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Equity Considerations in Siting Consolidated Interim Storage Facilities for Commercial Spent Nuclear Fuel – 24566

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ABSTRACT

Questions of equity and fairness are often raised by representatives from state, Tribal, and local governments and members of the public when resolving conflicts over siting of nuclear facilities. However, the two terms are not synonymous; equity can be quantified while fairness is much more subjective. The Department of Energy's (DOE's) December 2021 request for information sought input on how to site federal facilities for the temporary, consolidated storage of spent nuclear fuel (SNF) using a consent-based approach. It is anticipated that just such questions about equity and fairness associated with the potential emergence of more than one host site may be raised by the twelve groups of university, nonprofit, and private sector partners (Consortia) working to support community engagement, inclusively involve stakeholders, build relationships, and develop innovative forms of mutual learning and public capacity to participate in the consent-based siting process for a federal consolidated interim storage facility during the current planning and capacity building stage of the consent-based siting process.[a] In terms of DOE's Integrated Waste Management System (IWMS), sociopolitical equity concepts are a factor in all aspects of IWMS development and operations and will be particularly applicable should two or more host sites become a possibility, either by the emergence of multiple volunteer hosts or by pursuit as an IWMS program strategy.

This paper summarizes recent analyses that explore how four equity metrics—number of states, division of the projected SNF total by the year 2083, current population, and land area—might be perceived by host communities, states, and regions if two, three, or four sites for hosting federal consolidated interim storage facilities were to be contemporaneously realized. Existing institutional arrangements—including Nuclear Regulatory Commission regions, Federal Energy Regulatory Commission regions, and Low-Level Radioactive Waste Disposal Compacts—were selected to create hypothetically merged two, three, and four-region scenarios to calculate how the four metrics balance out. Projected SNF burden was prioritized with regional contiguity of the consolidated regions, a requirement for a functional scenario. The intent was not to promote or suggest any construct as a program objective; the configurations are geopolitical abstractions only to explore potential perceptions of equity. Understanding the possible issues of equity that could arise may benefit program efforts toward achieving a cooperative federalism wherein both the federal and multiple state governments share the goal of manifesting more than one federal consolidated interim storage facility. The main finding is that it is not possible to optimize for all four metrics simultaneously. The analyses demonstrate that trying to create a sense of equity by backfitting a solution to a random population and land distribution will always contain a degree of artificiality.

BACKGROUND

[a] U.S. Department of Energy, Consent-Based Siting Process for Federal Consolidated Interim Storage of Spent Nuclear Fuel, April 2023, https://www.energy.gov/sites/default/files/2023-05/Consent-Based%20Siting%20Process%20Report-0424%203.pdf

Commercial spent nuclear fuel (SNF) is stored on-site at 75 operating or shutdown nuclear power plant sites in 33 states. Five states—Iowa, Maine, Massachusetts, Oregon, and Vermont—currently have SNF and no operating reactors. This number is expected to increase as more reactors reach the end of their operating licenses or are otherwise closed, and there are no new units to take their place. Based on the recent Department of Energy (DOE) Inventory Report [1] and current Nuclear Regulatory Commission (NRC) licenses, more than 86,000 (86K) metric tons of heavy metal (MTHM) of commercial SNF have been generated, and as of 2055, approximately 97% (~136K MTHM) of the projected total SNF inventory will have been generated, with 31 states having SNF and no operating reactors. With the addition of Tennessee's Watts Bar Nuclear Plant, Unit 2 (Watts Bar 2), Georgia's Vogtle Electric Generating Plant, Unit 3 (Vogtle 3), and the expected addition of Vogtle Unit 4, the projected SNF total is expected to be 141,025 MTHM by about the year 2083. This assumes Watts Bar 2 receives a 20-year license extension in 2055 and Vogtle 3 and 4 operate for 60 years and ignores the possibility of contributions from new reactors that may be constructed and begin operation in the next decades. The three states with the largest current SNF totals are: Illinois (9,762 MTHM), Pennsylvania (7,302 MTHM), and South Carolina (5,274 MTHM). The three states with the largest projected SNF totals by 2083 are: Illinois (16,826 MTHM), Pennsylvania (13,898 MTHM), and Georgia (8,750 MTHM).

INTRODUCTION

Questions of "equity," "fairness," and "justice" are often raised by stakeholders when resolving conflicts over siting of nuclear facilities.[b] However, the two terms are not synonymous; equity can be more easily quantified while fairness is much more subjective. This paper explores how some factors of equity might be perceived by host communities, states, and regions if two, three, or four sites for hosting federal consolidated interim storage facilities (CISF) were to be contemporaneously realized. These are not the only possible metrics. In defining and analyzing six hypothetical bipartite, tripartite and quadripartite geopolitical configurations ("models") for consolidation of SNF inventories, the intent is not to promote or suggest any construct as a program objective; the configurations are geopolitical abstractions only to explore potential perceptions of equity. While any number of regional constructs are conceivable, more than four with equally distributed total SNF inventories (~35K MTHM each) raise additional issues of diminishing returns on the investment needed, project risk management, logistics, etc. The six hypothetical models for consolidation of SNF inventories analyzed are: NRC regions, Census Bureau regions, North American Electric Reliability Corporation, Federal Energy Regulatory Commission, Council of State Governments, and Low-Level Radioactive Waste Disposal Compacts. Projected SNF burden is prioritized, and regional contiguity of the consolidated regions is a requirement for a functional scenario.

MODELING OBJECTIVES

A federal consolidated interim storage facility is often conceived as a single facility backed by DOE and arranged with the consent of one state and locality. The "one site/one state" model suggests a two-agent (DOE and state/community) sociopolitical dynamic. In previous siting efforts using the "one site/one state" model, the decision-making agents have often been viewed as engaged in a more adversarial than

[b] The Federal Government has set a "goal that 40 percent of the overall benefits of certain Federal investments flow to disadvantaged communities that are marginalized, underserved, and overburdened by pollution." The White House, Justice40, https://www.whitehouse.gov/environmentaljustice/justice40/.

cooperative endeavor.[c] In a strategy that involves more than two agents, the number and effect of coalitions with direct vested interest in the outcome of siting are changed. The "two site/two region" approach is smallest number required to begin addressing the inherent inequity of a "one site/one state" model. "Three sites/three regions" and "four sites/four regions" approaches result in different SNF distributions, potentially generating greater perceptions of equity which may promote greater acceptance under notions of fairness.

Models are laid atop state borders to calculate the current and projected SNF inventory held within each region. A federal CISF is imagined to be manifested in an unspecified location within each of the regional boundaries. The six models analyzed were selected because they illustrate different frameworks with defined geopolitical divisions wherein the measures of equity can be readily assessed. The objective is to identify, without considering sociopolitical or legal feasibility, the potential sociopolitical dynamics that go beyond the "one site/one state" model. The specific measures of equity considered for each defined region are number of states, projected SNF total by the year 2083, population[d], and total land area. Of these measures, the division of the total SNF inventory[e] was the principal measure of equity. Whether the assumed inventory is taken as the currently existing ~86K MTHM or the 2083 projected ~141K MTHM, issues of perceived equity are largely the same, although the SNF imbalance tends to increase over time due to the larger inventory growth in the Southeast.

Value to Consent-Based Siting

DOE's December 2021 request for information sought input on using a consent-based process to identify sites for federal CISF [2]. It might be anticipated that issues associated with more than one host site will be raised by the twelve groups of university, nonprofit, and private sector partners (Consortia) during the current capacity building phase of the consent-based siting process [3]. DOE has long endeavored to address its responsibilities under the Nuclear Waste Policy Act of 1982, as amended, for the management and disposal of SNF and high-level waste to protect public health, safety, and the environment. Intended to provide an equitable regional solution to disposal, Section 112(a) of the Nuclear Waste Policy Act, as passed in 1983, directed DOE to "consider . . . the advantages of regional distribution in the siting of repositories" and further required the president to recommend a repository site to Congress by March 1987 and recommend a second site by March 1990 [4]. It was widely understood, although not written in the act, that the first site would be in the West and the second in the East, though the dividing line of East and West were undefined [5].

Issued in 1982 during the Senate debates on a nuclear waste bill, the Office of Technology Assessment report *Managing Commercial High-Level Radioactive Waste* articulated three reasons for developing several simultaneously operating repositories instead of developing and filling one at a time [6]: (1) "a network of repositories would be more equitable and could allay the fears of any State that it might become the nation's sole dumping ground," (2) "the development of two or more sites is likely to encounter less

[c] See, for example, U.S. Supreme Court, "New York v. United States, 505 U.S. 144." 1992, https://supreme.justia.com/cases/federal/us/505/144/ and Governor Mike Sullivan, "Letter to Fremont County Commissioners," transcribed from scanned copy of original, August 21, 1992, https://wyomingoutdoorcouncil.org/wp-content/uploads/2019/08/Gov.-Sullivan_letter_declining_MRS.pdf.

[d] Population numbers are taken from December 2021 Census Bureau data.

[e] There are 75 operating or shutdown NPP sites in 33 states.

political opposition than an effort to develop only the first single site of a centralized system," (3) "if acceptably safe, licensable sites can be found in the East near the majority of existing and projected reactors, the costs and risks of waste transportation—as well as the number of communities affected by it—would be substantially less than those of a system based on a single repository in the West, where most sites now under consideration for the first repository are located."

However, the 1987 amendments to the 1982 NWPA limited government efforts to one designated geologic repository, while keeping the relationship to limited interim storage until disposal capacity was licensed, provoking protests from western politicians that the compromise between eastern and western interests that helped facilitate passage of the act had been repudiated [7]. Understanding the possible issues of equity that could arise may benefit program efforts toward achieving a cooperative federalism wherein both the federal and multiple state governments share the goal of manifesting more than one federal interim storage facility.

MODELS AND SCENARIOS

NRC Regions

In 1961, the Atomic Energy Commission established five regional office boundaries to provide field regulatory oversight of commercial reactor operations. On April 4, 1994, due primarily to the permanent shutdown of nuclear power plant facilities and the termination of some materials licenses, the NRC abolished Region V and its seven states (Alaska, Arizona, California, Hawaii, Nevada, Oregon, and Washington) were incorporated into an expanded Region IV—see Figure 1.

Analysis

The total SNF distribution for the four NRC region cohort (Table 1) is indicative of the larger growth of the Region II inventory over time relative to the other regions (47K MTHM compared with 35K MTHM, 31K MTHM, and 28K MTHM). Reflecting historical trends of population and the development of nuclear power as well as the nature of state borders and size, Region IV's preponderance of states, population, and land area results in a less balanced cohort for these metrics. For the same reasons, the two-region scenario (Table 3), which combines Region I with III and II with IV, produces similar distributions for number of states, population, and land area. However, the two-region scenario produces a more balanced total SNF distribution (66K MTHM and 73K MTHM). The three-region scenario (Table 2) provides a rough equivalence in SNF totals (35K MTHM, 47K MTHM, and 59K MTHM) but exacerbates the imbalance among number of states, population, and land area. Combining Region IV with Region II increases the SNF imbalance while combining Region IV with Region I also increases the SNF imbalance and is not contiguous. As the four-region metric distributions persist or are exacerbated in the three-region scenario, the comparisons with the two-region scenario are broadly the same.

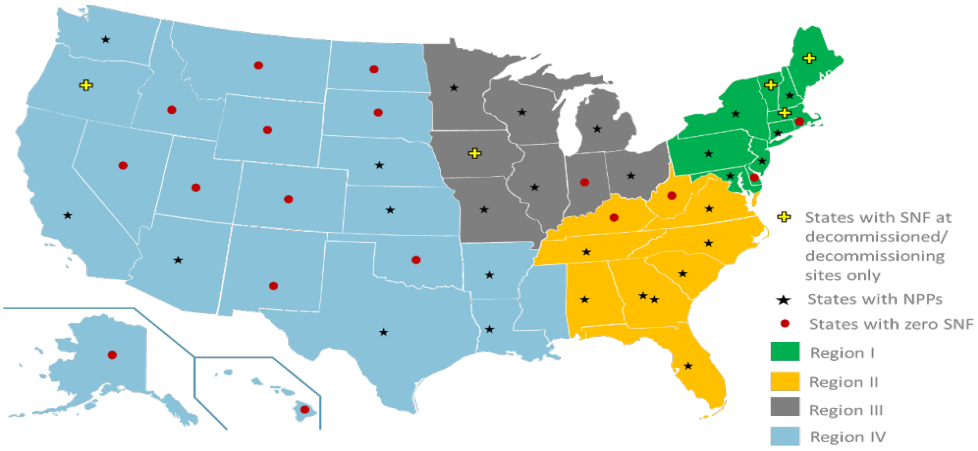

Figure 1. Four NRC regions.

Table 1. NRC – 4 regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Land Area
					MTHM	MTHM	Millions	Square Miles
I	34	20	11	9	21,321	34,599	64,328,351	196,214
II	38	33	9	7	24,307	47,373	75,272,283	412,999
III	30	22	8	7	18,948	31,046	62,272,846	514,286
IV	27	17	22	10	15,782	28,007	129,350,215	2,673,177
Total	129	92	50	33	80,358	141,025	331,223,695	3,796,676

Table 2. NRC – 3 regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Land Area
					MTHM	MTHM	Millions	Square Miles
I	34	20	11	9	21,321	34,599	64,328,351	196,214
II	38	33	9	7	24,307	47,373	75,272,283	412,999
III+IV	57	39	30	17	34,730	59,053	191,623,061	3,187,463
Total	129	92	50	33	80,358	141,025	331,223,695	3,796,676

Table 3. NRC – 2 regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Land Area
					MTHM	MTHM	Millions	Square Miles
I+III	64	42	19	16	40,269	65,645	126,601,197	710,500
II+IV	65	50	31	17	40,089	75,380	204,622,498	3,086,176
Total	129	92	50	33	80,358	141,025	331,223,695	3,796,676

Census Bureau Regions

Since 1880, the Census Bureau has divided the country into regions for the purposes of providing data about the nation's people and economy. The four current regions—Northeast, Midwest, South, and West—have been standard data tabulation units since 1950, with the North Central Region renamed the Midwest Region in June 1984—see Figure 2 [8].

Analysis

The four-region scenario (Table 4) provides an equitable balance in number of states (12, 9, 16, 13). There is also a rough balance in population, although the contrast between the Northeast (57 million [M]) and the South (127M) is considerable. Total SNF inventory and land area are less well balanced as evidenced by comparing the lowest and highest numbers for these metrics: 11K MTHM SNF in the West and 64K MTHM SNF in the South and 181K mi² land area in the Northeast and 1.9M mi² land area in the West. The two-region scenario (Table 6) provides an equitable total SNF balance (66K MTHM, 75K MTHM) and similar distributions for the number of states and population metrics but exacerbates the land area imbalance. The three-region scenario (Table 5) provides a more equitable total SNF distribution (32K MTHM, 45K MTHM, and 64K MTHM) than the four-region scenario. However, combining the Midwest and West results in less balance for the other metrics. The two-region scenario provides a more equitable balance than the three-region scenario in all metrics except population.

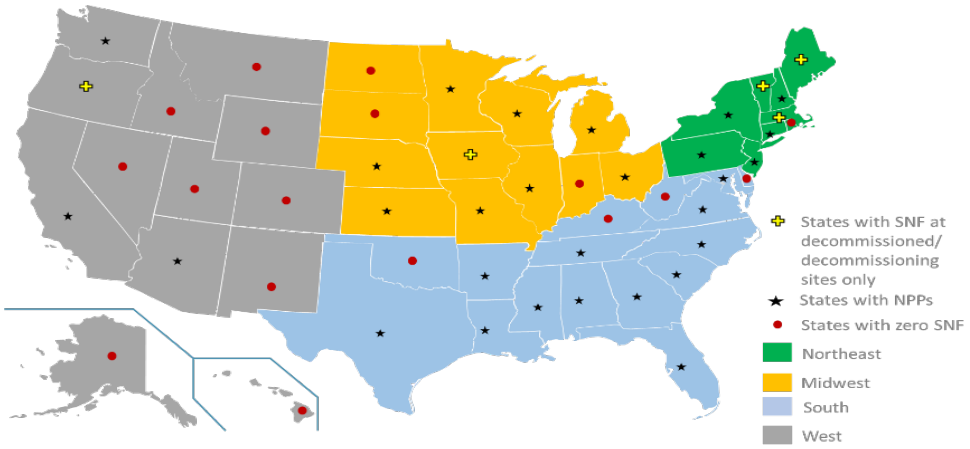

Figure 2. Four Census Bureau regions.

Table 4. Census Bureau – 4 regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Land Area
					MTHM	MTHM	Millions	Square Miles
Midwest	34	24	12	9	20,909	33,918	68,841,444	821,726
Northeast	32	18	9	8	19,855	32,284	57,159,838	181,319
South	49	44	16	12	32,584	63,646	126,555,279	920,378
West	14	6	13	4	7,010	11,177	78,667,134	1,873,253
Total	129	92	50	33	80,358	141,025	331,223,695	3,796,676

Table 5. Census Bureau – 3 regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Land Area
					MTHM	MTHM	Millions	Square Miles
Northeast	32	18	9	8	19,855	32,284	57,159,838	181,319
West+Midwest	48	30	25	13	27,919	45,095	147,508,578	2,694,979
South	49	44	16	12	32,584	63,646	126,555,279	920,378
Total	129	92	50	33	80,358	141,025	331,223,695	3,796,676

Table 6. Census Bureau – 2 regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Land Area
					MTHM	MTHM	Millions	Square Miles
Northeast+Midwest	66	42	21	17	40,764	66,202	126,001,282	1,003,045
West+South	63	50	29	16	39,594	74,823	205,222,413	2,793,631
Total	129	92	50	33	80,358	141,025	331,223,695	3,796,676

North American Electric Reliability Corporation (NERC)

The 2005 Energy Policy Act called for the creation of an Electric Reliability Organization (ERO) to develop and enforce compliance with mandatory reliability standards in the United States. This nongovernmental, self-regulatory organization was created in recognition of the interconnected and international nature of the bulk power grid. In 2006, the North American Electric Reliability Corporation (NERC) applied for, and was granted, ERO designation by the Federal Energy Regulatory Commission. The ERO Enterprise encompasses six regional reliability entities of similar size and complexity—Midwest Reliability Organization (MRO), Northeast Power Coordinating Council (NPCC), ReliabilityFirst (RF), SERC Reliability Corporation (SERC), Texas Reliability Entity (Texas-RE), and Western Electricity Coordinating Council (WECC)—incorporating the interconnected power systems of Canada, the contiguous United States, and a portion of Mexico.[f]

Analysis

Four regions provide a rough balance in number of states (9, 17, 12, and 12) and, to a lesser extent, population (51 million, 113 million, 90 million, and 77 million). Land area (910K mi², 522K mi², 612K mi², and 1,752 mi²) is less balanced due to the large square mileage of the WECC region while the SNF burden is substantially greater for the SERC (56K MTHM) and NPCC + RF (61K MTHM) regions than for the MRO + Texas-RE (12K MTHM) and WECC (11K MTHM) regions. The two-region scenario provides less balance for number of states, population, and land area but a more equitable SNF distribution (63K MTHM and 78K MTHM). The three-region scenario provides an equitable balance in population (90 million, 113 million, and 128 million) and a rougher balance in number of states (12, 17, and 21). The total SNF inventory and land area metrics are less equitable: the RF + NPCC region has the largest SNF total (61K MTHM) and the smallest land area (522K mi²) while the MRO + Texas-RE + WECC region has the smallest SNF total (23K MTHM) but the largest land area (2.7M mi²). The two-region scenario provides

[f] Some load-serving entities participate in one region while associated transmission owners/operators participate in another. As Wisconsin is divided between two regional groupings, MRO and RF, to simplify the analysis, Wisconsin's reactors and inventory are included in the RF regional grouping.

less balance for number of states and population, a similar balance for land area and a more equitable SNF distribution (63K MTHM and 78K MTHM).

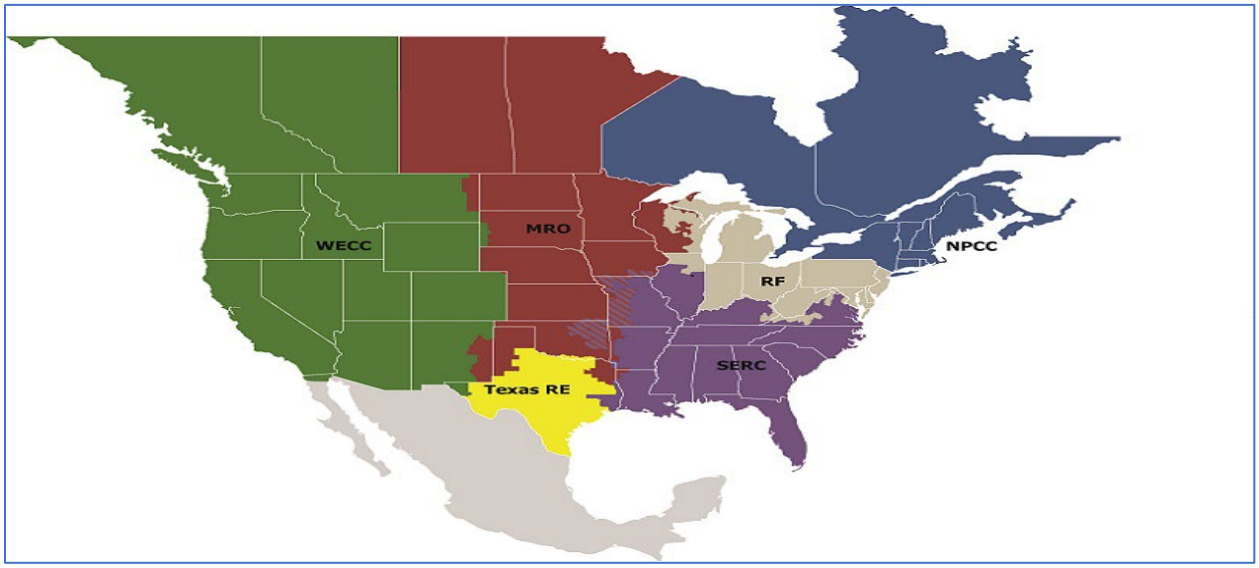

Figure 3. Six NERC regions.

Table 7. NERC – 6 regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Land Area
					MTHM	MTHM	Millions	Square Miles
MRO	8	5	8	4	4,254	5,812	21,571,583	642,138
NPCC	17	7	7	6	9,525	13,277	34,928,652	126,542
RF	42	31	10	7	27,604	47,884	78,386,848	395,272
SERC	44	39	12	11	29,220	56,431	90,257,414	612,465
Texas RE	4	4	1	1	2,745	6,444	29,527,941	268,596
WECC	14	6	12	4	7,010	11,177	76,551,257	1,751,663
Total	129	92	50	33	80,358	141,025	331,223,695	3,796,676

Table 8. NERC – 4 regions.

Regions	**Units**	**Units Operating**	**States**	**States with SNF**	**Current Inventory**	**Total Inventory**	**Population**	**Land Area**
					MTHM	MTHM	Millions	Square Miles
MRO+Texas RE	12	9	9	5	6,999	12,256	51,099,524	910,734
NPCC+RF	59	38	17	13	37,129	61,161	113,315,500	521,814
SERC	44	39	12	11	29,220	56,431	90,257,414	612,465
WECC	14	6	12	4	7,010	11,177	76,551,257	1,751,663
Total	129	92	50	33	80,358	141,025	331,223,695	3,796,676

Table 9. NERC – 3 regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Land Area
					MTHM	MTHM	Millions	Square Miles
SERC	44	39	12	11	29,220	56,431	90,257,414	612,465
RF+NPCC	59	38	17	13	37,129	61,161	113,315,500	521,814
MRO+Texas RE +WECC	26	15	21	9	14,009	23,433	127,650,781	2,662,397
Total	129	92	50	33	80,358	141,025	331,223,695	3,796,676

Table 10. NERC – 2 regions.

Regions	**Units**	**Units Operating**	**States**	**States with SNF**	**Current Inventory**	**Total Inventory**	**Population**	**Land Area**
					MTHM	MTHM	Millions	Square Miles
SERC+Texas RE	48	43	13	12	31,965	62,875	119,785,355	881,061
MRO+NPCC+RF+WECC	81	49	37	21	48,393	78,150	211,438,340	2,915,615
Total	129	92	50	33	80,358	141,025	331,223,695	3,796,676

Federal Energy Regulatory Commission (FERC)

The transfer of electricity between states is considered interstate commerce so electric grids spanning multiple states are regulated by the Federal Energy Regulatory Commission (FERC). In April 1996, FERC promoted the concept of independent system operators (ISOs) Along with facilitating open-access to transmission, ISOs operate the transmission system independently of, and foster competition for, electricity generation among wholesale market participants. In December 1999, FERC encouraged utilities to join regional transmission organizations (RTOs) which, like ISOs, would operate the transmission systems, develop innovative procedures to manage transmission equitably, and promote economic efficiency, reliability, and non-discriminatory practices while reducing government oversight.

While major sections of the country operate under more traditional market structures, two-thirds of the nation's electricity load is served in seven ISO/RTO regions.

Analysis

The four-region scenario (Table 12) produces imbalances in all measures of equity. The Southeast region only has six states while the other regions have 15, 10, and 17. For all the other metrics, the CAISO + ERCOT + Northwest + Southwest + SPP region causes the imbalance. It has the smallest SNF inventory (20K MTHM compared with 36K, 42K, and 43K MTHM), the largest population (117M compared with 60M, 61M, and 91M) and the largest land area (1.8M mi² compared with 306K, 348K, and 623K mi²). The two-region scenario provides a more equitable balance for number of states and population; the SNF and land area imbalances are equivalent. Three regions (Table 13) provide a rough SNF balance (43K MTHM, 42K MTHM, and 56K MTHM) but is less balanced in population (91M, 60M, and 177M). The merged Northwest + MISO + SPP + CAISO + Southwest + ERCOT region creates a large imbalance in number of states (15, 6, and 27) and land area (348K mi², 306K mi², and 2.5M mi²). The SNF balance is more equitable than the two-region (Table 14) distribution (85K MTHM and 56K MTHM) but less equitable than the two-region distribution for number of states and population. For the latter metric, the two-region scenario provides a more equitable population balance than any of the three- or four-region scenarios (151M and 178M).

Figure 4. Ten FERC regions.

Table 11. FERC – 10 regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Land Area
					MTHM	MTHM	Millions	Square Miles
ISO-NE	9	3	6	5	5,093	7,147	15,092,739	71,987
MISO	33	25	10	9	21,627	35,872	61,092,732	623,449
New York ISO	8	4	1	1	4,432	6,130	19,835,913	54,555
PJM	23	19	8	5	16,159	29,497	56,114,343	221,911
CAISO	8	2	1	1	3,380	3,900	39,237,836	163,695
ERCOT	4	4	1	1	2,745	6,444	29,527,941	268,596
Northwest	2	1	7	2	1,126	1,792	22,050,810	693,568
Southeast	34	29	6	6	21,331	41,886	60,337,656	305,586
Southwest	4	3	3	1	2,503	5,485	15,204,262	339,674
SPP	4	2	5	2	1,961	2,872	10,555,237	377,339
Total	129	92	48	33	80,357	141,025	329,049,469	3,120,360

Table 12. FERC – 4 regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Area Land
					MTHM	MTHM	Millions	Square Miles
ISO-NE+New York ISO+PJM	40	26	15	11	25,684	42,774	91,042,995	348,453
MISO	33	25	10	9	21,627	35,872	61,092,732	623,449
CAISO+ERCOT+Northwest+ Southwest+SPP	22	12	17	7	11,715	20,493	116,576,086	1,842,872
Southeast	34	29	6	6	21,331	41,886	60,337,656	305,586
Total	129	92	48	33	80,357	141,025	329,049,469	3,120,360

Table 13. FERC – 3 regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Land Area
					MTHM	MTHM	Millions	Square Miles
ISO-NE+NYISO+PJM	40	26	15	11	25,684	42,774	91,042,995	348,453
Southeast	34	29	6	6	21,331	41,886	60,337,656	305,586
MISO+SPP+ERCOT+ Southwest+CAISO+ Northwest	55	37	27	16	33,342	56,365	177,668,818	2,466,321
Total	129	92	48	33	80,357	141,025	329,049,469	3,120,360

Table 14. FERC – 2 regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Land Area
					MTHM	MTHM	Millions	Square Miles
ISO-NE+NY ISO+ SE+PJM	74	55	21	17	47,015	84,660	151,380,651	654,039
CAISO+ERCOT+NW+ MISO+SW+SPP	55	37	27	16	33,342	56,365	177,668,818	2,466,321
Total	129	92	48	33	80,357	141,025	329,049,469	3,120,360

Council of State Governments

Founded in 1933, the Council of State Governments (CSG) is the largest nonpartisan organization serving all three branches of state elected and appointed officials and was predicated on the belief that interstate cooperation was imperative for states to maintain control over inherent state issues. Four regional offices—CSG East, CSG Midwest, CSG South, and CSG West—allow state officials to connect on shared issues that are geographically based, including federal lands, water rights, agriculture, and border relations.

Analysis

Given the purpose of the organization, it is not surprising that the four existing CSG regions (Table 15) provide an equitable balance for number of states (13, 11, 11, and 15). The total SNF inventory and land area are less well balanced as evidenced by comparing the lowest and highest numbers for these metrics. For the former, there is 11K MTHM SNF in the West and 63K MTHM SNF in the South. For the latter, the East has a land area of 196K mi², and the West has a land area of 1.9M mi². The three-region scenario (Table 16) provides a rough equivalence in current SNF totals (32K MTHM, 21K MTHM, and 27K MTHM) although the imbalance increases over time due to the larger growth of the inventory in the South (63K MTHM, 35K MTHM, and 44K MTHM) while combining the West with the Midwest creates less balance than the four-region scenario in number of states, population, and land area. The two-region scenario (Table 17) provides an equitable balance in number of states (28 and 22), SNF total (74K MTHM and 67K MTHM) but somewhat less balance in population (204M and 127M), and land area (2.8M mi² and 900K mi²).

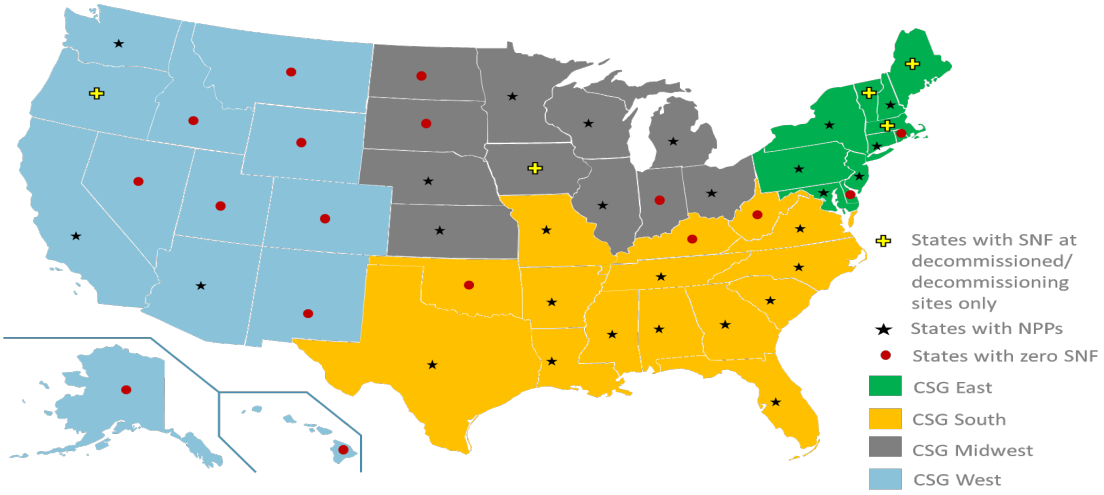

Figure 5. Four CSG regions.

Table 15. CSG – 4 regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Area Land
					MTHM	MTHM	Millions	Square Miles
West	14	6	13	4	7,010	11,177	78,667,134	1,873,253
Midwest	33	23	11	8	20,062	32,374	62,673,257	752,019
East	34	20	11	9	21,321	34,599	64,328,351	196,214
South	48	43	15	12	31,965	62,875	125,554,953	975,190
Total	129	92	50	33	80,358	141,025	331,223,695	3,796,676

Table 16. CSG – 3 regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Area Land
					MTHM	MTHM	Millions	Square Miles
South	48	43	15	12	31,965	62,875	125,554,953	975,190
East	34	20	11	9	21,321	34,599	64,328,351	196,214
West+Midwest	47	29	24	12	27,072	43,551	141,340,391	2,625,272
Total	129	92	50	33	80,358	141,025	331,223,695	3,796,676

Table 17. CSG – 2 regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Area Land
					MTHM	MTHM	Millions	Square Miles
West+South	62	49	28	16	38,975	74,052	204,222,087	2,848,443
East+Midwest	67	43	22	17	41,383	66,973	127,001,608	948,233
Total	129	92	50	33	80,358	141,025	331,223,695	3,796,676

Low-Level Radioactive Waste Disposal Compacts

In December 1980, Congress passed the Low-Level Radioactive Waste Policy Act. This act “encouraged states to form regional compacts [subject to congressional consent] to meet their collective disposal needs, minimize the number of new disposal sites, and more equitably distribute the responsibility” for commercial low-level radioactive waste (LLRW) disposal [9]. As amended in 1985, compact disposal facilities can prohibit disposal of out-of-compact waste [10]. Ten compacts comprising 42 states exist but not all provide in-compact disposal services; only four disposal facilities are in operation around the country, and one of those, the Clive facility in Utah, was developed outside the compact framework and is licensed for Class A LLRW only. For various reasons, five compacts are not contiguous. Eight states are not affiliated with a compact—these have been consolidated into an imagined single “unaffiliated” compact. Alaska and Hawaii are included in the model.

Analysis

Due to the large number of compacts, eleven when counting the unaffiliated states as an imagined compact and the fact that six of these (Atlantic, Midwest, Rocky Mountain, Southwestern, Texas, and Unaffiliated) are not contiguous themselves, it is not possible to create a contiguous four[g] or three[h] region scenario under any compact combination. While they do not meet the requirement for a functional scenario, the non-contiguous combinations shown above are included for illustrative purposes. The non-contiguous four-region (Table 19) creates an equitable SNF balance—33K MTHM, 36K MTHM, 37K MTHM, and 35K MTHM—although the other metrics are unbalanced due to the small number of states, population, and land in the Appalachian/Atlantic region and Southeast region. The three-region scenario (Table 20) creates an equitable balance across all metrics except land area, with total SNF inventory balancing almost exactly (47K MTHM, 48K MTHM, and 46K MTHM).

Combining the Appalachian, Atlantic, Central, Texas, Central Midwest, Southeast, Midwest, and Unaffiliated Compacts and the Northwest, Southwestern, and Rocky Mountain Compacts produces two contiguous regions (Table 21) and an equitable land area balance (1.8M mi^2, 2M mi^2) but large differences in total SNF distribution (130K MTHM and 11K MTHM), population distribution (251M and 80M), and number of states (35 and 15).

[g] A Central + Texas region (14K MTHM SNF), Northwest + Southwestern + Rocky Mountain region (11K MTHM SNF), Southeast + Appalachian + Atlantic region (68K MTHM SNF) and Midwest + Unaffiliated + Central Midwest region (48K MTHM SNF) combination comes closest to a functional scenario, but Vermont's membership in the in the Texas Compact, Connecticut's membership in the Atlantic Compact, and North Carolina's unaffiliated status break the contiguity.

[h] A Central + Texas + Southeast region (49K MTHM SNF), Northwest + Southwestern + Rocky Mountain region (11K MTHM SNF) and Midwest + Unaffiliated + Central Midwest + Appalachian + Atlantic region (81K MTHM SNF) combination comes closest to a functional scenario, but Vermont's membership in the Texas Compact, North Carolina's unaffiliated status, and South Carolina's membership in the Atlantic Compact break the contiguity.

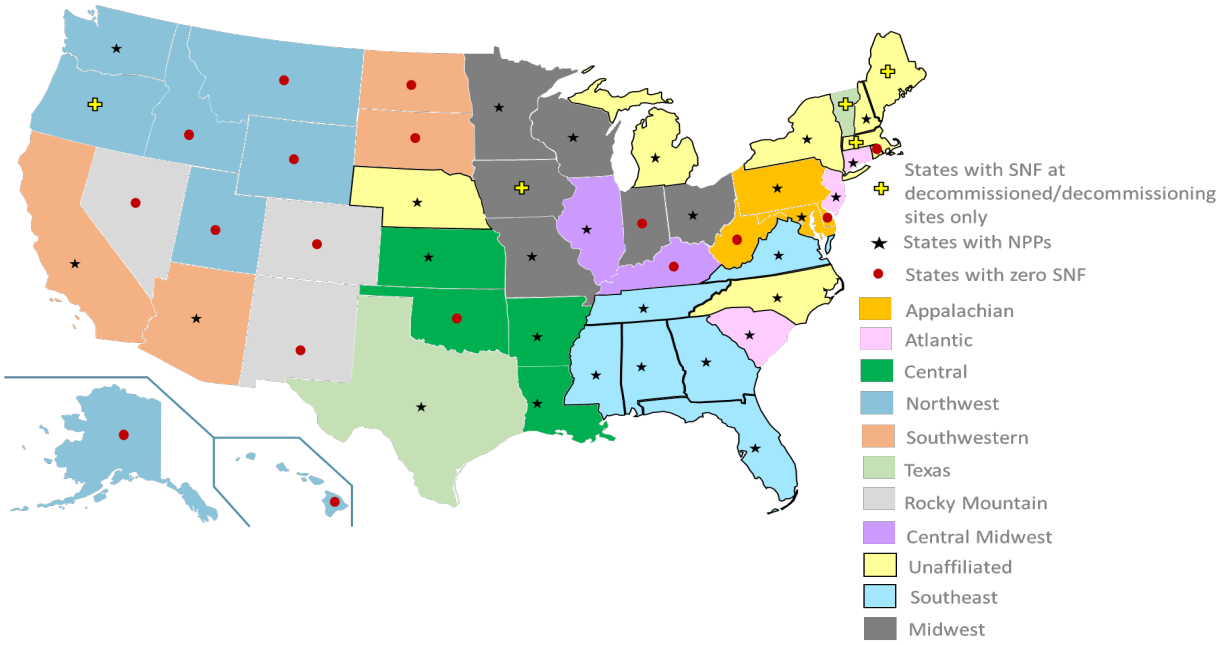

Figure 6. Eleven LLRW compact regions.

Table 18. LLRW compacts.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Land Area
					MTHM	MTHM	Millions	Square Miles
Appalachian	13	10	4	2	8,767	16,213	21,915,528	85,179
Atlantic	17	12	3	3	10,624	17,015	18,063,432	46,286
Central	5	5	4	3	3,871	6,920	14,571,159	257,734
Central Midwest	14	11	2	1	9,762	16,826	17,180,863	98,322
Midwest	11	8	6	5	6,065	9,138	39,550,566	359,658
Northwest	2	1	8	2	1,126	1,792	21,081,045	1,259,312
Rocky Mountain	1	0	3	0	0	0	11,071,937	336,256
Southeast	25	22	6	6	16,350	34,502	56,188,028	310,954
Southwestern	12	5	4	2	5,884	9,385	48,184,476	425,499
Texas	5	4	2	2	3,451	7,149	30,173,511	278,212
Unaffiliated	24	14	8	7	14,458	22,083	53,243,150	339,264

Total	129	92	50	33	80,358	141,025	331,223,695	3,796,676

Table 19. LLRW compacts – 4 non-contiguous regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Land Area
					MTHM	MTHM	Millions	Square Miles
Appalachian+ Atlantic	30	22	7	5	19,391	33,228	39,978,960	131,465
Central+Rocky Mountain+Texas+ Unaffiliated	35	23	17	12	21,780	36,152	109,059,757	1,211,466
Central Midwest+Midwest + Northwest+ Southwestern	39	25	20	10	22,837	37,141	125,996,950	2,142,791
Southeast	25	22	6	6	16,350	34,502	56,188,028	310,954
Total	129	92	50	33	80,358	141,025	331,223,695	3,796,676

Table 20. LLRW compacts – 3 non-contiguous regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Land Area
					MTHM	MTHM	Millions	Square Miles
Appalachian+ Atlantic+Central+ Texas	40	31	13	10	26,713	47,297	84,723,630	667,411
Central Midwest+ Midwest+ Unaffiliated	49	33	16	13	30,285	48,047	109,974,579	797,244
Northwest+Rocky Mountain+ Southeast+ Southwestern	40	28	21	10	23,360	45,679	136,525,486	2,332,021
Total	129	92	50	33	80,358	141,025	331,223,695	3,796,676

Table 21. LLRW compacts – 2 regions.

Regions	Units	Units Operating	States	States with SNF	Current Inventory	Total Inventory	Population	Land Area
					MTHM	MTHM	Millions	Square Miles
Appalachian+ Atlantic+Central+ Texas+ Central Midwest+ Unaffiliated+ Southeast+ Midwest	114	86	35	29	73,348	129,848	250,886,237	1,775,609
Northwest+ Southwestern+ Rocky Mountain	15	6	15	4	7,010	11,177	80,337,458	2,021,067
Total	129	92	50	33	80,358	141,025	331,223,695	3,796,676

SUMMARY OF FINDINGS

There are many ways to partition the country based on existing or artificial political, economic, regulatory, and geographic constructs. Many such constructs can be fundamentally abstracted or modified to produce "multiple site/multiple region" scenarios with varying degrees of rationale. Six models and four metrics were selected to create merged four-, three-, and two-region scenarios that enumerate measures of equity in consolidating commercial SNF inventories. The four equity measures are number of states, division of projected SNF total by 2083, current population, and land area. Projected SNF burden was prioritized with regional contiguity of the consolidated regions, a requirement for a functional scenario. These are not the only possible metrics. The objective was not to promote or even suggest any construct as a goal but rather to explore the potential sociopolitical dynamics that go beyond the "one site/one state" model and identify possible issues that could arise in achieving cooperative federalism wherein both the federal and multiple state governments share the goal of operating more than one federal CISF. Based on the analysis, the findings are as follows.

It is not possible to optimize for all four metrics simultaneously. The two-region CSG scenario provides the most balanced total SNF distribution overall (74K/67K). The four-region CSG scenario provides the most balanced overall distribution by number of states (13/11/11/15). The two-region FERC scenario provides the most balanced overall distribution by population (157M/178M). The four-region NERC scenario provides the most balanced overall distribution by land area (910K/522K/612K/1.76M).

For the majority of models, the most balanced SNF scenario creates significant imbalances in land area and/or other measures that can affect perceptions of equity. In the two-region analysis, scenarios for two of the six models produce a more balanced SNF distribution among non-contiguous regions than contiguous

regions. Similarly, in the three- and four-region analysis, scenarios for four of the six models produce a more balanced SNF distribution among non-contiguous regions than contiguous regions. The three-region non-contiguous LLRW compacts scenario produces the most equitable balance by total SNF burden (47K/48K/46K) across all model scenarios. LLRW compacts is also the only model for which a functional (contiguous) three- or four-region scenario cannot be created.

The scenarios and analyses demonstrate that trying to create a sense of equity by backfitting a solution to a random population and land distribution will always contain a degree of artificiality. The two artifacts of history that have most impact are (1) most nuclear plants are located east of the Mississippi and the states with the largest SNF totals, both current and projected, are in the East, and (2) there is less population in the West. Hence imbalance in one or more of the metrics used is inherent in the pursuit of almost any sense of equity.

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