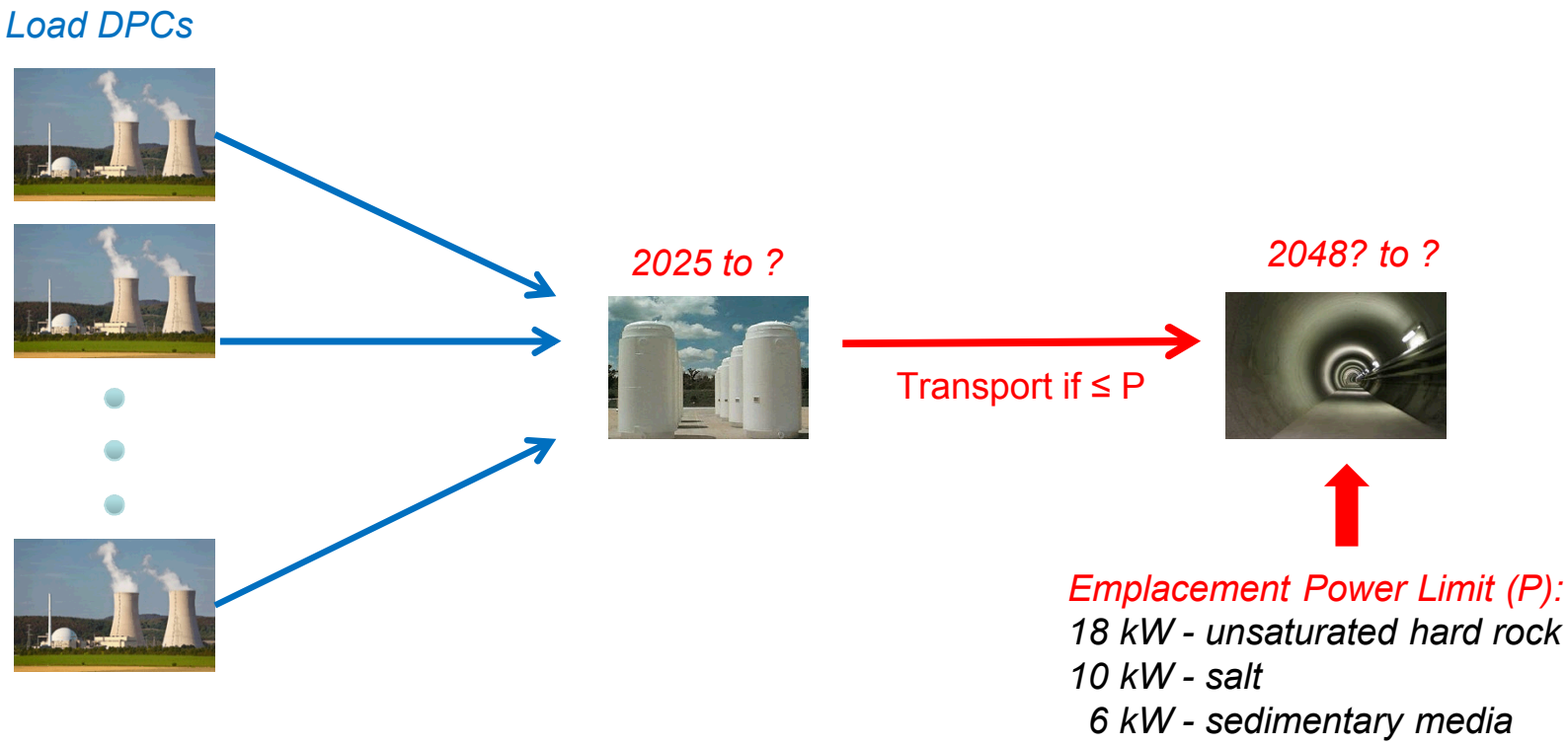
LOGISTIC SIMULATION OBJECTIVES

- *Amount of SNF in DPCs available each year for disposal.*
- *Repository annual acceptance rate constrained by emplacement power limit*
- *Maximum capacity and operating time of an interim storage facility (ISF).*
- *Fuel age and burnup at emplacement.*



LOGISTIC SIMULATION SETUP

Parameters

- *Repository Starting Dates: 2036 (early start); 2048 (planned start); and 2060 (late start).*
- *Emplacement Thermal Power Limits: 6 kW; 10 kW; and 18 kW.*
- *Fuel Loading Scenarios: DPCs-Only and DPCs and MPCs (4PWR)*

Assumptions

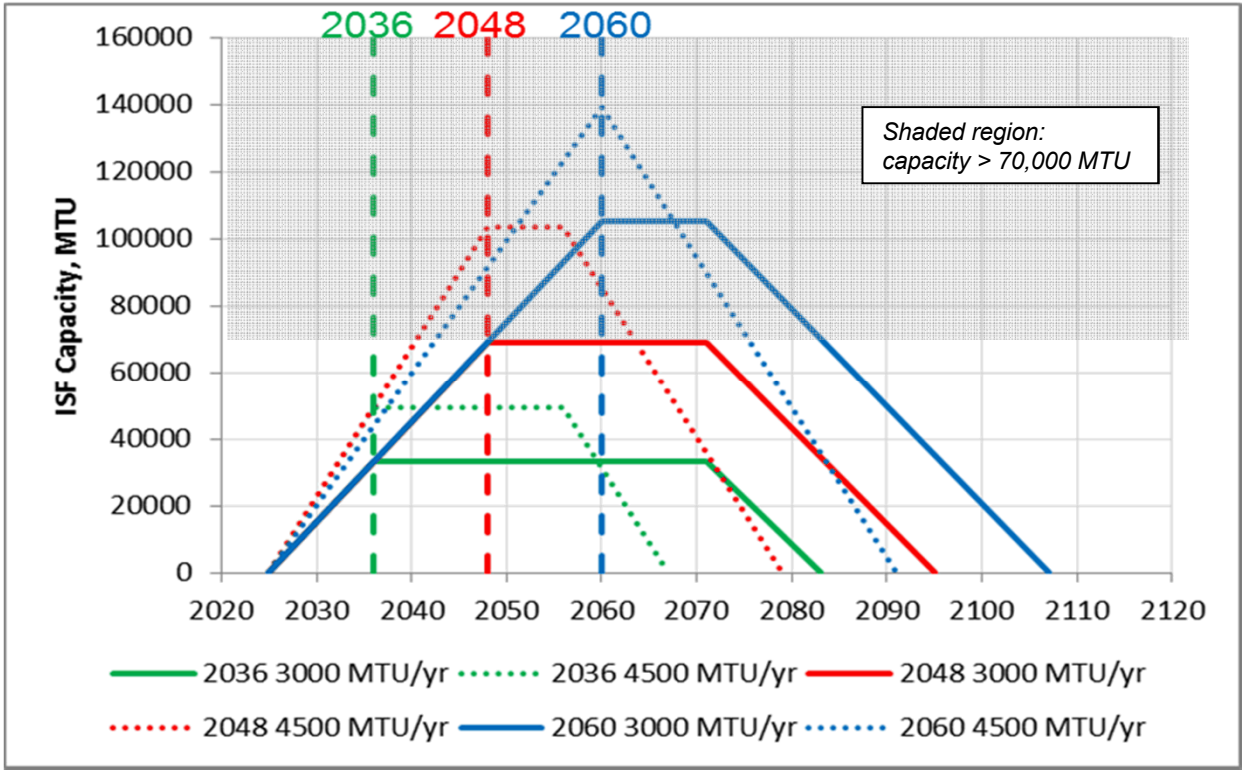
- *Loading of MPCs at power plants begins 5 years prior to the repository opening.*
- *All DPCs (and "storage only" canisters) are transportable and disposable.*
- *ISF begins its full operations in 2025.*
- *The DPCs and MPCs are stored at ISF until they meet the repository emplacement power thermal limit.*

DIRECT DISPOSAL OF DPCS LOGISTIC SCENARIOS

Scenario	Repository Starting Date	Emplacement Power Limit (kW)	Fuel Loading Strategy
1	2036	6	DPCs-Only
2			DPCs and MPCs
3		10	DPCs-Only
4			DPCs and MPCs
5		18	DPCs-Only
6			DPCs and MPCs
7	2048	6	DPCs-Only
8			DPCs and MPCs
9		10	DPCs-Only
10			DPCs and MPCs
11		18	DPCs-Only
12			DPCs and MPCs
13	2060	6	DPCs-Only
14			DPCs and MPCs
15		10	DPCs-Only
16			DPCs and MPCs
17		18	DPCs-Only
18			DPCs and MPCs

NEEDED ISF CAPACITY AND DURATION OF OPERATIONS

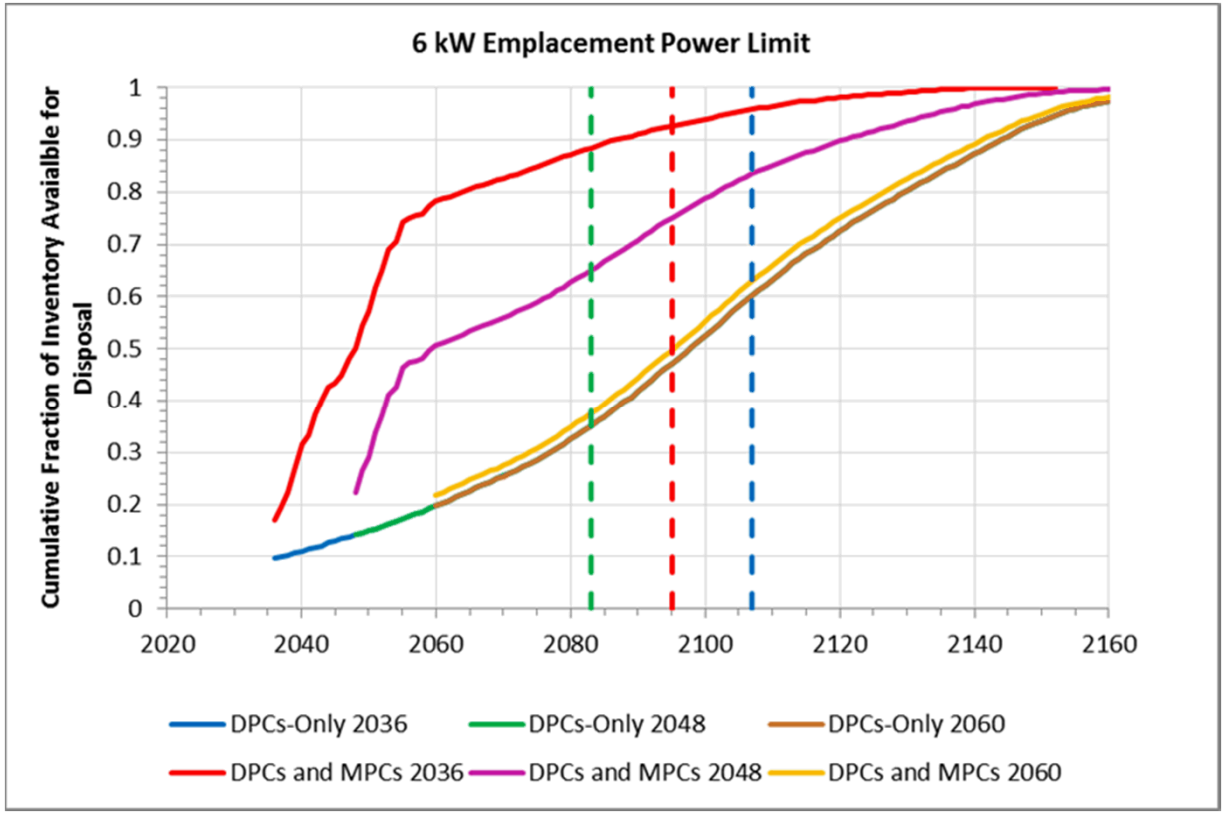
ISF Capacity and Operational Time for Different Repackaging Alternatives



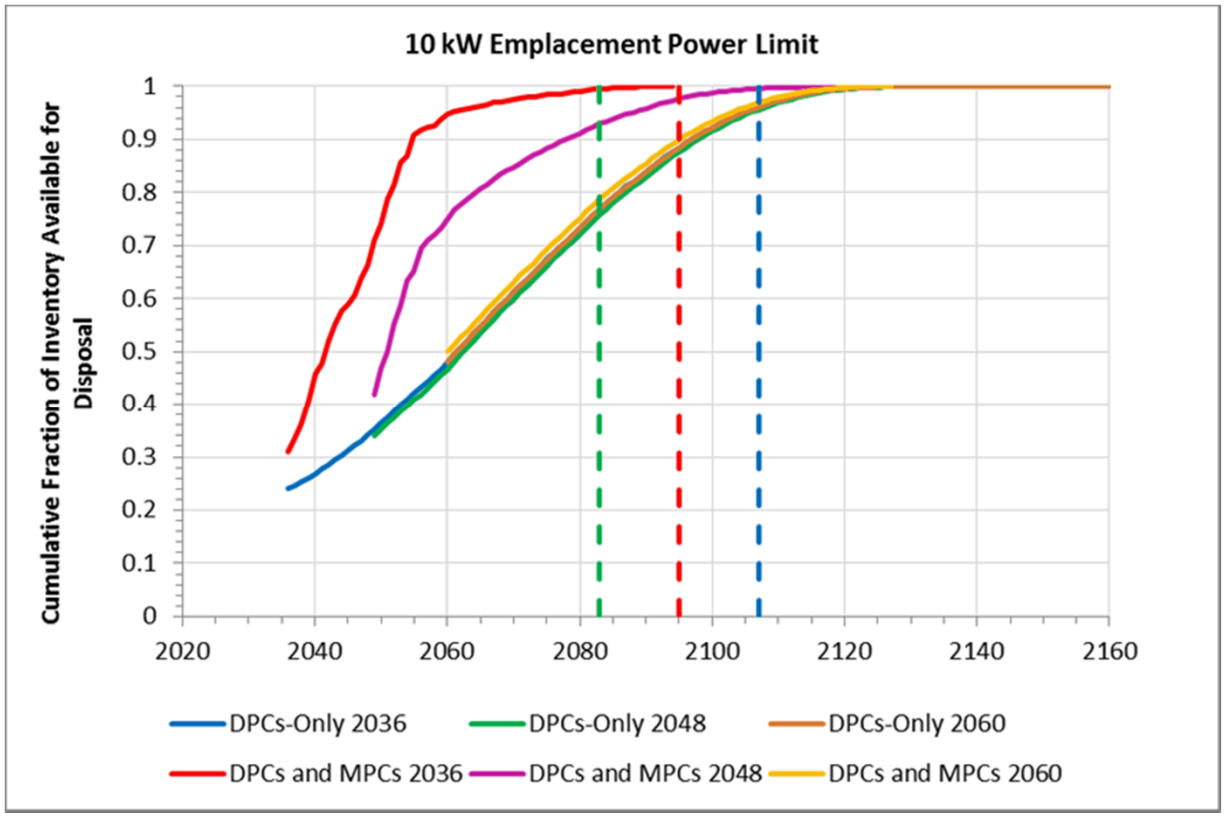
ISF Operational Time:

- 47 yrs for all alternatives with 3,000 MTU/yr *repository throughput*
- 31 yrs for all alternatives with 4,500 MTU/yr *repository throughput*

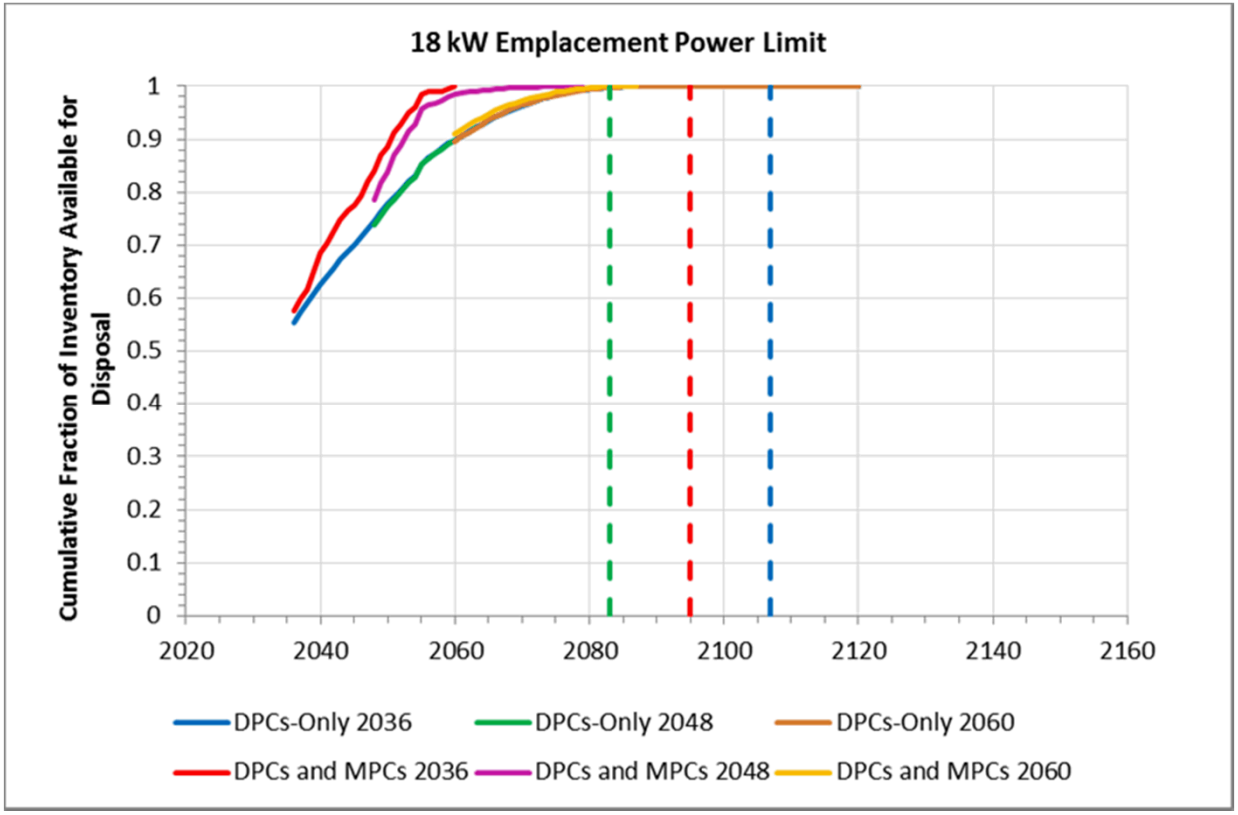
WHEN IS SNF COOL ENOUGH FOR DISPOSAL? 6 KW WITH DPCS AND MPCS



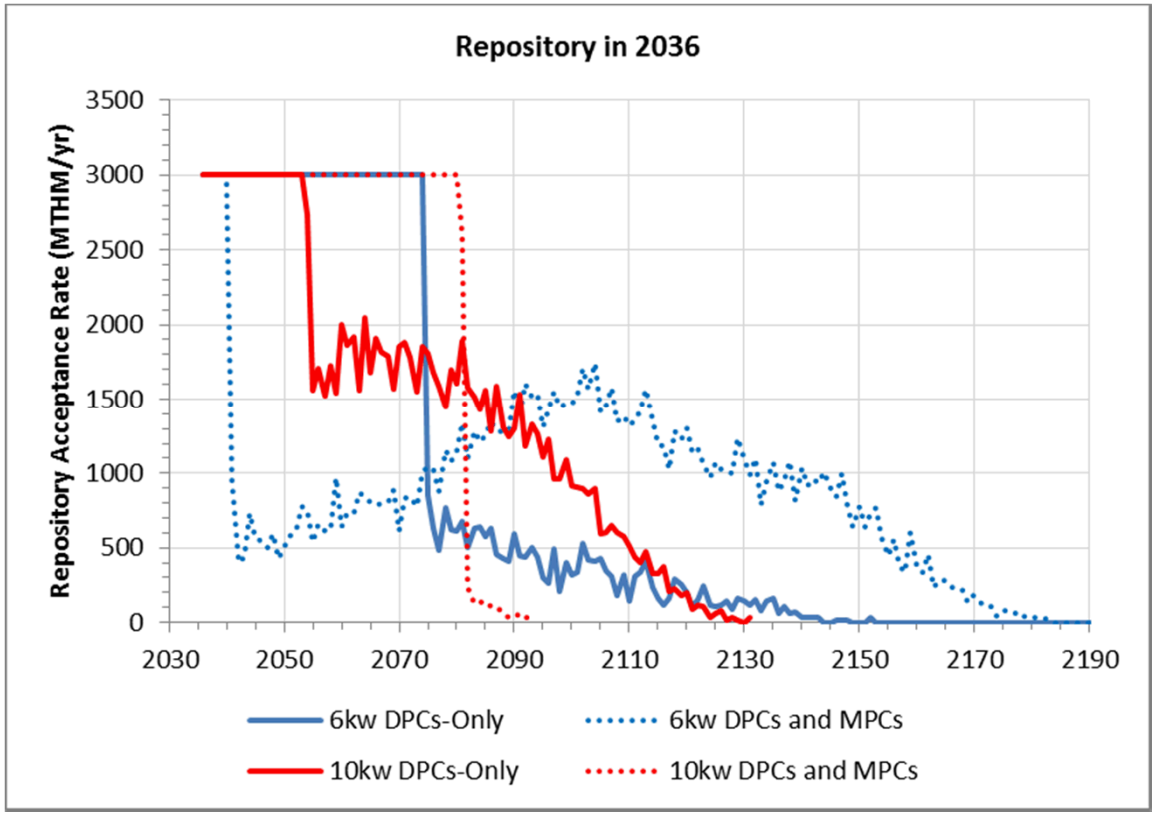
WHEN IS SNF COOL ENOUGH FOR DISPOSAL? 10 KW WITH DPCS AND MPCS



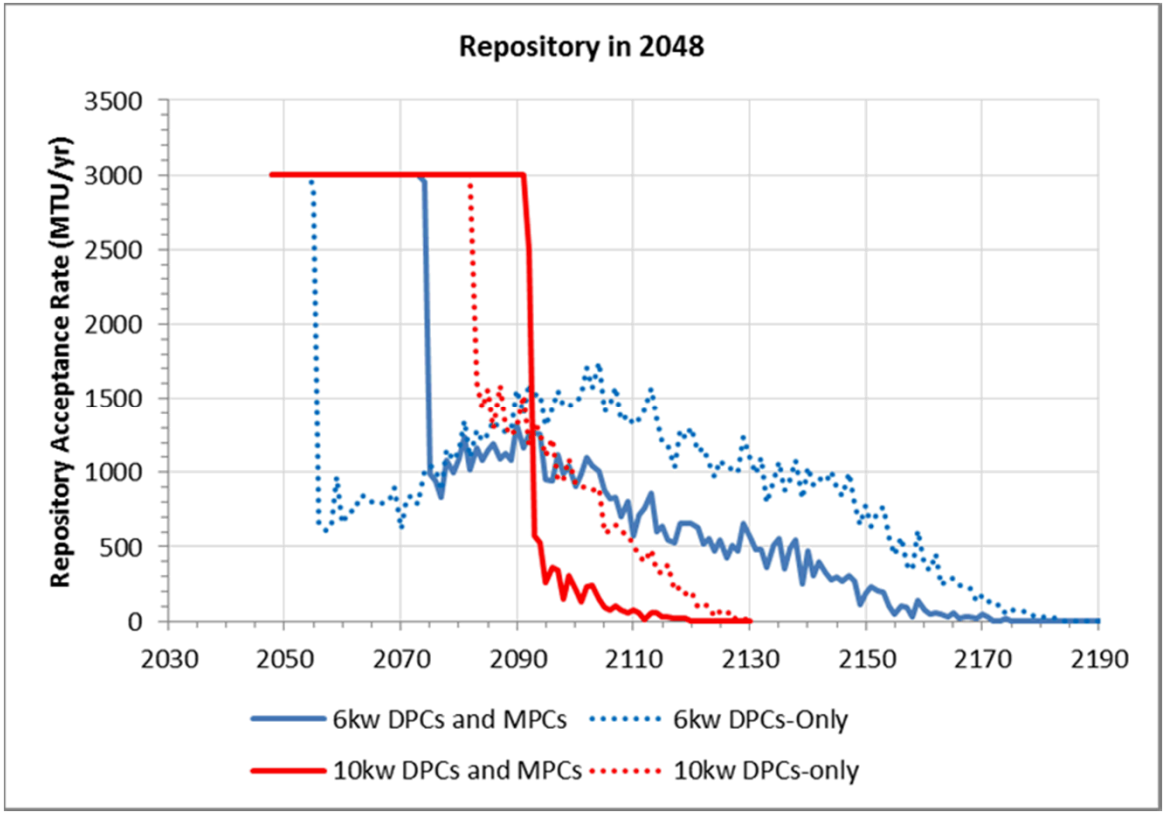
WHEN IS SNF COOL ENOUGH FOR DISPOSAL? 18 KW WITH DPCS AND MPCS



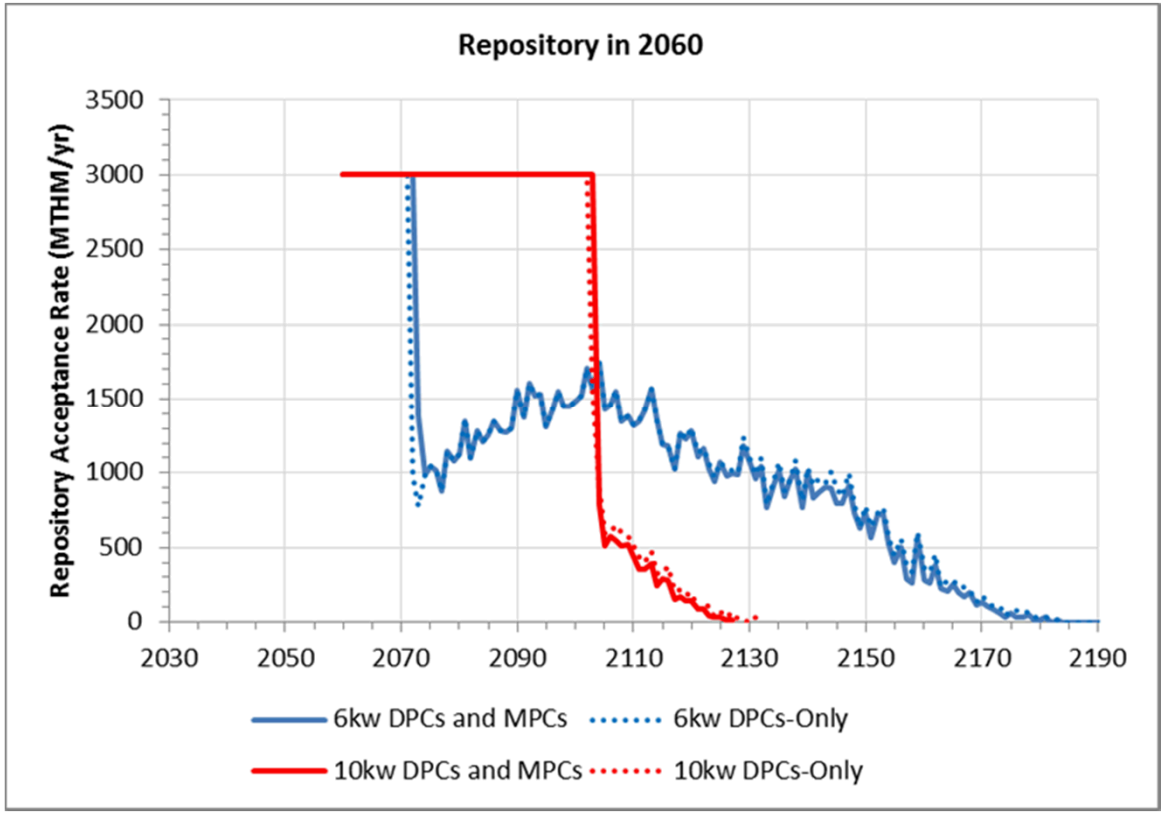
REPOSITORY ACCEPTANCE RATE REPOSITORY IN 2036



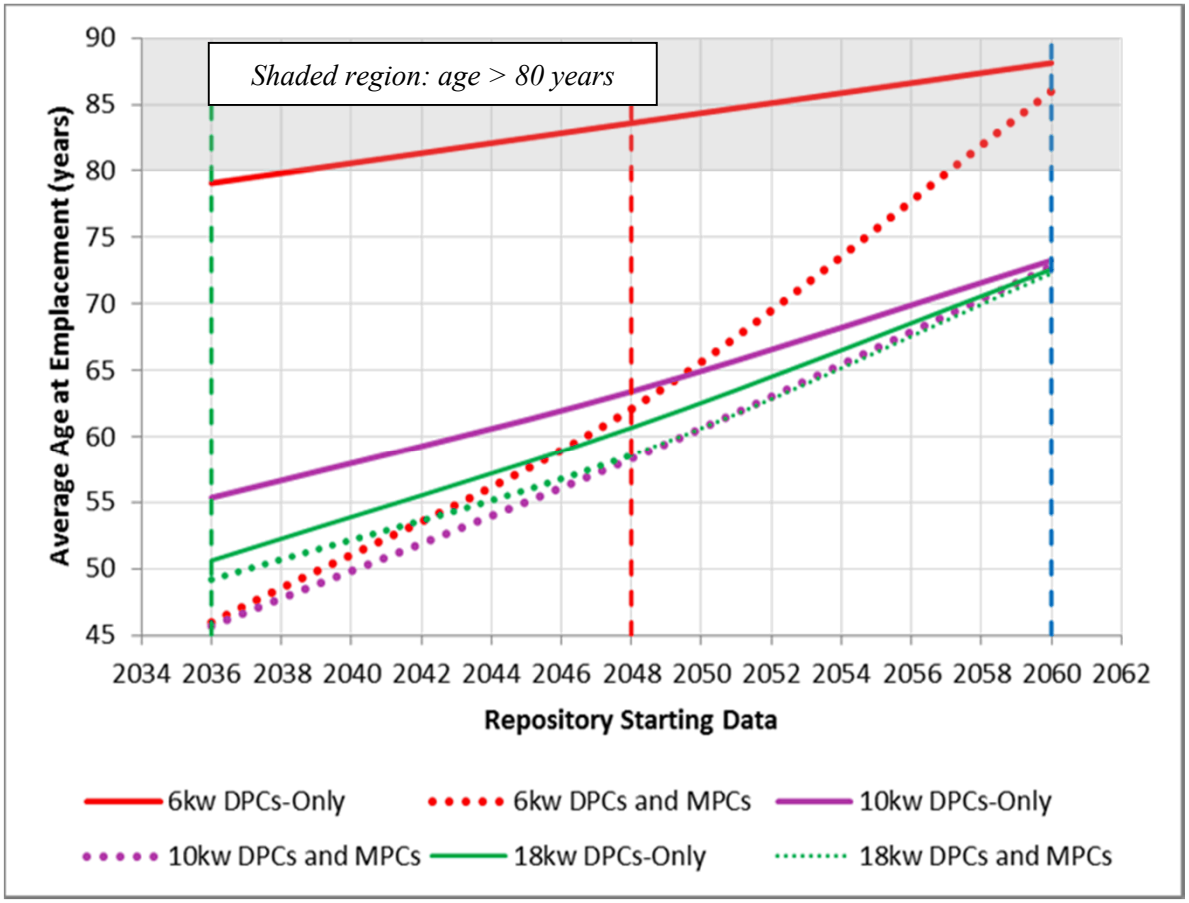
REPOSITORY ACCEPTANCE RATE REPOSITORY IN 2048



REPOSITORY ACCEPTANCE RATE REPOSITORY IN 2060

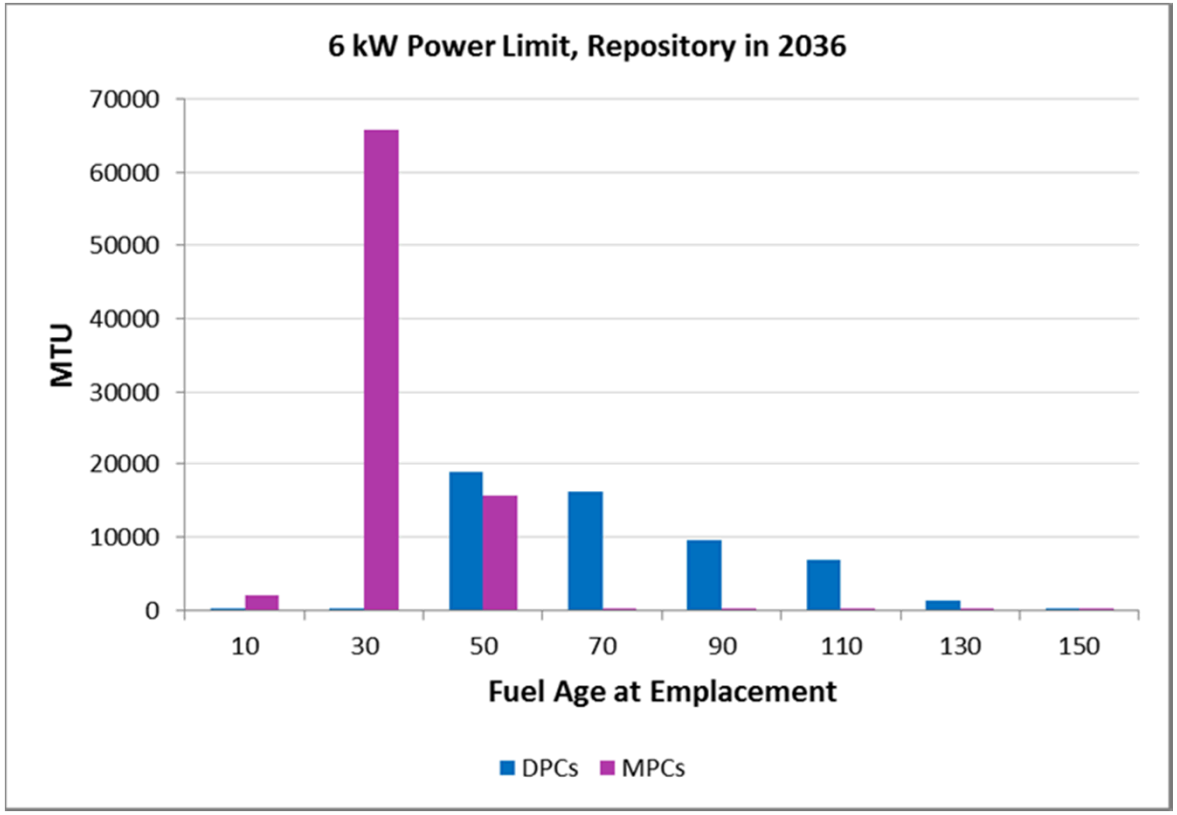


AVERAGE AGE AT EMPLACEMENT

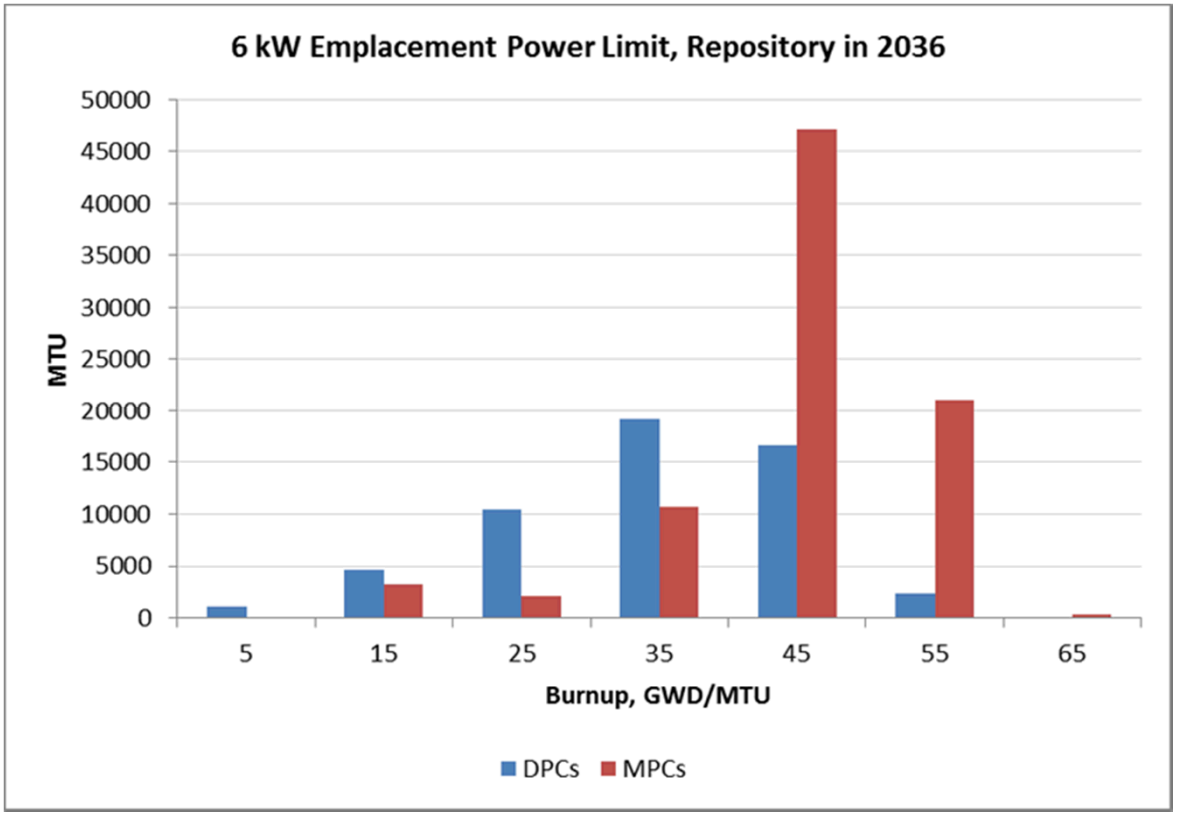


AGE AT EMPLACEMENT

6 kW, DPCS AND MPCS



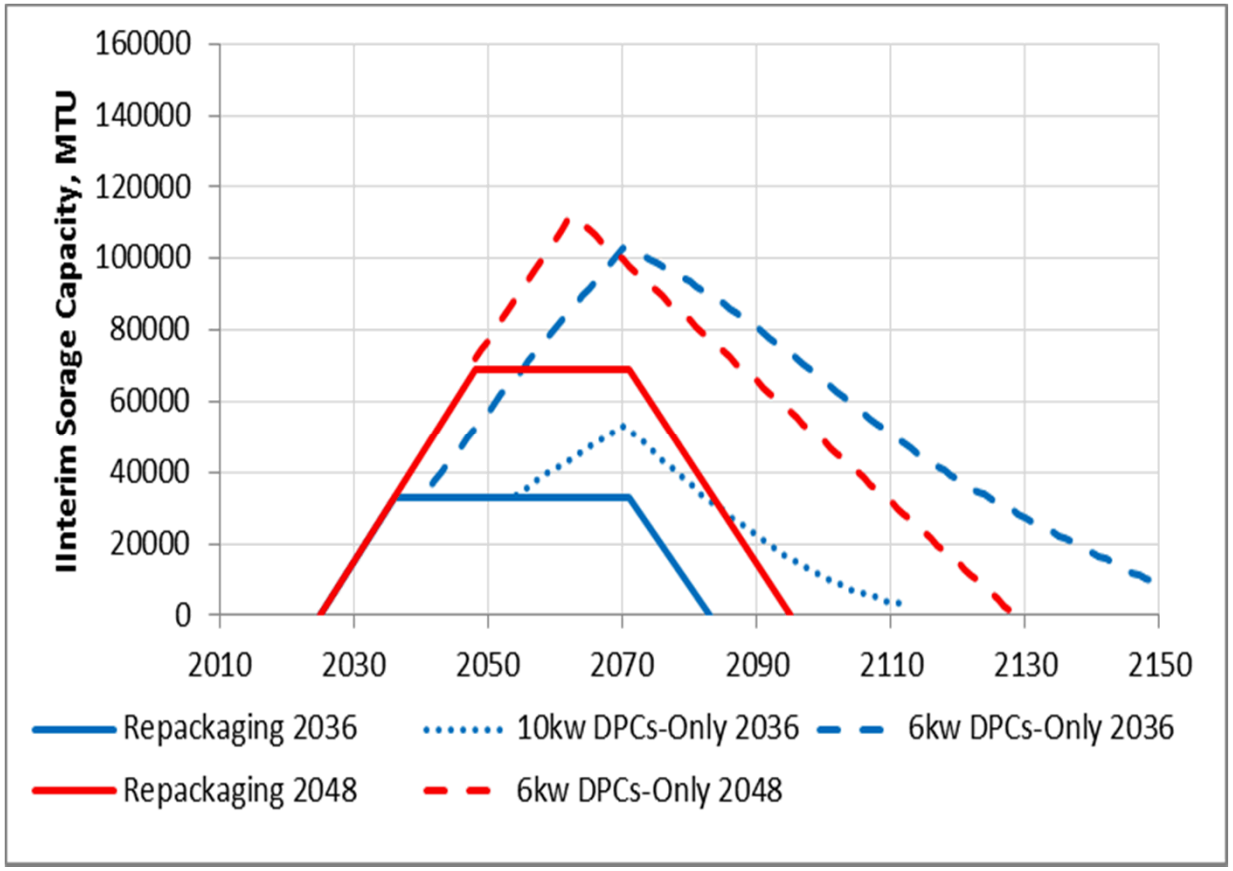
BURNUP AT EMPLACEMENT
6 kW, DPCS AND MPCS



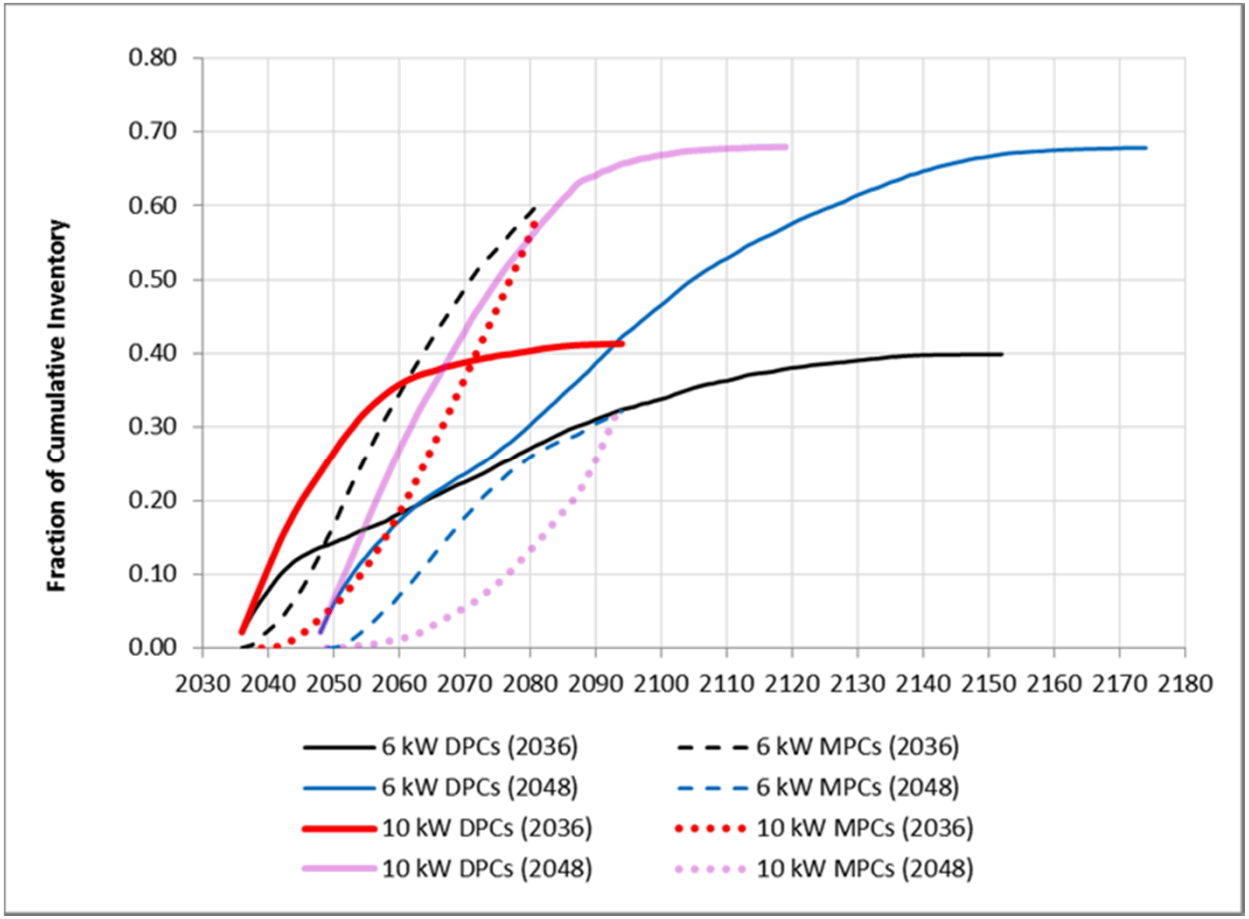
ISF MAXIMUM CAPACITY AND OPERATIONAL TIME

Repository Start Date	Emplacement Power Limit (kW)	Fuel Loading Strategy	Additional Capacity (MTU)	Additional Operation (yrs)
2036	6	DPC only	69,701	79
		DPCs and MPCs	0	36
	10	DPC only	20,245	29
		DPCs and MPCs	0	0
	18	DPC only	0	0
		DPCs and MPCs	0	0
2048	6	DPC only	33,701	67
		DPCs and MPCs	0	50
	10	DPC only	0	17
		DPCs and MPCs	0	0
	18	DPC only	0	0
		DPCs and MPCs	0	0
2060	6	DPC only	0	55
		DPCs and MPCs	0	53
	10	DPC only	0	5
		DPCs and MPCs	0	3
	18	DPC only	0	0
		DPCs and MPCs	0	0

CASES WITH LONGER THAN FOR RE-PACKAGING ISF STORAGE



Cumulative Inventory Cooled to 6 kW and 10 kW (Repository in 2036 and 2048)



CONCLUSIONS

- *18 kW Scenarios – Direct disposal of DPCs is possible with no additional cooling time or ISF capacity.*
- *10 kW Scenarios – Direct disposal of DPCs requires some additional cooling time and ISF capacity. With MPCs, little additional cooling time or ISF capacity would be needed.*
- *6 kW Scenarios – Direct disposal of DPCs requires significant additional cooling time and ISF capacity. With MPCs less cooling time and no additional ISF capacity would be needed.*
- *Throughput – 3,000 MTU/yr throughput is only possible for 18 kW scenarios.*
- *MPC Benefits – Greatest for low power limits and early repository start dates.*
- *MPC Usage – Used for relatively young (<30 yr), higher burnup fuel.*
- *Cooling Time with MPCs – For 6 kW scenarios the cooling time is still reasonable (~80 yr or less) when MPCs are used.*
- *SNF in MPCs does not require decay storage and can be disposed off as soon as the repository becomes operational.*

Effects of Repository Thermal Limits for System Architecture Study (FY15)

Purpose: Examines the impact of repository thermal limits on capacity of the ISF

Scenarios

1. *4 PWR – Clay/Granite, (a) ISF and (b) MGR Repackaging, 3000 MTHM/yr, Cans*
2. *4 PWR – Clay/Granite, (a) ISF and (b) MGR Repackaging, 3000 MTHM/yr, Cans+Bare*
3. *4 PWR – Clay/Granite, (a) ISF and (b) MGR Repackaging, 4500 MTHM/yr, Cans*
4. *4 PWR – Clay/Granite, (a) ISF and (b) MGR Repackaging, 4500 MTHM/yr, Cans+Bare*
5. *12 PWR – Salt, (a) ISF and (b) MGR Repackaging, 3000 MTHM/yr, Cans*
6. *12 PWR – Salt, (a) ISF and (b) MGR Repackaging, 3000 MTHM/yr, Cans+Bare*
7. *12 PWR – Salt, (a) ISF and (b) MGR Repackaging, 4500 MTHM/yr, Cans*
8. *12 PWR – Salt, (a) ISF and (b) MGR Repackaging, 4500 MTHM/yr, Cans+Bare*
9. *21 PWR – Open, (a) ISF and (b) MGR Repackaging, 3000 MTHM/yr, Cans*
10. *21 PWR – Open, (a) ISF and (b) MGR Repackaging, 3000 MTHM/yr, Cans+Bare*
11. *21 PWR – Open, (a) ISF and (b) MGR Repackaging, 4500 MTHM/yr, Cans*
12. *21 PWR – Open, (a) ISF and (b) MGR Repackaging, 4500 MTHM/yr, Cans+Bare*

Used Fuel Disposition

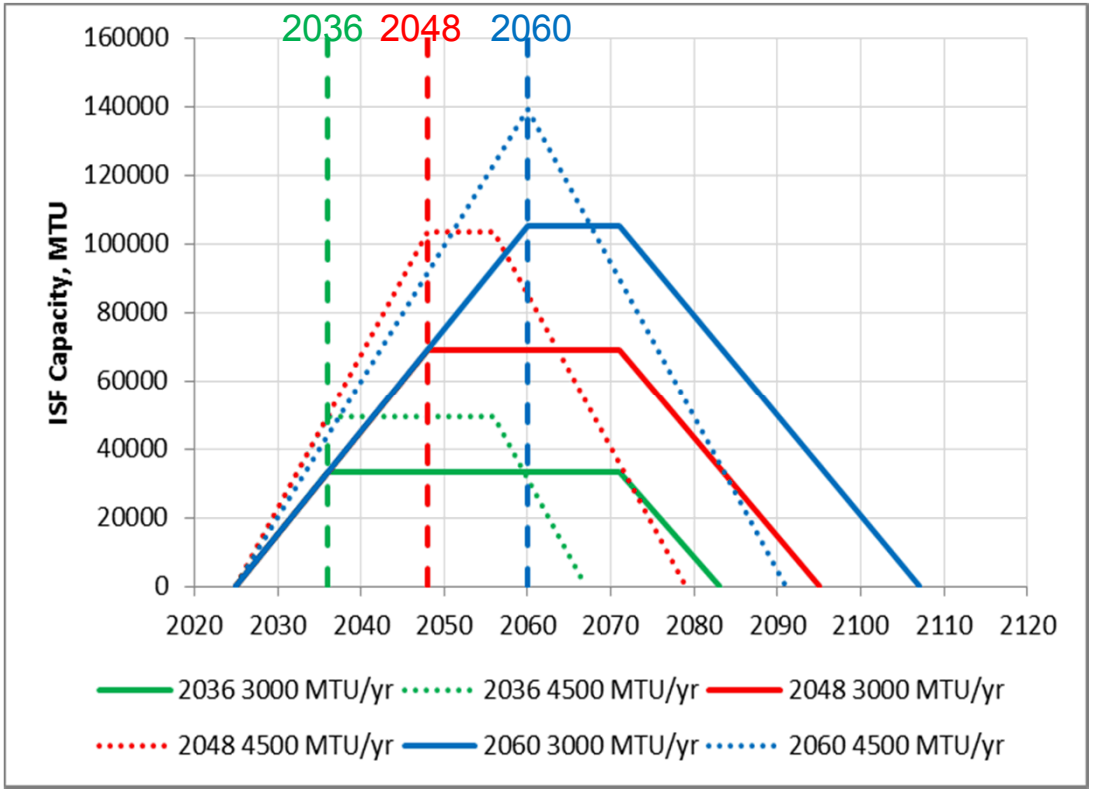
System-Level Analysis Alternatives

Alternative	Repository Starting Date	Thermal Power Limit (kW)	Fuel Loading Scenario
Alternative 1	2036	6	DPCs-Only
Alternative 2	2036	6	DPCs and STADs
Alternative 3	2036	10	DPCs-Only
Alternative 4	2036	10	DPCs and STADs
Alternative 5	2036	18	DPCs-Only
Alternative 6	2036	18	DPCs and STADs
Alternative 7	2048	6	DPCs-Only
Alternative 8	2048	6	DPCs and STADs
Alternative 9	2048	10	DPCs-Only
Alternative 10	2048	10	DPCs and STADs
Alternative 11	2048	18	DPCs-Only
Alternative 12	2048	18	DPCs and STADs
Alternative 13	2060	6	DPCs-Only
Alternative 14	2060	6	DPCs and STADs
Alternative 15	2060	10	DPCs-Only
Alternative 16	2060	10	DPCs and STADs
Alternative 17	2060	18	DPCs-Only
Alternative 18	2060	18	DPCs and STADs

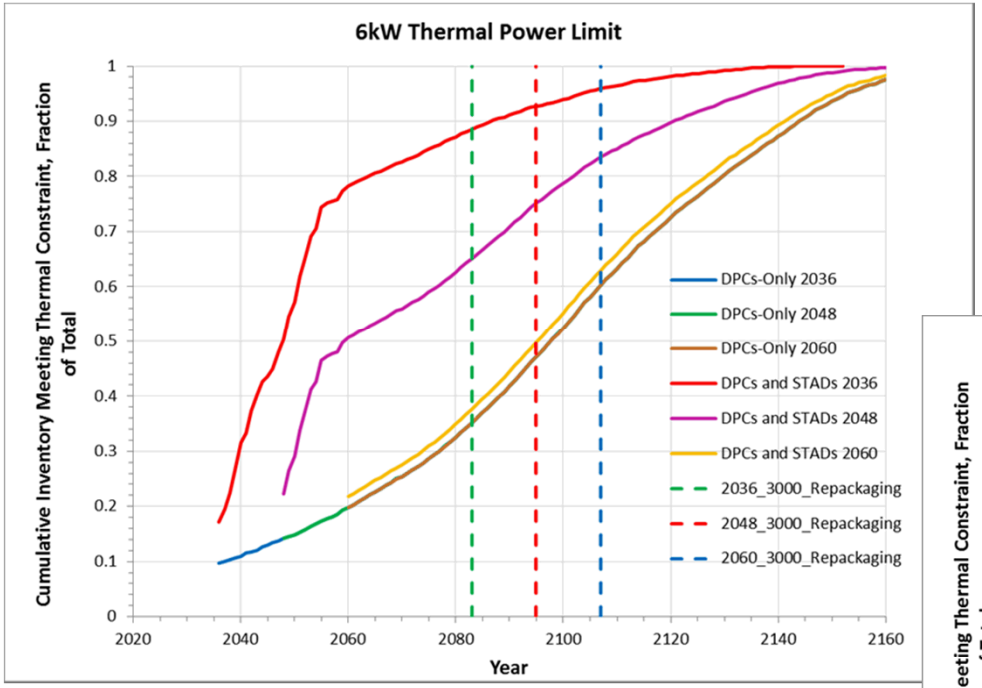
ISF Capacity for the Reference Repackaging Cases.

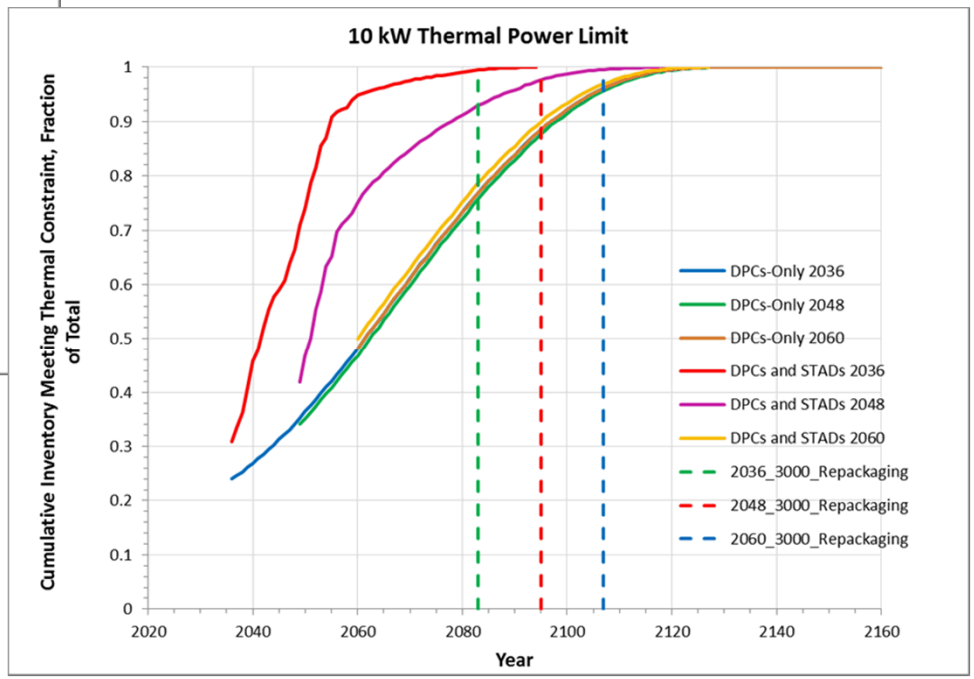
ISF Operational Time from the Repository Opening Date:

- 47 years (3,000 MTU/yr)
- 31 years (4,500 MTU/yr)

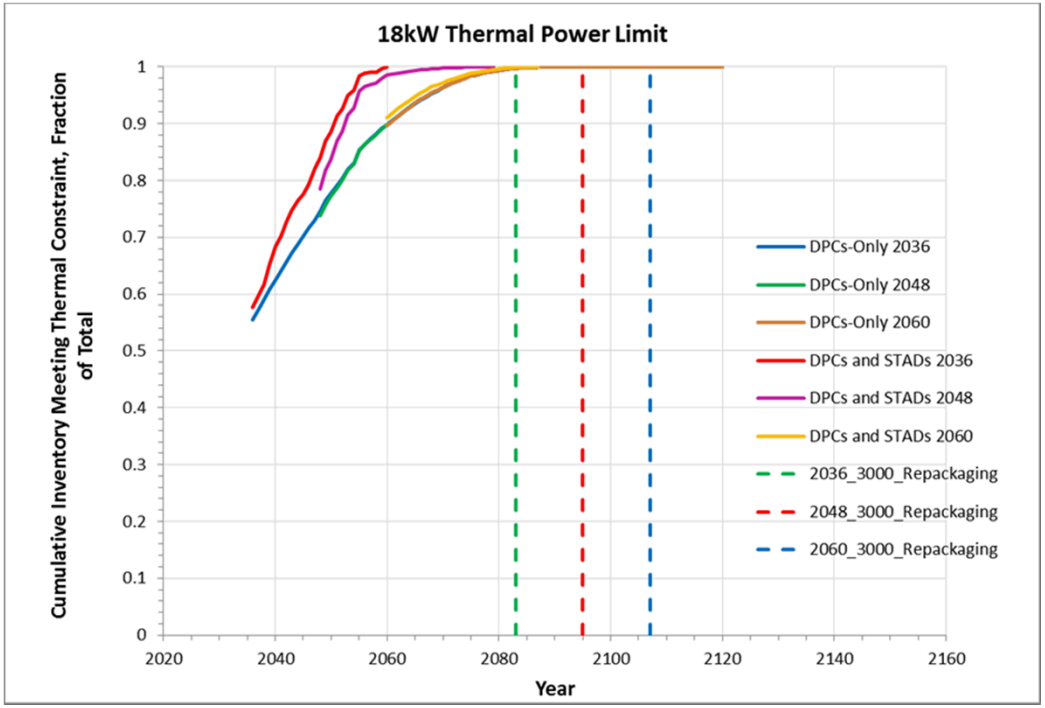


RESULTS: DPCs and STADs Availability





RESULTS: DPCs and STADs Availability



Small Difference due to STADs:

- All alternatives with repository in 2060.
- All alternatives with the 18 kW thermal power limit.

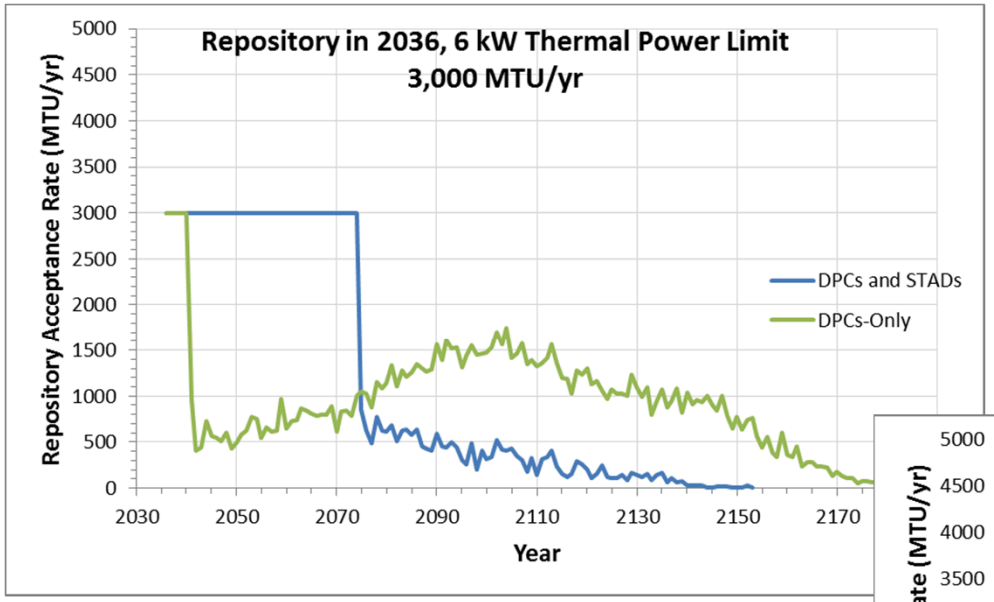
Some Difference due to STADs:

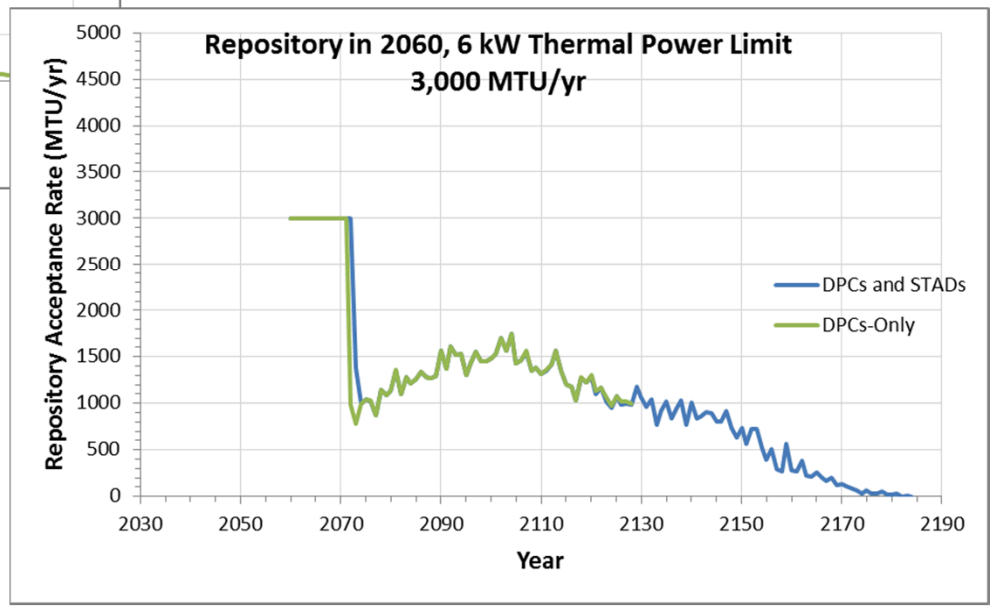
- 10 kW thermal power limit alternative with repository in 2048.

Significant Difference due to STADs:

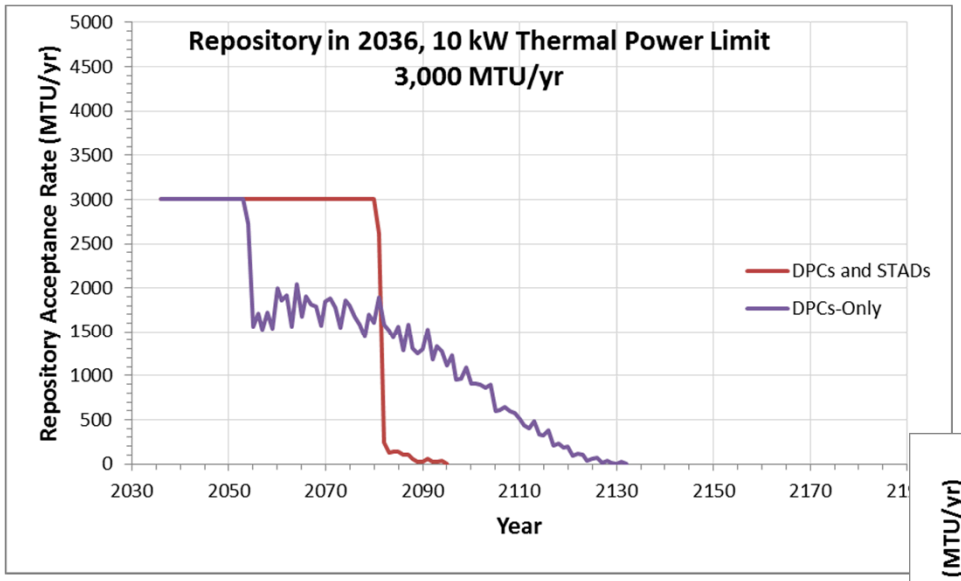
- 6 kW thermal power limit alternatives with repository in 2036 and 2048.
- 10 kW thermal power limit alternative with repository in 2036.

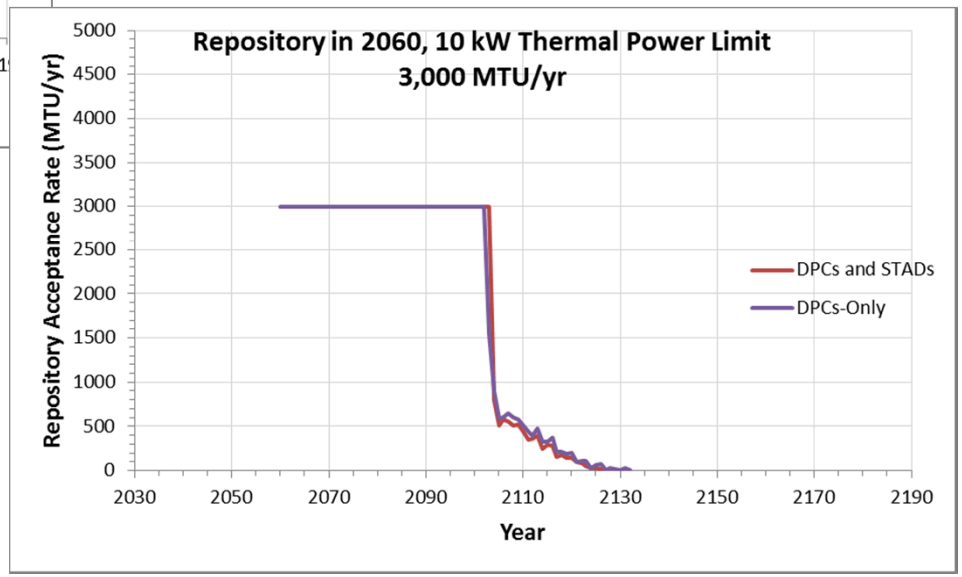
RESULTS: Repository Acceptance Rates: 6 kW Thermal Power Limit





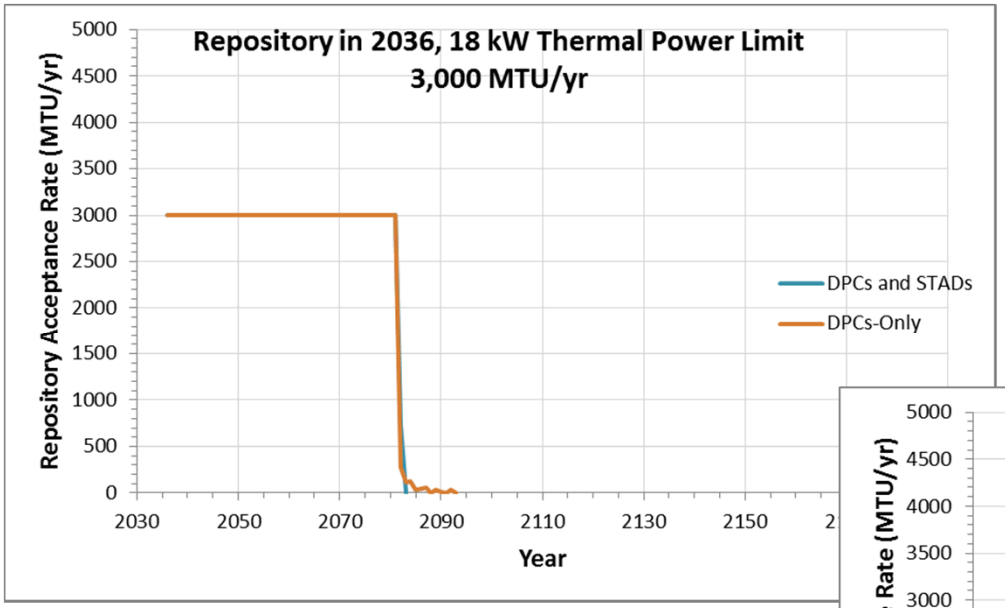
RESULTS: Repository Acceptance Rates: 10 kW Thermal power Limit

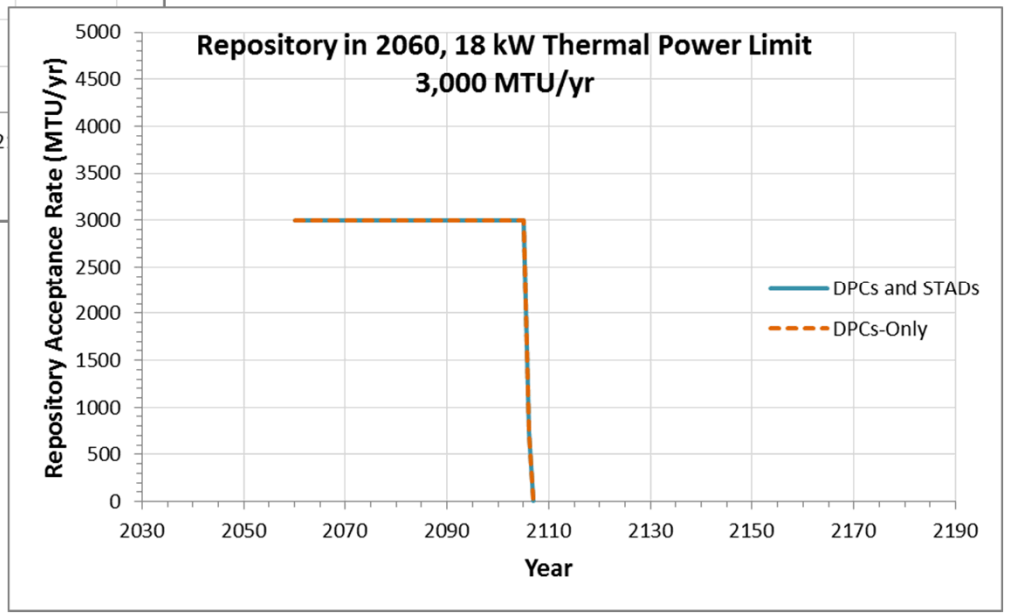




Used Fuel Disposition

RESULTS: Repository Acceptance Rates: 18 kW Thermal power Limit





RESULTS: Comparison with Repackaging Scenario

Repository Starting Date	Thermal Limit kW	Fuel Loading Scenario	Additional ISF Capacity, MTU		Additional Emplacement Time	
			3,000 MTU/yr	4,500 MTU/yr	3,000 MTU/yr	4,500 MTU/yr
2036	6	DPC only	69,701	65,304	79	95
	6	DPCs and STADs	0	0	36	52
	10	DPC only	20,245	30,944	29	45
	10	DPCs and STADs	0	0	0	6
	18	DPC only	0	0	0	7
	18	DPCs and STADs	0	0	0	0
2048	6	DPC only	33,701	11,307	67	83
	6	DPCs and STADs	0	0	50	66
	10	DPC only	0	0	17	33
	10	DPCs and STADs	0	0	0	16
	18	DPC only	0	0	0	0
	18	DPCs and STADs	0	0	0	0
	NA	Repackaging				
2060	6	DPC only	0	0	55	71
	6	DPCs and STADs	0	0	53	69
	10	DPC only	0	0	5	21
	10	DPCs and STADs	0	0	3	19
	18	DPC only	0	0	0	0
	18	DPCs and STADs	0	0	0	0

LOGISTIC SIMULATION SETUP

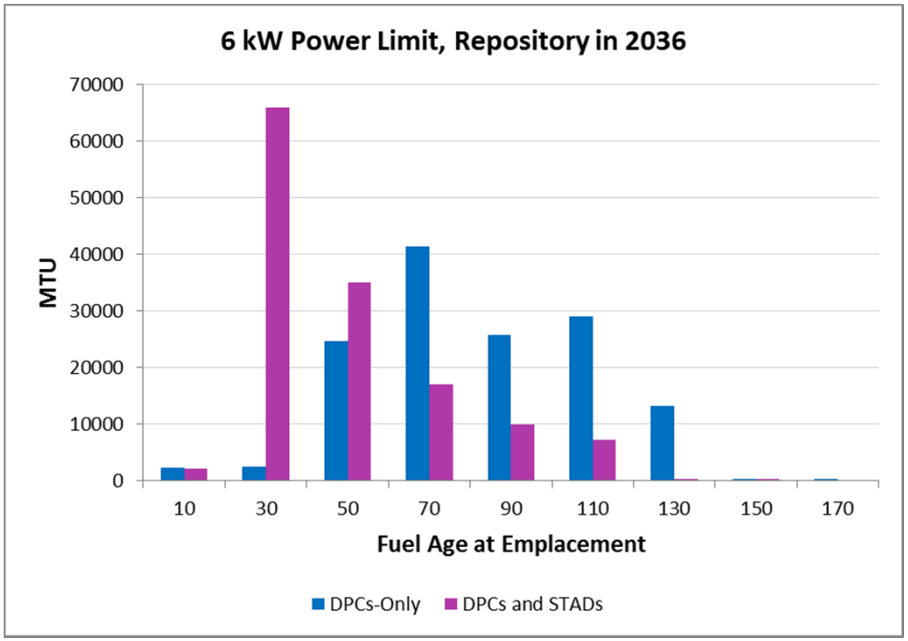
Parameters

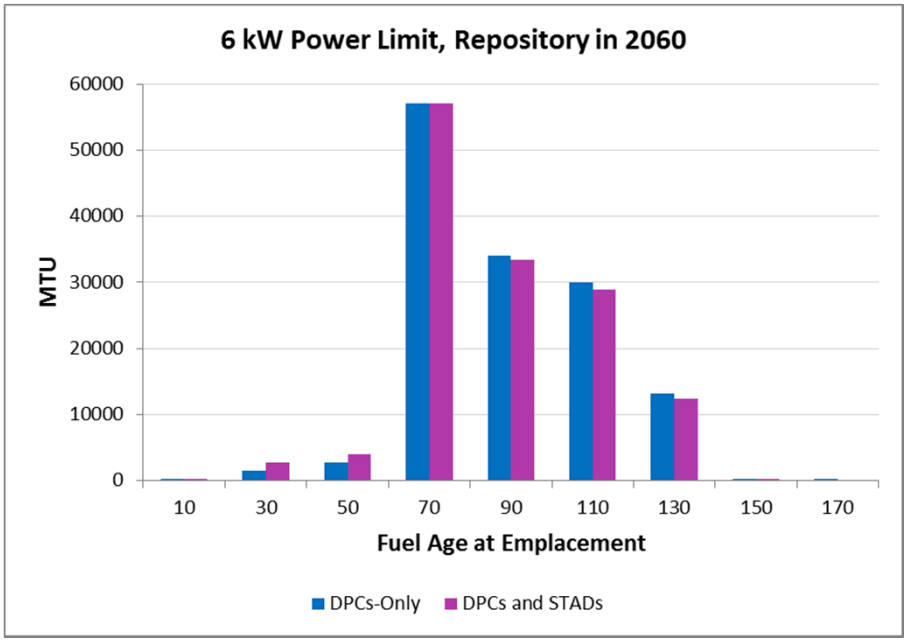
- Repository Starting Dates: 2036 (early start); 2048 (planned start); and 2060 (late start).
- Emplacement Thermal Power Limits: 6 kW; 10 kW; and 18 kW.
- Fuel Loading Scenarios: DPCs-Only and DPCs and small STADs

Assumptions

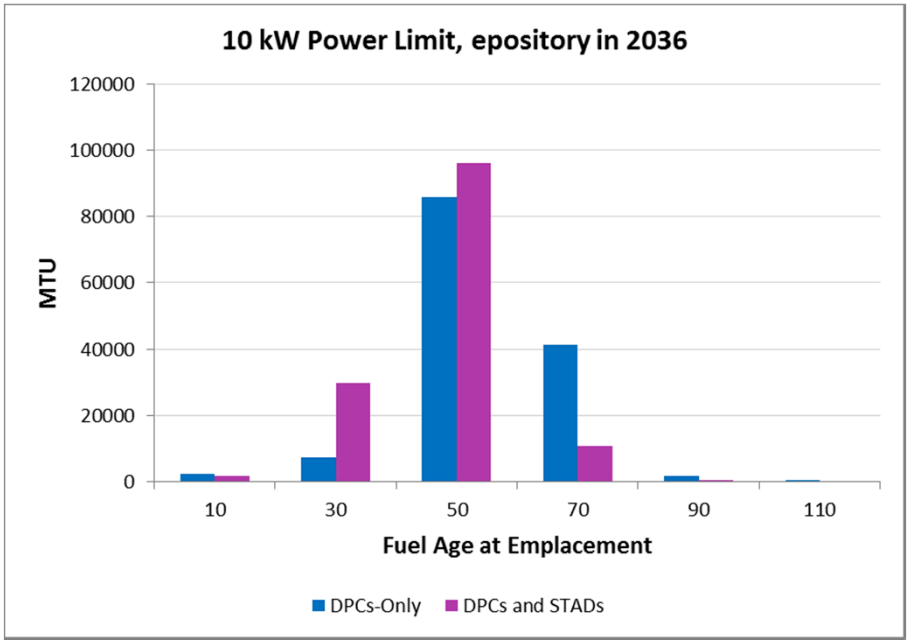
- Loading of STADs begins 5 years prior to the repository opening.
- All DPCs are transportable and disposable.
- ISF begins its operations in 2025.
- The DPCs and STADs are stored at ISF until they meet the repository emplacement power thermal limit.

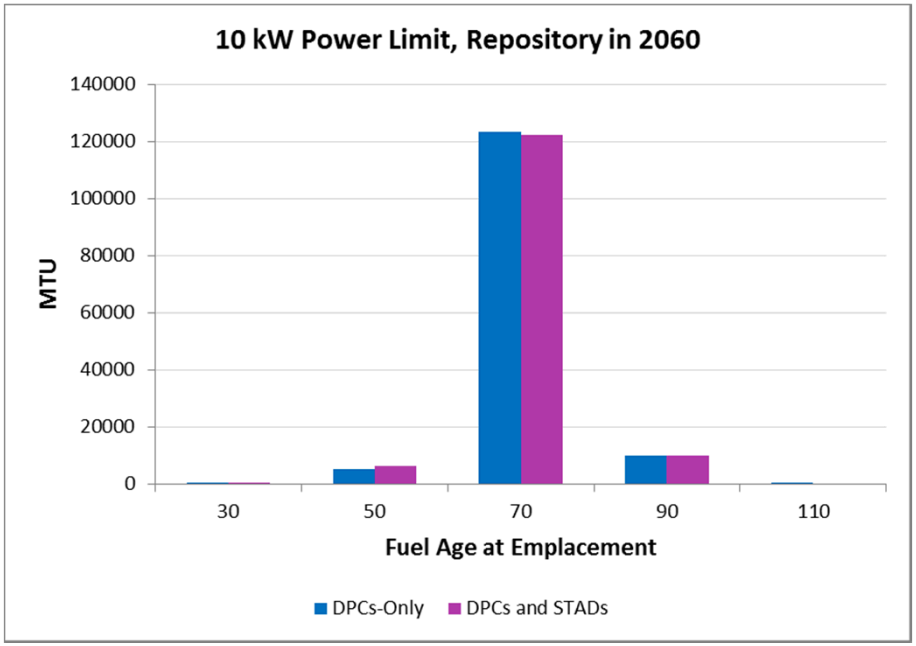
RESULTS: Fuel Age at Emplacement: 6 kW Thermal Power Limit



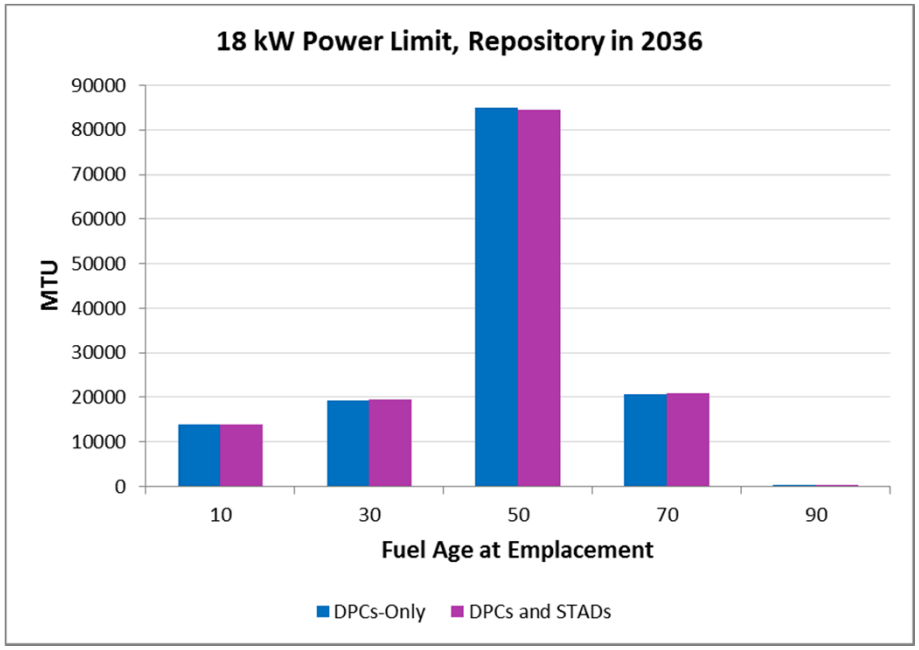


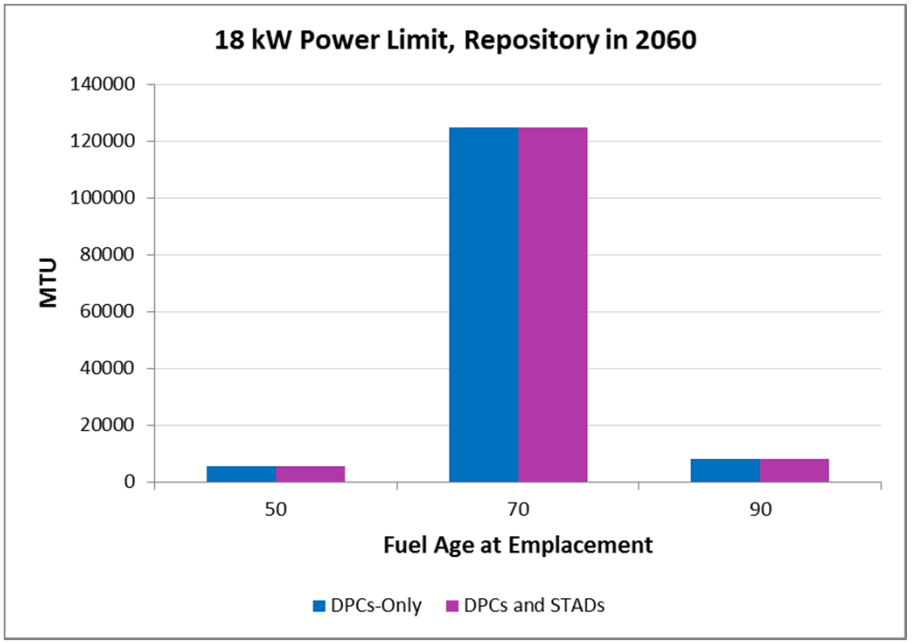
RESULTS: Fuel Age at Emplacement: 10 kW Thermal Power Limit



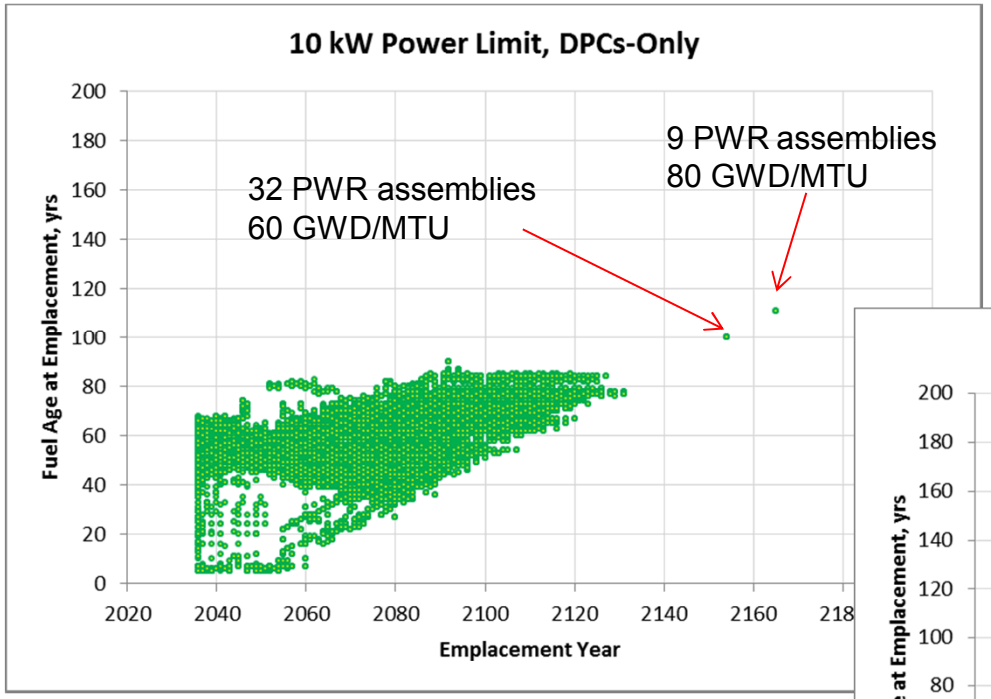


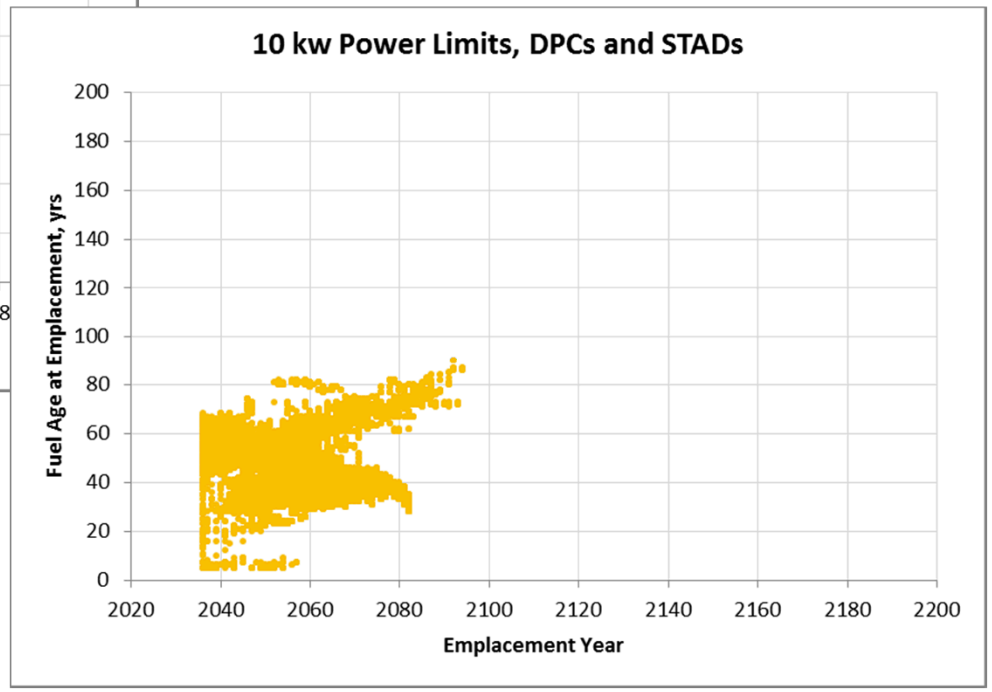
RESULTS: Fuel Age at Emplacement: 18 kW Thermal Power Limit



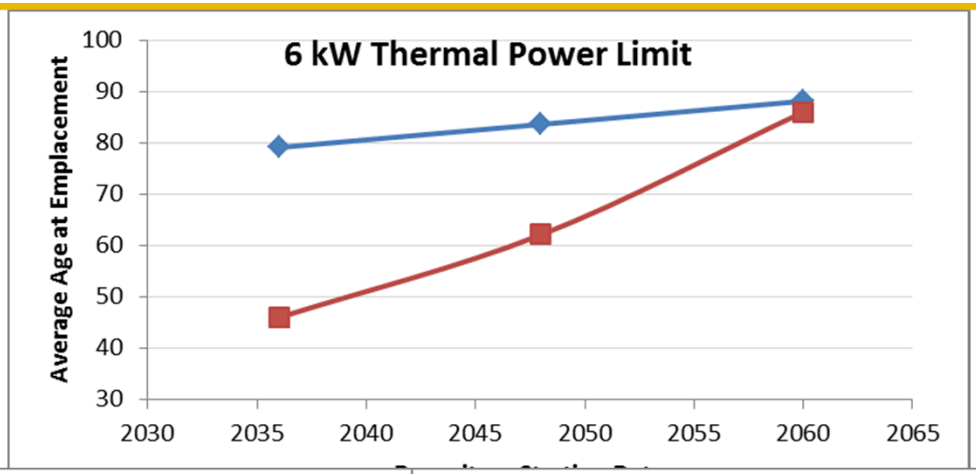


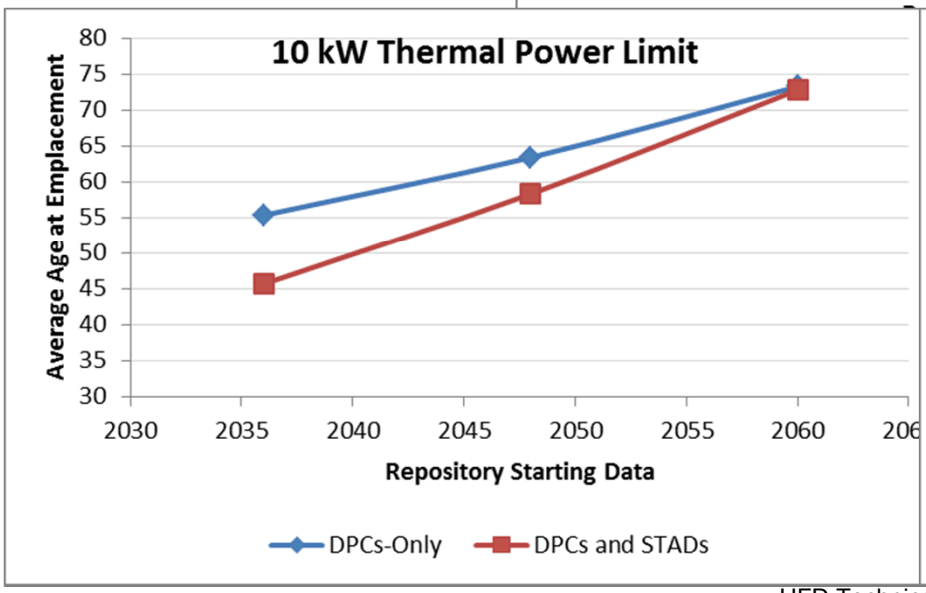
RESULTS: Fuel Age at Emplacement: Repository in 2036

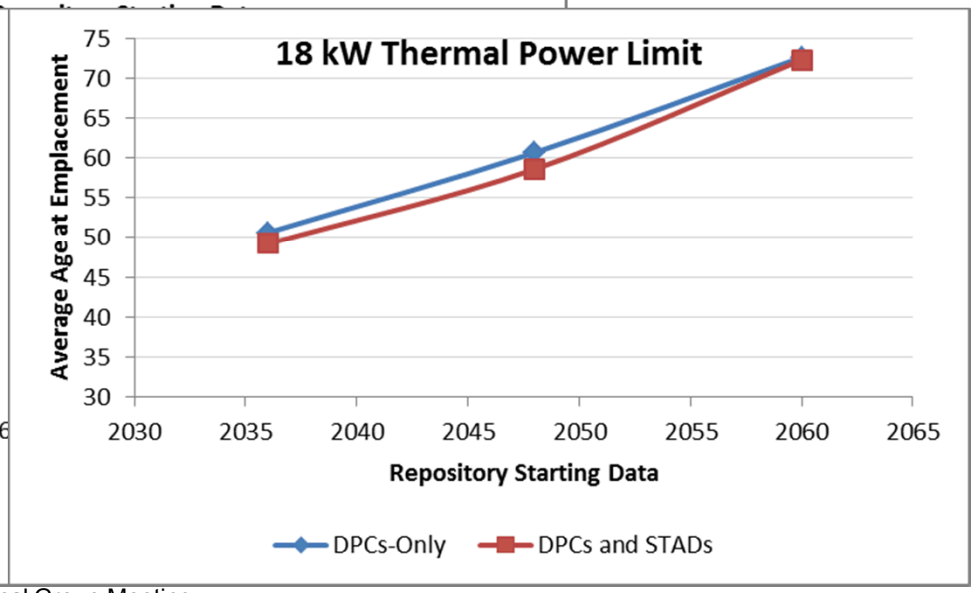




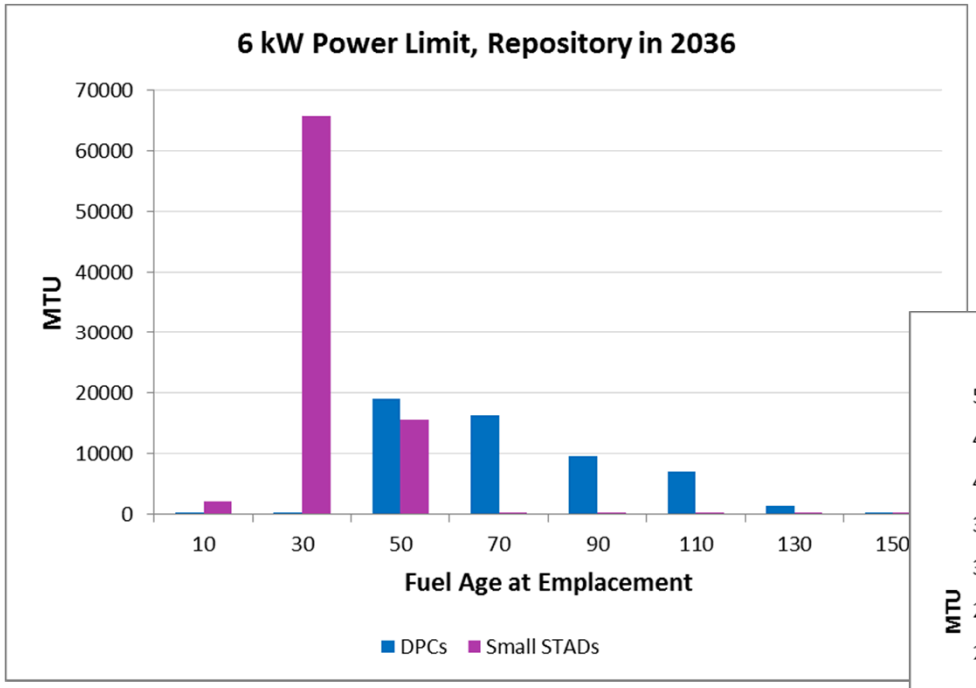
RESULTS: Average Age at Emplacement as a Function of Repository Starting Date

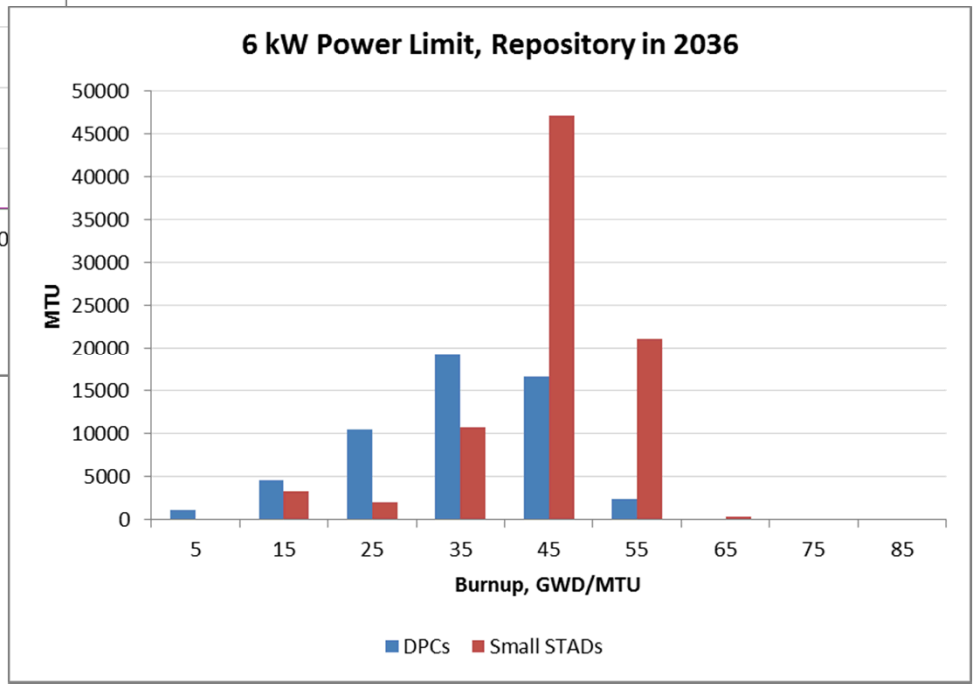






RESULTS: Age and Burnup of Fuel in DPCs and STADs





CONCLUSIONS

- All the 18 kW alternatives and 10 kW alternatives with STADs are comparable to repackaging scenarios.
- 6 kW alternatives with DPCs only require additional storage capacity and emplacement time (repository in 2036 and 2048).
- Implementing STADs make 6 kW alternatives more comparable to the repackaging scenarios (repository in 2036 and 2048).
- The role of STADs is to store young high burnup fuel (60% of the total inventory for 6 kW alternative with repository in 2036).
- The future study needs to evaluate the transportability and disposability of DPCs.
- The other factors to consider are costs, worker dose, dose to members of the public, and economic benefits to host entities.