Check the Storage Stack: Comparing Behind-the-Meter Energy Storage State Policy Stacks in the United States

Jeffrey J. Cook, Kaifeng Xu, Sushmita Jena,
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NREL is a national laboratory of the U.S. Department of Energy
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List of Acronyms

BTM	behind the meter
DER	distributed energy resource
DSIRE	Database of State Incentives for Renewables and Efficiency
FERC	Federal Energy Regulatory Commission
IREC	Interstate Renewable Energy Council
ISO	Independent System Operator
MW	megawatts
NYSERDA	New York State Energy Research and Development Authority
RTO	Regional Transmission Organization

Executive Summary

In 2020, the United States had 960 MW of behind-the-meter (BTM) battery storage capacity in the residential and nonresidential sectors, and this market is expected to increase by 7.5 times (to 7,300 MW) through 2025 (Wood Mackenzie, 2019; Barbose, Elmallah and Gorman, 2021).

Current deployment is not equally distributed nationwide, in part because state policy, among other factors, can be critical to shaping clean energy markets and related deployment opportunities (Krasko and Doris, 2013; Cook, Ardani, *et al.*, 2018). Researchers further suggest state policy may be more effective when it aligns with the concept of policy sequencing, or policy stacking. In short, the implementation of a sequencing or stacking framework—where market preparation, market creation, and expansionary policies are adopted either sequentially or in tandem—may enable a more effective and cost-efficient policy framework that better achieves policymakers' intended deployment goals than if similar policies are adopted either out of sequence or alone (Krasko and Doris 2013).

A variety of studies and disparate data sets track state energy storage policies, but these datasets do not cover all BTM-related storage policy. Moreover, these databases do not align policies with the policy stacking framework. Thus, it is unclear which BTM storage policies are adopted across the country, what should comprise a complete storage policy framework or stack, or how states policies compare with that stack. This report addresses this gap in the literature by developing a state policy stack for BTM battery storage that we compare across all 50 states.

This first-of-its-kind BTM storage policy stack includes 11 parent policy categories and 31 policies across the market preparation, creation, and expansion policy components. The max score was 13, and the average state's policy stack score is 4.8, with a range of 2.5–13.0 (Figure ES-1). California, New York, and Massachusetts lead with scores of 13.0, 10.6, and 9.1 respectively. California is the only state that received the highest possible score across all categories. Nine states scored over 50% in the market preparation category, which helped them into the top ten. On the other hand, Connecticut is the only states that ranked in the top 10 with a lower score (40%) in the market preparation category.

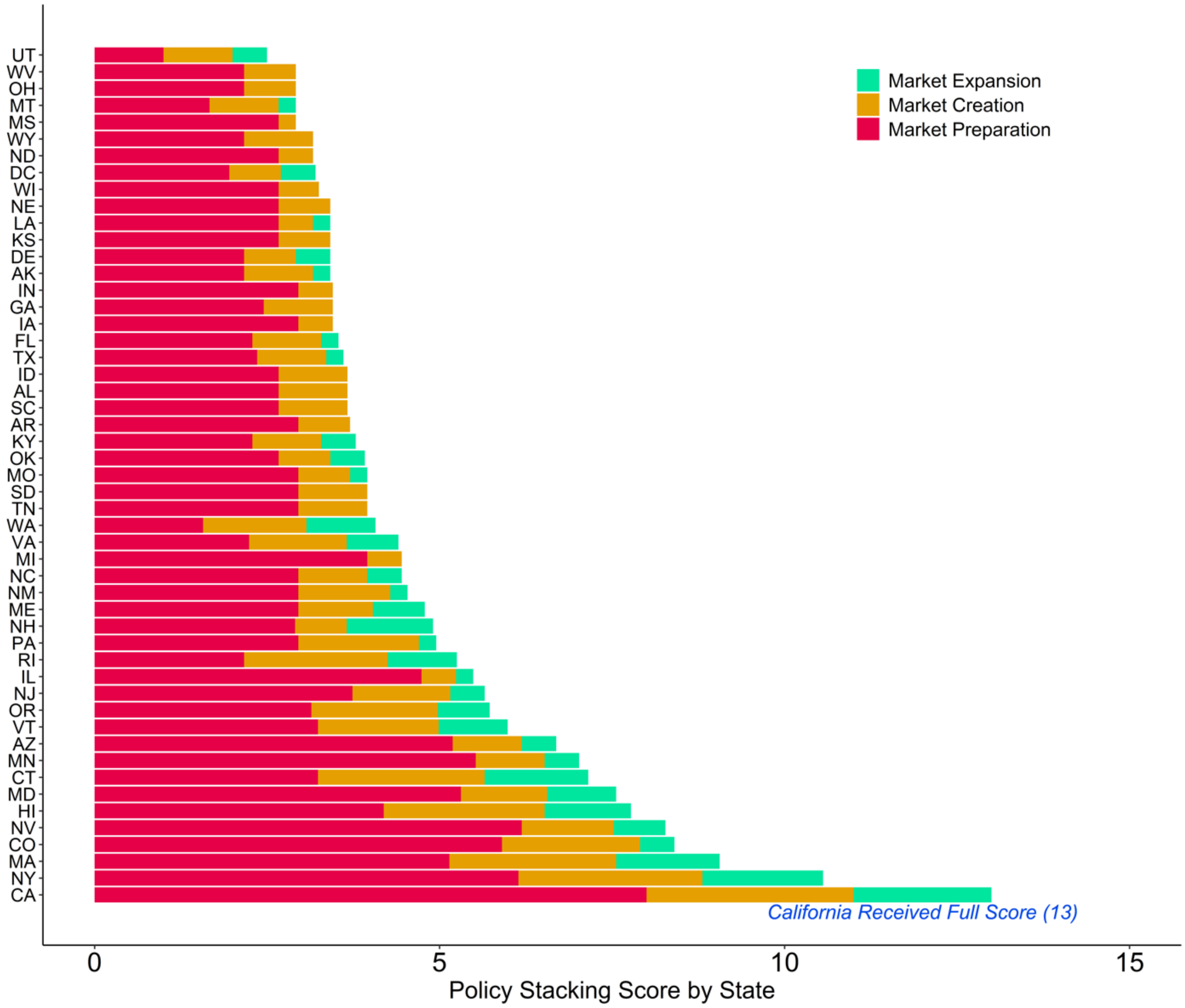

Figure ES- 1. State policy stacking scored in preparation, creation and expansion categories

There are several opportunities to expand on the research and insights generated through this report , including expanding on the policies included within the stack, how these policies influence deployment by state, and how they interact with existing wholesale energy market and federal policies. Regardless of the research path taken, continued analysis in this space will likely prove valuable as BTM energy storage markets and policy evolve.

Table of Contents

List of Figures

List of Tables

1 Introduction

In 2020, the United States had over 3,000 MW of total installed battery storage capacity (Wood Mackenzie, 2021). Of that total, 960 MW was behind-the-meter (BTM) battery storage capacity split between the residential and nonresidential sectors. BTM energy storage markets are expected to increase by 7.5-fold for a cumulative 7,300 MW of capacity through 2025, with many of these systems being paired with solar (Wood Mackenzie, 2019; Barbose, Elmallah and Gorman, 2021).

Market interest in BTM battery storage, often paired with solar or other distributed generation assets, has been driven by economics, interest in resilience, and policy factors. First, economic applications include electricity arbitrage, where customers with distributed generation can charge the battery during times of excess generation (for free or at low cost) and discharge during periods of high demand, when prices are high, thereby generating more economic value from the distributed generation system (Cook, Ardani, *et al.*, 2018). In certain states, such as Hawaii, commercial customers can also use batteries to reduce their peak load, creating cost savings through demand charge management. And in many states, battery storage assets can be aggregated into virtual power plants to provide a variety of grid services, including load response, voltage regulation, and frequency response (Cook, Ardani, *et al.*, 2018; Bowen and Gokhale-Welch, 2021). Second, BTM storage assets have been deployed for a variety of resilience applications. Most BTM storage equipment can be combined with islanding controls and solar to provide backup power during grid outages, allowing residents and businesses to continue operating critical facilities and applications (Booker, 2021). Third, policy drivers can incentivize BTM storage deployment. Federal, state, and local policymakers can influence BTM markets along with regional electricity markets that cross state lines. This report focuses on state policy, and a variety of states such as California (Hart, 2017; California Energy Commission, 2018) and Massachusetts (Engel, 2021), have adopted suites of policies that enable or encourage the adoption of BTM storage.

Given the federated or multi-layered government system of the United States, the policy environment for BTM storage is inconsistent nationwide. Moreover, researchers suggest state policy, along with local and federal policies, can be critical to shape clean energy markets and related deployment opportunities (Krasko and Doris, 2013; Cook, Ardani, *et al.*, 2018). Such state policies may also be more effective when they align with the concept of policy sequencing, or policy stacking. In short, when policymakers engage in a process of market preparation, creation, and finally expansionary policies, it may enable a more effective policy framework that helps achieve the policymakers' intended deployment goals more cost-efficiently than if similar policies were adopted out of sequence (Krasko and Doris 2013). This is not to suggest policymakers must always adopt such policies in stepwise. Rather, the goal is to ensure policymakers consider all the necessary market preparation, creation, and expansionary policy aspects when adopting omnibus legislation. Furthermore, it is not our intent to suggest state policy is the only, or the most impactful driver of BTM markets. Rather, our intent is to focus on areas that are within the purview of state governments. State governments have various policy tools they can apply to influence BTM markets in their states, but of course the impact of these policies is also influenced by federal policies.

Given the importance and prevalence of state policies, a variety of studies and disparate data sets track BTM storage policies at the state level, but the data sets do not cover all BTM-related storage policy (as summarized in Section 2). Moreover, the data sets do not align the policies with the policy stacking framework. Thus, it is unclear what BTM storage policies are adopted across the country, which should comprise a complete storage policy framework or stack, or how the policies of individual states compare with that stack.

We address this gap in the literature by developing a policy stack for BTM storage that we compare across states' policy environments. An analysis of existing policy databases, paired with qualitative interviews and convenings of 19 BTM storage subject matter experts from 12 organizations, serves as the basis to generate the policy stack.

Our first-of-its-kind BTM storage policy stack includes 11 parent policy categories and 31 policy questions across the market preparation, creation, and expansion categories. This report summarizes our methodology, the policy stacking framework, and the results by state.

2 BTM Storage Policy and the Policy Stacking Framework

Given the decentralized nature of the energy market, BTM storage markets are significantly impacted by state and local policy decisions. As a result, these BTM storage policies and trends have been tracked and reported by various organizations, including Sandia National Laboratories, Pacific Northwest National Laboratory, and the North Carolina NC Clean Energy Technology Center. These institutions organize the policies with varying focus areas and formats. Sandia National Laboratories maintains the Global Energy Storage Database (Sandia, 2021), which tracks policy activity with respect to energy storage at the federal and state levels. This database focuses on 10 policy questions with associated data from 10 states. The Pacific Northwest National Laboratory's energy storage policy database tracks data through the lens of energy storage procurement targets, regulatory requirements, demonstration programs, financial incentives, consumer protection-related policies, and other policy aspects across 25 states (PNNL, 2021). The NC Clean Energy Technology Center manages the Database of State Incentives for Renewables and Efficiency (DSIRE) (DSIRE, 2022). This database most commonly includes state storage-related financial incentives, but it also includes other federal, state, and local policies. And it has more than 2,600 policies and programs, including 33 that specifically target BTM storage across 16 states.

This policy tracking research is essential to identify which policies have been adopted nationwide, but these databases do not describe how policies complement each other within or across states. Further, it is challenging to assess an individual state's policy environment to identify policy gaps or compare policy environments across states. Analysis of these gaps is important given that researchers assert that policy sequencing or stacking is important to ensure decisionmakers' clean energy policy goals are achieved efficiently (Krasko and Doris, 2013; Meckling, Sterner and Wagner, 2017; Cook, Volpi, *et al.*, 2018).

Krasko and Doris (2013), who have conducted seminal work in this area, find that (1) the order in which distributed solar policies are implemented can affect the efficacy of the policies and (2) states that adopt market preparation, creation, and expansion policies in that order can see more solar deployment. In short, they find that states that originally implemented market preparation policies such as interconnection standards and compensation programs, prior to or in tandem with market creation (i.e., procurement mandates), and finally market expansion policies (i.e., financial incentives) had more robust solar markets than those that did not adopt a stacked policy approach. And Meckling, Sterner and Wagner (2017) suggest policy sequencing or starting with more incremental clean energy enabling policies before moving up the stack can both encourage market growth and help states navigate the often-incremental policymaking process.

As mentioned, the policy stacking literature for clean energy organizes policies into three general categories: market preparation, creation, and expansion (Figure 1). Market preparation policies are designed to remove institutional barriers and hence provide access to the market. For example, interconnection and compensation rules (i.e., net energy metering) that can facilitate BTM storage deployment are foundational to market development. As a result, these policies have been included as market preparation policies for solar and other clean energy technologies (Krasko and Doris, 2013) and the same is done here.

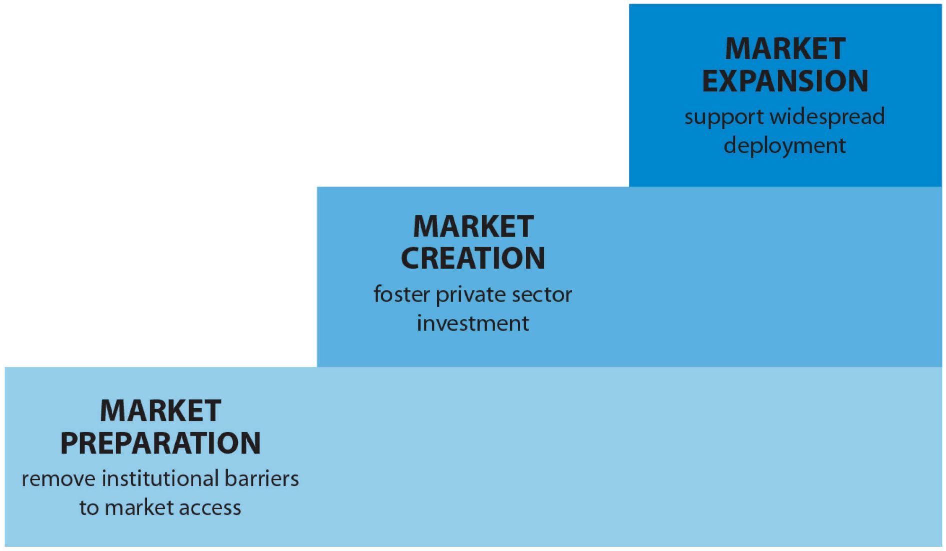

Figure 1. Policy stacking framework

Adapted from Cook, Volpi, *et al.*, 2018

Once market preparation policies are in place, policymakers might consider market creation policies such as mandates or procurement targets that require the development of a market and associated technology deployment (Cook, Volpi, *et al.*, 2018). These policies give clear signals about policymakers' intent, thereby boosting investor confidence and ushering in private investment.

Lastly, market expansion policies are designed to further support or improve the market appetite for the desired technology through incentives or tax breaks that can spur participation across more market participants. From a policy stacking perspective, these policies may be more effective when adopted after or in tandem with preparation and creation policies (Krasko and Doris, 2013).

This policy stacking concept has been applied beyond the solar space to assess policy environments in the microgrid and resiliency sectors (Cook, Volpi, *et al.*, 2018) and in some aspects of the energy storage sector. For example, Stanfield, Petta and Auck (2017) developed a state policy road map for foundational energy storage policies that could be considered by states to build a storage market. These authors emphasize the need for a variety of planning, grid access, value stream, and ownership-related policies to enable more-mature storage markets (IREC, 2017). However, the Interstate Renewable Energy Council's (IREC's) study does not assess all state BTM energy storage policies nationally; in addition, battery storage technologies and related markets have rapidly evolved since 2017. To address this gap, our analysis applies the policy stacking concept to the BTM energy storage sector, to compare states' existing policies and help policymakers make more-informed decisions.

3 Methods

The BTM energy storage policy stack was generated through a review of existing policy databases, interviews with a variety of subject matter experts, and additional data collection. The resulting policy stack was then vetted by the same interviewees. In this section, we summarize how we collected the data, assembled the stack, and compared states with each other.

3.1 Data Collection

We originally collected energy storage policies from databases developed by Sandia National Laboratories (Sandia, 2021), Pacific Northwest National Laboratory (PNNL, 2021), the NC Clean Energy Technology Center (DSIRE, 2022), and America Clean Power (ACP, 2022). Second, we collected BTM policy information through market reports published by Wood Mackenzie, North Carolina Clean Energy Technology Center, Interstate Renewable Energy Council, Bloomberg, and Clean Energy Group. Third, we conducted interviews with 19 representatives of 12 organizations to help us identify the key policies supporting BTM energy storage development in the United States.

Interviewees represented BTM storage project developers, research institutions, trade associations, corporate purchasers of electricity, and other key subject matter experts. And these interviewees were asked to identify other individuals to provide additional perspectives.[1] The interviews were semi-structured, thus allowing flexibility in how they were completed. Each interviewee was asked to discuss five key questions:

- How would you categorize BTM storage state policy, from foundational to supportive?
  - Which policies do you believe foster a market?
  - Which policies do you believe establish a market?
  - Which policies support or expand existing markets?
- Within those state policies, what are key factors or issues you look for to identify a policy's impact?
- What are some key regulatory barriers that energy storage faces?
- How would you rank states on their BTM storage policies?
- Which additional provisions should be incorporated in state energy storage policies?

Individuals were originally interviewed separately, to identify policy gaps. We then conducted our own primary research to collect policy information for policies that were not already included in existing databases. After concluding this work, we reassembled all interviewees to review and vet the draft policy stack together.

3.2 Policy Stack Development and Scoring

Based on interviewee feedback and existing literature, we developed 11 parent policy categories that cover the state energy storage policy stack from market preparation to market expansion.

[1] Utilities were not identified in this process, though future work in this space, might consider consulting those interests.

We then generated 31 related questions that are associated with the 11 parent policies. We did this because some parent policies cover a broad array of potential policies (e.g., the "planning and permitting" parent policy) or they were composed of a variety of discrete policy elements (e.g., "interconnection"). For example, interviewees confirmed there were a variety of critical characteristics within a state's interconnection policy that required deeper review. In short, not all interconnection policies are uniform or have the same impact. Therefore, we generated additional interconnection-related questions to cover the nuance and variation more effectively within a policy area, thereby allowing for clearer differentiation of interconnection policies.

For each of the 31 discrete policy-related topics or questions, we scored a state with a one if the policy was present or the answer to the question was yes. If a state did not have a policy, or an answer to the question was not found, the state received a zero for the question. It is important to clarify that in some cases multiple states may score on the same policy, yet those individual state policies are not in fact equally impactful. For example, a state could have a compensation policy in place with low compensation for BTM storage and it would be graded the same as a state with a compensation policy with high compensation. In many situations, cases like this are addressed through other questions within the same policy category, but in others, research would be needed to differentiate the policies. Regardless, each question associated with a parent variable was summed before scoring the parent variable.

Given that the literature stresses the importance of considering market preparation, and then creation, and finally expansion policies, we adjust the weight of the parent policies associated with each category. Those questions in the market preparation category receive a score of 2.0, followed by 1.0 and 0.5 respectively for creation and expansion policies.

3.3 Limitation of Methods

The three key limitations to this study relate to policy data collection and valuation.

First, many policies will affect BTM storage markets, including those outside a state's control (i.e., federal or wholesale market policies). Policies under the purview of the state can cover hundreds of pages, so identifying the exact impacts of certain policies and their content is resource intensive. As a result, this study had to rely in part on available data to assemble the policy stacks and focus on policy questions that could be evaluated efficiently. Therefore, some policies may be overvalued (i.e., they receive a full score when their policy is less supportive of BTM storage than another state policy that received the same score), and some state policies may be absent in our data set that do exist but were not publicly or otherwise readily documented.[2]

Second, we did not include various policies, programs, or concepts that were referenced by at least some interviewees, and others whose definitions were still evolving because:

- The data were unavailable (i.e., certain interconnection-related questions).
- The policy or topic was referenced by only a few interviewees and its BTM storage impact was uncertain (i.e., technical assistance to public utility commissions)

[2] Our BTM Storage Policy Stack is available: https://data.nrel.gov/submissions/192

- The referenced policy was too broad or its definition was too unclear to include here (i.e., cybersecurity requirements and grid modernization).

We excluded 33 policy questions under 8 parent policies from our state policy stacking results; a full summary of the excluded parent and child policies is provided in Appendix A. We recognize that many of these policies are important and future work could attempt to collect data in these policy areas to improve the policy stack analysis.

Third, to compare states with each other, and in keeping with the policy stacking framework, this study values market preparation, creation, and expansion policies differently via using weights of a somewhat arbitrary 2.0, 1.0, and 0.5, respectively. This metric is rudimentary and further implies parent policies within each of the three categories (preparation, creation, and expansion) are equally important. Ultimately, given the nature of how the policies were organized, removing the weights, and analyzing just the raw scores presents a very similar picture of the top states as the weighted scores. As a result, this weighting does not appear to significantly affect the results, in either a positive or negative direction. Regardless, future work could consider different or more refined weighting schemes across and within the three policy categories, especially where market preparation, creation, and expansion policies may be adopted in omnibus legislation (i.e., all at once and not in sequence).

Despite these challenges, this first-of-its-kind study can still provide policymakers relevant information to consider their BTM storage policy environment. In addition, it offers a baseline from which future work can build.

4 Interviewee Perspectives on Key Storage Policies

We focus on the perspectives of interviewees regarding BTM energy storage policies and markets by state. Interviewees were first asked to identify key state energy storage policies that should be considered when evaluating a state's policy environment. Interviewees were then asked to help categorize policies based on those that are considered foundational or critical as opposed to supportive.

In total, interviewees referenced 20 policies (Table 1). The seven most-referenced policies were interconnection, net metering, rate design, financial incentives, distributed energy resource (DER) aggregation, Federal Energy Regulatory Commission (FERC) Order No 2222, and resilience. Thereafter, interviewees somewhat frequently referenced various clean energy mandates, demand response, non-wires alternatives, and emission targets. Far fewer referenced cybersecurity, new construction measures, utility ownership, or other policies.

Table 1. Most-Referenced Energy Storage Policies

Policy	No. of References	Policy	No. of References
Interconnection	11	Equity	4
Net Metering	10	Carbon Emission Targets	4
Rate Design	10	Grid Modernization	3
Financial Incentives	10	Permitting	3
DER Aggregation	9	Value Stacking	3
FERC Order No. 2222	8	Technical Assistance for Public Utilities Commissions	2
Resilience	8	Cybersecurity	2
Clean Peak Standards/Renewable Portfolio Standards/Procurement Mandates for Storage	6	Utility Distribution Planning/Hosting Capacity	2
Demand Response	5	New Construction Standards	1
Non-Wires Alternatives	4	Utility/Customer Ownership	1

Interviewees had varying perspectives on different policies and programs that should be categorized as foundational or what would be considered market preparation in the policy stacking literature. However, they mostly agreed on the types of policies that should be categorized under the umbrella of market creation and expansion, as shown in Figure 2. In the context of market preparation policies, interviewees most frequently referenced interconnection, net-metering, rate design, and implementation of FERC Order No. 2222. This was not always consistent, as some also suggested these policies were important to support market creation. There was also overlap of all the aforementioned policies and those considered market expansionary policies. DER aggregation programs are a good example of this, where most interviewees considered these to be either a market creation policy or an expansion policy, with fewer references as a market preparation policy.

Overall, the variation here is in part driven by interviewee pespectives that all these policies can be important in delivering a more mature energy storage market. This aligns with the perspective that policymakers should consider all these policies when considering changes to their BTM storage markets, which aligns with the concept of policy stacking. Of course, the policy stacking literature would suggest if policymakers are going to take a piecemeal approach, they should consider their market preparation policies first, before creation or finally expansion.

Figure 2. Interviewees' identification of key preparation, creation, and expansion policies

Finally, interviewees identified states they perceived as having a favorable policy environment. Here, perspectives were mixed, but the top five most frequently referenced states were California, Massachusetts, New York, Arizona, and Vermont (Figure 3).

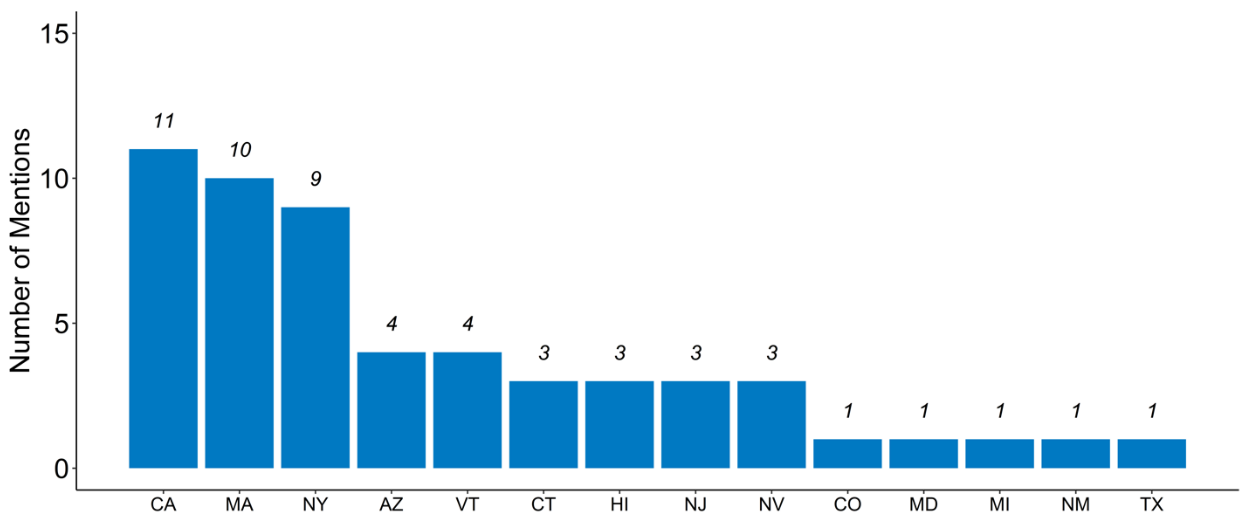

Figure 3. Interviewees' most-referenced states with perceived favorable BTM energy storage policy frameworks

5 BTM Energy Storage Policy Stack and State Scores

Based on the interviewee feedback and existing storage policy literature, we developed a BTM energy storage policy stack with 11 parent policies and 31 associated policy questions. The 11 parent policies were organized into one of the three policy stack categories: market preparation, creation, or expansion (Table 2). Recall, the market preparation category is designed to capture policies that would enable access to the market, market creation policies are those that foster or build a market, and expansionary policies are those that can broaden an existing market to additional sectors or applications.

Table 2. State BTM Energy Storage Policy Stack and Parent Policy Description

Policy Category	Parent Policy	Definition
Market Preparation	**Planning and Permitting**	The state has planned for BTM energy storage, piloted its use in different situations, developed permitting standards and/or guidance, and has undertaken other related activities.
	Interconnection	The state or utilities in the state have established requirements for connecting BTM energy storage to the grid.
	Compensation	The state or utilities in the state have established clear BTM energy storage compensation mechanisms.
	Rate Making	Time-of-use, demand charge, and/or other rate mechanisms are employed or available in the state.
Market Creation	**Wholesale Market**	When a state has rules on enabling BTM energy storage participation in wholesale markets, they are clear.
	Mandate	The state has adopted mandates that incentivize or require BTM energy storage.
	Distributed Energy Resource (DER) Aggregation	The state or utilities in the state have approved, developed and/or operate DER aggregation programs.
Market Expansion	**Storage Funding and Incentives**	The state offers financial incentives for BTM energy storage development.
	Resilience	The state has an energy resilience policy or programs in operation that incorporate BTM energy storage.
	Equity	The state considers BTM energy storage development impacts on disadvantage communities.
	Emission and Life Cycle Impact	The state has an emission target and an end-of-life battery storage program.

As noted, each of the 11 parent variables has at least one related policy question. Most parent policies have more than one, and planning and permitting, compensation, ratemaking, wholesale market, and mandates have three or more policy questions. Table 3 lists each of the policy questions associated with the relevant parent variable and policy stack category.

Table 3. State BTM Energy Storage Parent Policy Stack and Child Policy Questions[a]

Policy Category	Parent Policy	Questions
Market Preparation	**Planning and permitting**	Has an energy storage policy/economic study been completed in the state?
		Is or has a BTM energy storage pilot program been completed in the state?
		Has the state modified local government permitting requirements specific to BTM energy storage?
		Does the state allow or mandate the inclusion of energy storage in utility integrated resource plans?
		Has the state approved or otherwise required consideration of non-wires alternatives or DERs to defer, mitigate, or obviate the need for certain transmission and distribution investments?
		Does the state have a policy on utility ownership of energy storage assets?
		Does the state have a policy addressing multiple use applications for energy storage?
	Interconnection	Do the state's interconnection requirements expressly address BTM energy storage export control?
		Does a utility in the state publish a hosting capacity map?
	Compensation	Does the state allow BTM energy storage to be eligible for net metering compensation?
		Has the state replaced its net energy metering programs with BTM energy storage-specific tariffs?
		Does a utility in the state have demand response programs?
	Ratemaking	Does at least one utility in the state offer time-of-use rates?
		Does the largest utility in the state offer time-of-use rates?
		Does at least one utility in the state offer demand charge rates?
		Does the largest utility in the state offer demand charge rates?
Market Creation	**Wholesale Market Access**	Is FERC 841 being partially implemented in the wholesale market in the state?
		Is FERC 841 being fully implemented in the wholesale market in the state?
		Has FERC order 2222 been partially implemented in the wholesale market in the state?
		Has FERC order 2222 been fully implemented in the wholesale market in state?

Policy Category	Parent Policy	Questions
	Mandates	Does the state have a renewable portfolio standard (or equivalent) of 80% or more?
		Does the state have a mandate or target for any energy storage?
		Does the state have a mandate for BTM energy storage?
	DER Aggregation	Has at least one utility in the state implemented a DER aggregation program?
		Has the largest utility in the state implemented a DER aggregation program?
Market Expansion	**Storage Funding and Incentives**	Does the state offer financial incentives for BTM energy storage development?
	Resilience	Has a resilience or microgrid-related rate structure been approved or implemented in at least one utility in the state?
		Has the state implemented any policies or programs to encourage microgrid/resilience development?
	Equity	Does the state consider low- and moderate-income incentives for BTM energy storage?
	Emission and Life Cycle Impact	Does the state have at least one energy storage technology end-of-life program?
		Does the state have a target to reduce carbon emissions?

[a] When energy storage is referenced, the policy can address utility-scale and BTM battery storage.

After weighting the parent variables, the maximum policy stack score is 13 points: 8 points for market preparation, 3 points for market creation, and 2 points for market expansion. All 50 states and Washington, D.C, have implemented at least one policy included in the policy stack.

The average policy stack score is 4.8, with a range of 2.5–13.0 (Figure 4). California, New York, and Massachusetts lead the states with scores of 13.0, 10.6, and 9.1 respectively. These states perform well in large part because they have complete or near complete market preparation stacks.[3]

The leading state, California, is the only state that received a complete score across all categories in the policy stack.[4] Ten states score over 50% in the market preparation category, which helped nine of them reach the top ten (excepting Illinois). Connecticut, the remaining state in the top 10, scored 40% in the market preparation category, as it had higher creation and expansion policy scores than many other states.

[3] Though these are more heavily weighted policies, the raw scores continue to place these states at the top of the rankings.
[4] This is not to suggest California has adopted all BTM energy storage policies that could support the market, see Appendix A for policies questions that have not yet been addressed.

In terms of market creation, only California, New York, Massachusetts, Connecticut, Hawaii, Rhode Island, Colorado, Oregon, Vermont, Pennsylvania, and Washington earned 50% or above, and six of them (excluding Rhode Island, Oregon, Vermont, Pennsylvania, and Washington) ranked in the top 10 as well.

Finally, some states in the top ten had lower expansion scores than those outside the top ten. For example, Colorado received only 25% of the expansion score. On the other hand, New Hampshire and Washington received over 50% of market expansion scores, but these two states had lower total scores (4.9 and 4.1), given they perform less favorably on the preparation and creation categories. The detailed state scores by parent policies are listed in Appendix B.

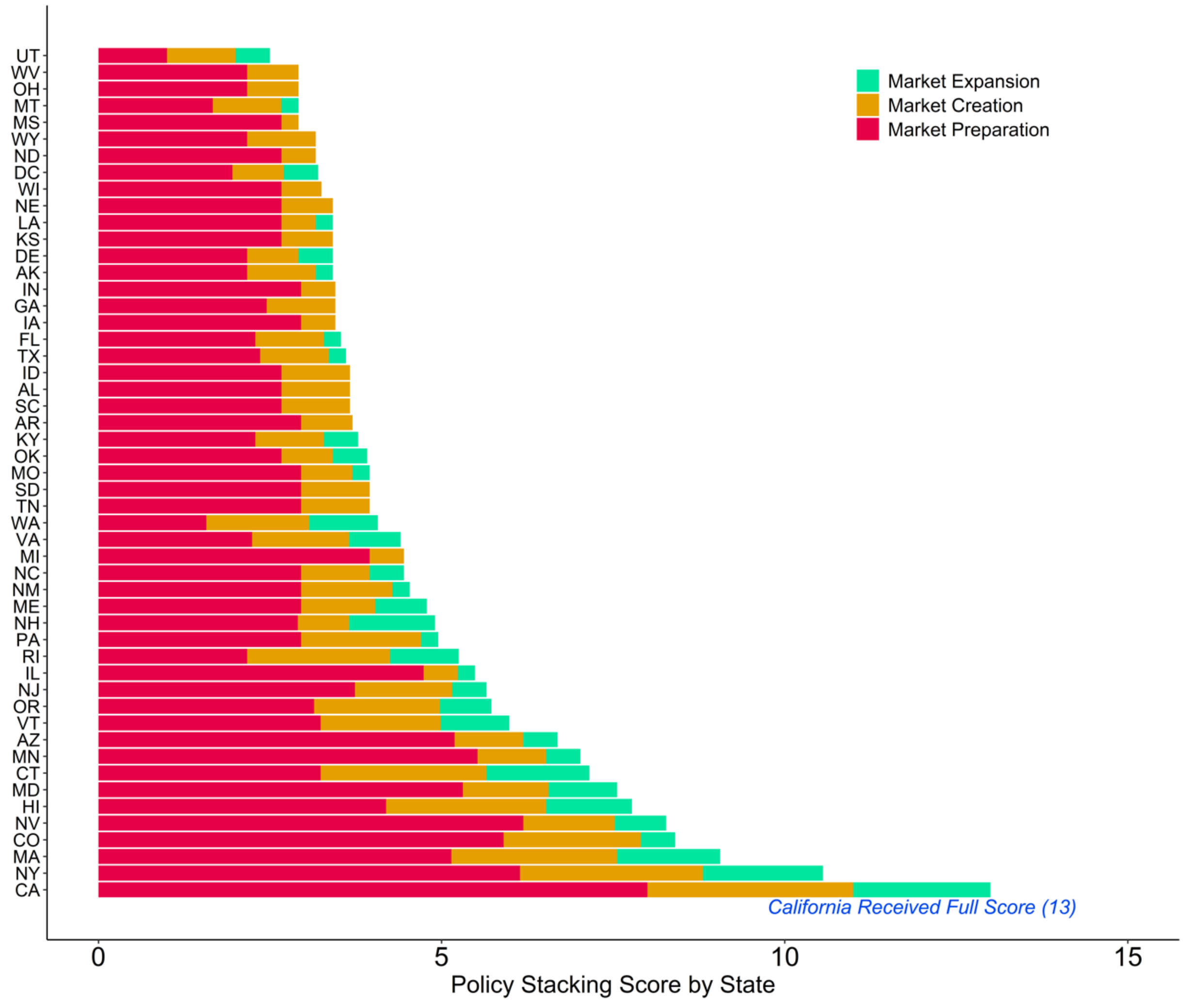

Figure 4. State policy stacking score in market preparation, creation, and expansion categories

Recall from Section 4, interviewees identified states they believed had favorable BTM energy storage policy frameworks. Of the 14 states interviewees mentioned, 11 were ranked in the top 15 in the policy stack. The three missing states are New Mexico (ranked 19), Michigan (ranked 20), and Texas (ranked 33).[5] Figure 5 illustrates the stacking scores of the top 15 states and the number of interviewee mentions. Here, California, New York, and Massachusetts were most frequently referenced states, and these three also had the best policy stack scores in this analysis.

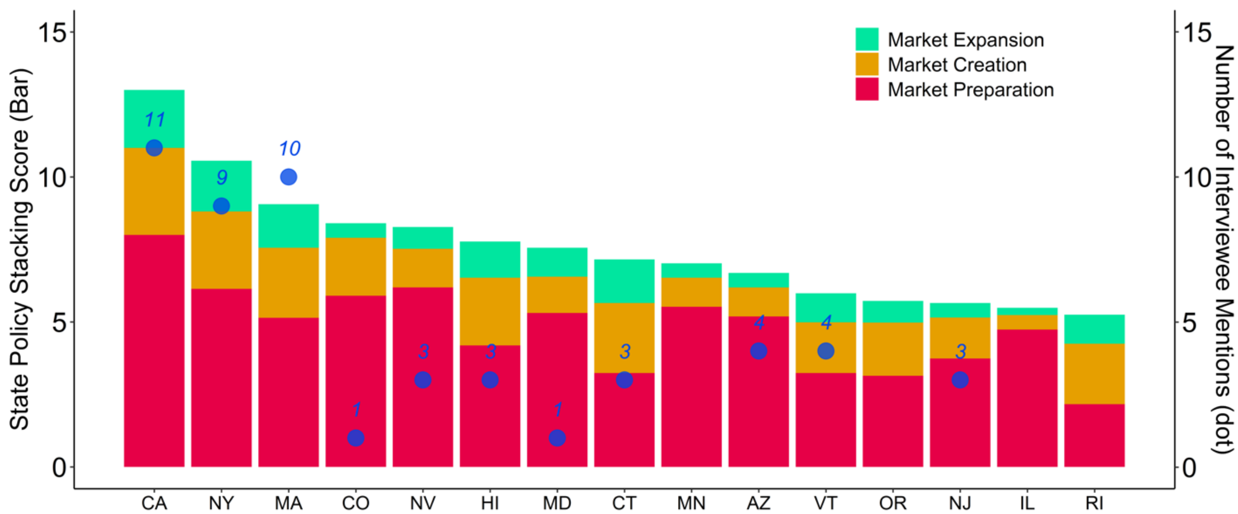

Figure 5. Top 15 highest state energy storage policy stack scores

[5] Each of these states was referenced by only one interviewee, while the other states in the list were referenced by many interviewees.

6 Understanding the Policy Stack

Each state varies in the policies they have adopted, and this is true across each policy stack category. In this section, we summarize the policies included in each of the three categories, and we provide examples of policies from various states. This section is not meant to be an exhaustive accounting of each state's policies or how they compare with each other. Rather, the goal here is to summarize the various parent policies and state-level examples that are included in each of the policy categories (i.e., preparation, creation, and expansion). Decision makers and other stakeholders can reference this material as they consider adjustments to their energy storage policy environments.

6.1 Market Preparation Policies

As defined in a Section 5, market preparation policies are designed to address fundamental market access barriers to BTM energy storage. In the case of BTM storage, these policies include planning and permitting, interconnection, compensation, and ratemaking. Fifty states and Washington, D.C. score within a range of 1.0–8.0 in the market preparation category, with an average score of 3.2 and a maximum score of 8.0. In this section, we describe policies from each of the four child policies that compose the overall score. Figure 6 shows how the 50 states and Washington, D.C scored for the four parent policies in the category.

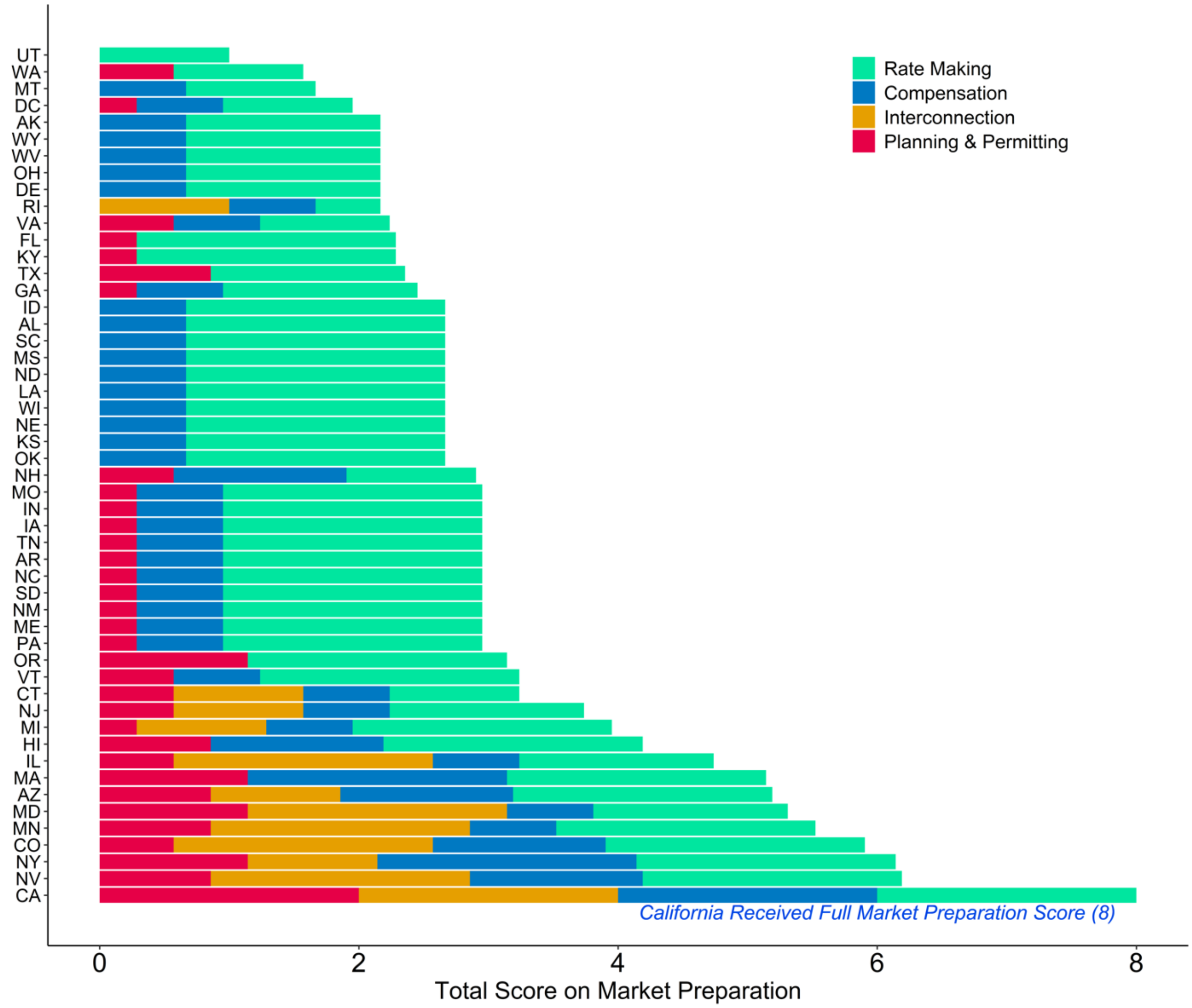

Figure 6. State policy stacking scored in market preparation category

The planning and permitting subcategory covers seven policy questions ranging from storage studies, pilot programs, permitting, and incorporating storage into various planning exercises (Table 3, page 11). Thirty-two states and Washington, D.C. have at least one policy associated with this category.[6] Most states covered in this category have adopted storage pilot programs (20 states and Washington D.C.), have adopted energy storage policy or economic studies (19 states), or include energy storage in utility integrated resource plans (16 states). Far fewer states have considered policies around non-wires alternatives or DER implementation for certain transmission and distribution investments (5 states), modifying permitting requirements specific

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[6] The New York State Energy Research & Development Authority (NYSERDA) has developed a comprehensive guidebook to help local government officials adopt legislation and regulations to accommodate battery energy storage systems in their communities. The guidebook details the permitting and inspection processes of battery energy systems. We did not give a full score to New York for planning and permitting parent policy because the guidebook is not legislation and hence nonbinding.

to energy storage (4 states), modifying utility ownership of energy storage assets (3 states), or addressing multiple use applications for energy storage (California).

Interconnection standards are another critical market creation policy, and this analysis includes two key questions: does the state's interconnection requirements expressly address BTM energy storage export controls and are hosting capacity maps available to support DER installation decisions. Twelve states score on at least one of these questions, and some score on both. We found eight states have interconnection rules and conditions that explicitly address BTM energy storage export controls. For example, Maryland's small generator interconnection standards state that utilities shall propose use for small generator facilities with energy storage devices subjected to inadvertent exports requirements (Maryland Division of State Documents, 2021). Moreover, utilities in 10 states have published hosting capacity maps either voluntarily or as required by the state. These hosting capacity maps are intended to help prospective customers identify where DER technologies including BTM storage may provide the most benefit to the grid along with lower interconnection costs (Driscoll, 2021). For example, the Minnesota Public Utility Commission issued an order in 2016 requiring Xcel Energy to conduct hosting capacity analysis for DER systems (Minnesota PUC, 2016; Xcel Energy, 2022).[7]

Compensation is the third policy in this category, and it has three associated policy questions relating to BTM storage eligibility in net metering programs, the availability of energy storage specific tariffs in place of or in tandem with net metering programs, and whether the states have demand response programs. Here, 44 states and Washington, D.C. score on this category, with all of them implementing demand response programs. Only five states (California, Massachusetts, Nevada, New Hampshire, and New York) allow customer-sited storage to be eligible for net metering compensation. In addition, six states have replaced their net energy metering scheme with storage-specific tariffs: Arizona, California, Colorado, Hawaii, Massachusetts, and New York. For example, the Hawaii Public Utilities Commissions ended its net metering program for new solar customers in 2015 and adopted two interim replacement tariffs (Dyson and Morris, 2015). In 2018, Hawaii subsequently implemented two new tariffs to replace the interim tariffs, including the smart export tariff that is designed for renewable systems paired with energy storage (DSIRE, 2018).

The fourth policy included in the market preparation category is ratemaking. Beyond compensation mechanisms that account for battery storage charging and discharging of renewable assets, certain rate designs can incentivize the use of battery storage systems, including rate structures with time-of-use and demand charges. All states and Washington, D.C. have at least one utility that offers demand charge rates, and 39 states and Washington, D.C. also score in this category given the largest utility in the state also offers demand charge rates. All states excluding Rhode Island and Washington, D.C. score on offering time-of-use rates, and 37 states receive credit for the largest utility in their state offering time-of-use rates.[8]

[7] Not all hosting capacity maps are the same, but best practices for how to develop effective maps are emerging (Stanfield, Zakai and McKerley, 2021).
[8] Future work might consider parsing these demand charge and time-of-use programs, including compensation thresholds. For example, higher thresholds/penalties for peak periods can influence BTM storage economics.

6.2 Market Creation Policies

The market creation category includes three child policies: wholesale market access, mandates, and DER aggregation. Fifty states and Washington, D.C. score within a range of 0.25–3.00 in the market creation category, with an average score of 1.2 (maximum score of 3). In this section, we describe policies from each of the three child policies that comprise the overall score. Figure 7 shows how the states and Washington, D.C scored for the three parent policies under the market creation category.

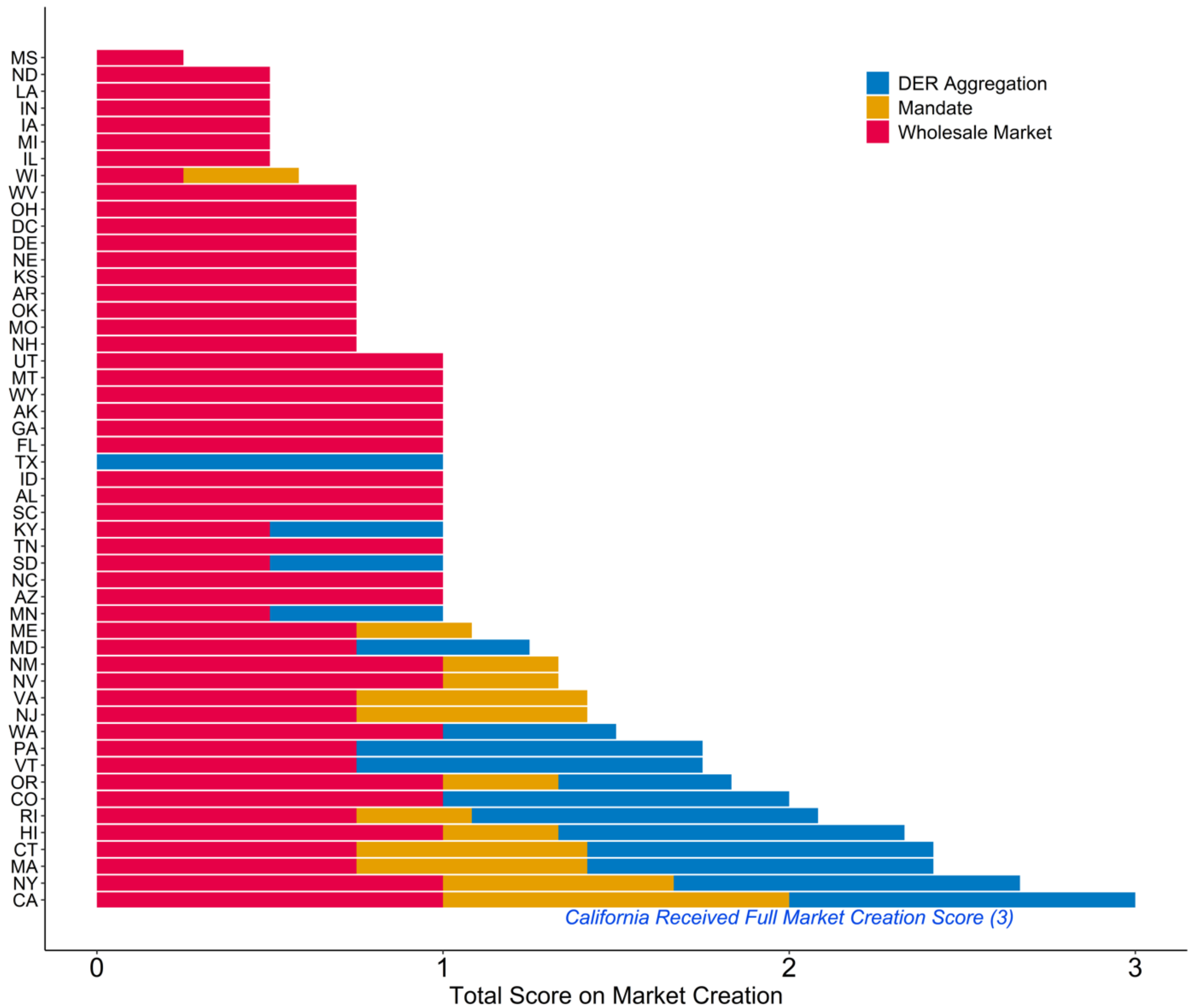

Figure 7. State policy stacking scored in market creation category

First, the wholesale market access policy addresses two FERC orders (FERC 841 and FERC 2222) that must be implemented across the 32 states and Washington D.C. that are served by independent system operators (ISOs) or regional transmission organizations (RTOs).[9] The overarching goals of these orders are to meet the increasing need for power system flexibility

[9] States that are not served by ISOs or RTOs received full credit on this question so as not to be penalized relative to the other 18 states.

and ancillary services, as well as to improve the system reliability by leveraging DER resources where economically viable (Zhou, Hurlbut and Xu, 2021).

FERC 841, which was adopted in February 2018, focuses on addressing wholesale market participation by both front-of-the-meter and BTM energy storage resources (FERC, 2020a, 2020b). FERC 841 orders regional transmission operators (RTOs) and independent system operators (ISOs) to reconfigure wholesale markets to accommodate storage resources to allow them to provide capacity, energy, and ancillary services. Subsequently, FERC 2222 was adopted in September 2020 to foster fair competition among market participants. Often DERs are small projects and do not meet the minimum size requirements to participate in RTO/ISO-operated markets. Order No. 2222 promotes the participation of DER in RTO/ISO markets by allowing aggregation of smaller resources to participate in those markets (Advanced Energy Economy, 2020; FERC, 2020a).

According to our study, FERC Order No. 841 has been fully implemented in 20 states and Washington, D.C. and partially implemented in 9 states. These 29 states are represented by six RTO/ISO-operated markets: Southwest Power Pool, New York Independent System Operator, PJM Interconnection, ISO New England Inc., California Independent System Operator, and Midcontinent Independent System Operator.[10] In comparison, FERC Order No. 2222 has been partially implemented in 31 states and Washington, D.C., and it has been fully implemented in California and New York (NYU, 2021).

Second, states may also consider adopting BTM energy storage mandates to support market growth. Thirty states and Washington, D.C have adopted a renewable portfolio standard that requires certain utilities to procure a percentage of their electricity supply from renewable sources (DSIRE, 2020). Of these, 11 states have targets exceeding 80% or more, and they scored in this study.[11] Only eight states have adopted some type of energy storage mandate: California, Connecticut, Massachusetts, Nevada, New Jersey, New York, Oregon, and Virginia. For example, New York announced energy storage targets of 1,500 MW by 2025 and 3,000 MW by 2030 (NYSERDA, 2019). California is the only state that has adopted a BTM energy storage mandate; it stipulates that 25% of their storage target be met with distributed systems.

Third, states could consider adopting or approving DER aggregation programs to expand solar and storage markets. These programs are designed to aggregate the electricity production and storage capacity from a wide variety of disparate energy sources and deploy them together to provide grid benefits as typical large, power generators do today. Sixteen states scored on this category, given at least one DER aggregation program has been piloted in each state by certain utilities. Of these, 10 programs were conducted by the largest utility in the state, suggesting future programs in these utility service territories could have a significant impact.

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[10] The 9 states within the Midcontinent Independent System Operator are the partially implemented states. In March 2021, the requested an extension to comply with FERC's Order 841 from June 6, 2022 until March 1, 2025 (Plautz, 2021).

[11] More than 30 states have RPSs, and this study selected 80% as an identifier of a high renewable deployment target. Having more variable electricity generation resources in the market could incentivize the development of energy storage projects (both utility-scale and BTM).

6.3 Market Expansion Policies

The third and final category in the policy stack is market expansion. It includes policies that are designed to support and expand BTM energy storage markets. In this category, we include four parent policies: incentives, resilience, equity, and emission and life cycle impacts. Fifty states and Washington, D.C. score within a range of 0.0–2.0 in the market expansion category, with an average of 0.5 (maximum score of 2.0). In this section, we describe policies from each of the four child policies that compose the overall score. Figure 8 shows how states and Washington, D.C scored for the four parent policies in the category.

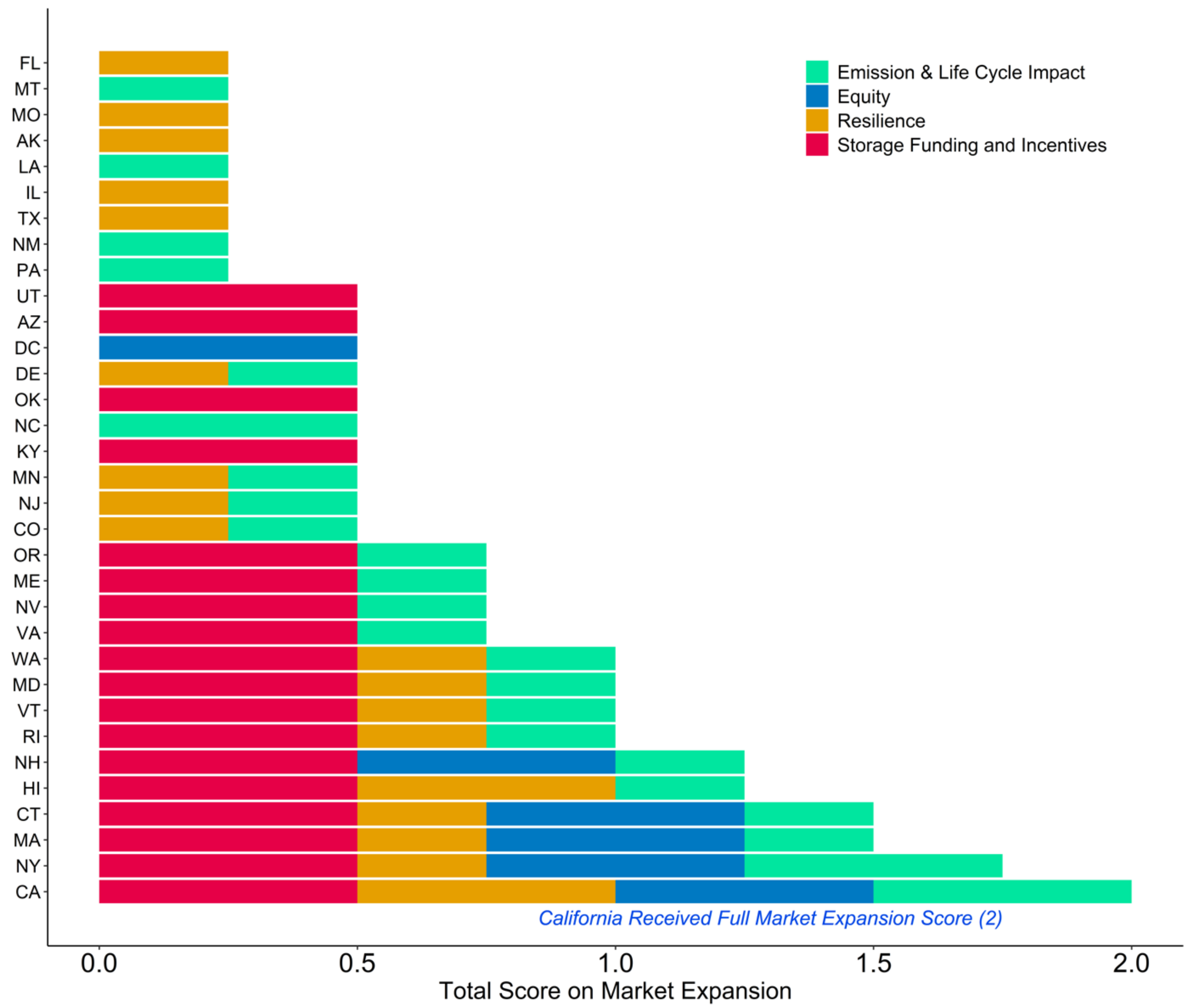

Figure 8. State policy stacking scored in market expansion category

Eighteen states that scored zero points in this category were excluded from the figure.

First, we found at least 18 states have some type of energy storage financial incentive. For example, California's self-generation incentive program provides incentives to DERs, including energy storage. Under this program, $378 million in incentives was set aside for BTM energy storage from 2017 through 2021 (California PUC, 2021; PNNL, 2021). New York offers another example, where the state provides multiple incentive programs relating to BTM energy storage, such as the Affordable Solar and Storage Predevelopment and Technical Assistance Program and other programs (NYSERDA, 2022).

Second, there are two key questions associated with resilience: has the state implemented any policies or programs to encourage microgrid and resilience development and has a resilience or microgrid-related rate structure been implemented by at least one utility in the state. Eighteen states have adopted some type of resiliency policies or programs. For example, Texas requires certain critical infrastructure to consider adopting combined heat and power systems to operate a full 14 days after a grid outage (State of Texas, 2009). Only two states score on the other question, given only utilities in California and Hawaii have designed microgrid rate structures. For example, Hawaii adopted a formal microgrid services tariff scheme in 2021 that includes energy storage (Hawaiian Electric, 2021).

Third, some states have adopted policies to expand adoption opportunities for low- and moderate-income customers. Here, five states (California, Connecticut, Massachusetts, New Hampshire, and New York) and Washington, D.C. have adopted such policies. One example is the Solar Massachusetts Renewable Target program implemented in 2018 that provides an income-based incentive adder for BTM storage projects in the state (Energysage, 2021).

The fourth policy in this category is emissions and life cycle impacts. This category includes two key questions: does the state have a target to reduce carbon emissions and has the state implemented an energy storage end-of-life program. Twenty-three states have developed carbon reduction targets and receive credit for this question. Only three states (California, New York, and North Carolina) have started to consider energy storage end-of-life initiatives. The California legislature has created a workgroup to advise on programs to prohibit landfilling lithium ion electric vehicle batteries and incentivize recovery and recycling (California EPA, 2021). And the New York State Energy Research and Development Authority (NYSERDA) created a battery storage model permitting program that addresses decommissioning, associated costs, and contingency plans to remove damaged batteries (NYSERDA, 2020). Finally, North Carolina passed a bill in 2019 to study issues and develop rules for the reuse, recycling, and disposal of stationary energy storage batteries (Curtis et al., 2021).

7 Conclusion

As BTM markets continue to evolve, state policy is likely to play a role in determining which states see more storage deployment going forward. To help identify how current BTM storage state policies vary, this research developed a first-of-its-kind BTM storage policy stack that included 11 parent policies and 31 child policies across the market preparation, creation, and expansion categories. The analysis identified California as leading the way on the policy stack, with New York, Massachusetts, Nevada, and Colorado rounding out the top five.

This research provides decision makers with insights regarding which policies they might consider along with how they might sequence them to potentially improve the likelihood of achieving their goals. States that have gaps in the stack may look to the policy activities of other states to consider pathways to adjust their policy environments. Further, even states that perform well on the stack might consider policy questions included in Appendix A to improve their stack, or they might review the specific content of their policies for areas of improvement.

There are several opportunities for future work to expand on the insights reported here. First, more work is needed to build out the policy stack for policies included and to expand it to include policies that were excluded from this analysis. For example, California received a complete score, but that does not mean the state could not be doing more to improve its existing policies or expand to address other areas not yet included in the stack. Therefore, continuing to expand the policy stack will ensure decision makers have more information to better refine their decision-making processes. Second, future work could evaluate policies' actual effects on BTM storage deployment to better describe how discrete policies, or a constellation of policies, are likely to affect BTM storage deployment within a state. In short, continued analysis in this space may prove valuable as BTM energy storage markets and policy evolve.

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Appendix A. Excluded Policy Questions

Table A-1. Excluded Policy Questions

Policy Category	Parent Policy	Questions
Market Preparation	**Interconnection**	Does the state consider the interconnected technologies' impact on distribution grid reliability?
		Is net metering required for interconnection?
		Is there an export limit for an energy storage technology?
		Is more than one energy storage technology type (I.e., lithium ion battery) eligible to be interconnected?
		Is there an expedited review option for smaller systems?
		Is the interconnection fee at or below the national average?
		Does the state have interconnection rules and requirements?
		What standard is referenced for setting technical requirements?
		Is there any System Capacity Limit?
		Is there a “Fast Track” option for applications?
		What sectors are eligible to participate?
		Is an external disconnect switch required for interconnected technologies?
		Is liability insurance required for homes and/or small business seeking to interconnect?
		Does the state have interconnection rules and requirements that explicitly include energy storage in the definition of eligible projects?
		Does the state require utilities to publish hosting capacity maps?
		Does or must the utility update the capacity map on a biennial or more frequent basis?
	Compensation	Is more than one energy storage technology type (I.e., lithium ion battery) eligible for the compensation scheme?
	Ratemaking	Are there any incentive-tied storage efforts on ratemaking?
		Has the state adopted a performance-based regulation/policy correlated with energy storage?
		Has the utility in the state revised its rate structures to drive adoption of BTM storage?
		Does the Time-of-use rate effectively incentive BTM energy storage development?
		Does the demand charge rate effectively incentive BTM energy storage development?

Policy Category	Parent Policy	Questions
Market Creation	**Energy Efficiency**	Does any utility in the state make storage eligible for energy efficiency programs?
	DER Aggregation	Does the provider of DER aggregation programs receive the performance payment?
		Does the utility develop a distributed energy resource management system and find cost-effective pathways to integrate DERs with different communication protocols?
		Does the utility work proactively with authorities having jurisdiction to resolve permitting issues particularly for energy storage?
		Does the utility pursue methods to increase communication reliability between DER aggregation program stakeholders?
		Does the utility consider the income-qualified components about DER aggregation program?
Market Expansion	**Storage Funding and Incentives**	Does the state have transparent incentive timelines?
		Does the state have transparent incentive capacity limits?
	Resilience	Does the state have a resilience plan?
		Does the resilience plan incorporate BTM storage?
	Emission and Life Cycle Impact	Does the state's climate policy encourage BTM storage?

Appendix B. State-by-State Policy Stack Scores

Table B-1. State Stacking Scores by Parent Policy

	Planning, Permitting	Interconnection	Compensation	Rate Making	Wholesale Market	Mandate	DER Aggregation	Storage Funding and	Resilience	Equity	Emission & Life Cycle		Market Preparation Total	Market Creation Total	Market Expansion Total	Total
Max Possible Score	2.0	2.0	2.0	2.0	1.0	1.0	1.0	0.5	0.5	0.5	0.5		8.0	3.0	2.0	13.0
California	2.0	2.0	2.0	2.0	1.0	1.0	1.0	0.5	0.5	0.5	0.5		8.0	3.0	2.0	13.0
New York	1.1	1.0	2.0	2.0	1.0	0.7	1.0	0.5	0.3	0.5	0.5		6.1	2.7	1.8	10.6
Massachusetts	1.1	0.0	2.0	2.0	0.8	0.7	1.0	0.5	0.3	0.5	0.3		5.1	2.4	1.5	9.1
Colorado	0.6	2.0	1.3	2.0	1.0	0.0	1.0	0.0	0.3	0.0	0.3		5.9	2.0	0.5	8.4
Nevada	0.9	2.0	1.3	2.0	1.0	0.3	0.0	0.5	0.0	0.0	0.3		6.2	1.3	0.8	8.3
Hawaii	0.9	0.0	1.3	2.0	1.0	0.3	1.0	0.5	0.5	0.0	0.3		4.2	2.3	1.3	7.8
Maryland	1.1	2.0	0.7	1.5	0.8	0.0	0.5	0.5	0.3	0.0	0.3		5.3	1.3	1.0	7.6
Connecticut	0.6	1.0	0.7	1.0	0.8	0.7	1.0	0.5	0.3	0.5	0.3		3.2	2.4	1.5	7.2
Minnesota	0.9	2.0	0.7	2.0	0.5	0.0	0.5	0.0	0.3	0.0	0.3		5.5	1.0	0.5	7.0
Arizona	0.9	1.0	1.3	2.0	1.0	0.0	0.0	0.5	0.0	0.0	0.0		5.2	1.0	0.5	6.7
Vermont	0.6	0.0	0.7	2.0	0.8	0.0	1.0	0.5	0.3	0.0	0.3		3.2	1.8	1.0	6.0
Oregon	1.1	0.0	0.0	2.0	1.0	0.3	0.5	0.5	0.0	0.0	0.3		3.1	1.8	0.8	5.7
New Jersey	0.6	1.0	0.7	1.5	0.8	0.7	0.0	0.0	0.3	0.0	0.3		3.7	1.4	0.5	5.7
Illinois	0.6	2.0	0.7	1.5	0.5	0.0	0.0	0.0	0.3	0.0	0.0		4.7	0.5	0.3	5.5
Rhode Island	0.0	1.0	0.7	0.5	0.8	0.3	1.0	0.5	0.3	0.0	0.3		2.2	2.1	1.0	5.3
Pennsylvania	0.3	0.0	0.7	2.0	0.8	0.0	1.0	0.0	0.0	0.0	0.3		3.0	1.8	0.3	5.0
New Hampshire	0.6	0.0	1.3	1.0	0.8	0.0	0.0	0.5	0.0	0.5	0.3		2.9	0.8	1.3	4.9
Maine	0.3	0.0	0.7	2.0	0.8	0.3	0.0	0.5	0.0	0.0	0.3		3.0	1.1	0.8	4.8
New Mexico	0.3	0.0	0.7	2.0	1.0	0.3	0.0	0.0	0.0	0.0	0.3		3.0	1.3	0.3	4.5
North Carolina	0.3	0.0	0.7	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.5		3.0	1.0	0.5	4.5
Michigan	0.3	1.0	0.7	2.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0		4.0	0.5	0.0	4.5
Virginia	0.6	0.0	0.7	1.0	0.8	0.7	0.0	0.5	0.0	0.0	0.3		2.2	1.4	0.8	4.4
Washington	0.6	0.0	0.0	1.0	1.0	0.0	0.5	0.5	0.3	0.0	0.3		1.6	1.5	1.0	4.1
Missouri	0.3	0.0	0.7	2.0	0.8	0.0	0.0	0.0	0.3	0.0	0.0		3.0	0.8	0.3	4.0
South Dakota	0.3	0.0	0.7	2.0	0.5	0.0	0.5	0.0	0.0	0.0	0.0		3.0	1.0	0.0	4.0
Tennessee	0.3	0.0	0.7	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0		3.0	1.0	0.0	4.0

	Planning, Permitting	Interconnection	Compensation	Rate Making	Wholesale Market	Mandate	DER Aggregation	Storage Funding and	Resilience	Equity	Emission & Life Cycle		Market Preparation Total	Market Creation Total	Market Expansion Total	Total
Oklahoma	0.0	0.0	0.7	2.0	0.8	0.0	0.0	0.5	0.0	0.0	0.0		2.7	0.8	0.5	3.9
Kentucky	0.3	0.0	0.0	2.0	0.5	0.0	0.5	0.5	0.0	0.0	0.0		2.3	1.0	0.5	3.8
Arkansas	0.3	0.0	0.7	2.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0		3.0	0.8	0.0	3.7
South Carolina	0.0	0.0	0.7	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0		2.7	1.0	0.0	3.7
Alabama	0.0	0.0	0.7	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0		2.7	1.0	0.0	3.7
Idaho	0.0	0.0	0.7	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0		2.7	1.0	0.0	3.7
Texas	0.9	0.0	0.0	1.5	0.0	0.0	1.0	0.0	0.3	0.0	0.0		2.4	1.0	0.3	3.6
Florida	0.3	0.0	0.0	2.0	1.0	0.0	0.0	0.0	0.3	0.0	0.0		2.3	1.0	0.3	3.5
Georgia	0.3	0.0	0.7	1.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0		2.5	1.0	0.0	3.5
Iowa	0.3	0.0	0.7	2.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0		3.0	0.5	0.0	3.5
Indiana	0.3	0.0	0.7	2.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0		3.0	0.5	0.0	3.5
Delaware	0.0	0.0	0.7	1.5	0.8	0.0	0.0	0.0	0.3	0.0	0.3		2.2	0.8	0.5	3.4
Alaska	0.0	0.0	0.7	1.5	1.0	0.0	0.0	0.0	0.3	0.0	0.0		2.2	1.0	0.3	3.4
Louisiana	0.0	0.0	0.7	2.0	0.5	0.0	0.0	0.0	0.0	0.0	0.3		2.7	0.5	0.3	3.4
Kansas	0.0	0.0	0.7	2.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0		2.7	0.8	0.0	3.4
Nebraska	0.0	0.0	0.7	2.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0		2.7	0.8	0.0	3.4
Wisconsin	0.0	0.0	0.7	2.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0		2.7	0.6	0.0	3.3
D.C.	0.3	0.0	0.7	1.0	0.8	0.0	0.0	0.0	0.0	0.5	0.0		2.0	0.8	0.5	3.2
Wyoming	0.0	0.0	0.7	1.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0		2.2	1.0	0.0	3.2
North Dakota	0.0	0.0	0.7	2.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0		2.7	0.5	0.0	3.2
Montana	0.0	0.0	0.7	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.3		1.7	1.0	0.3	2.9
Ohio	0.0	0.0	0.7	1.5	0.8	0.0	0.0	0.0	0.0	0.0	0.0		2.2	0.8	0.0	2.9
West Virginia	0.0	0.0	0.7	1.5	0.8	0.0	0.0	0.0	0.0	0.0	0.0		2.2	0.8	0.0	2.9
Mississippi	0.0	0.0	0.7	2.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0		2.7	0.3	0.0	2.9
Utah	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.5	0.0	0.0	0.0		1.0	1.0	0.5	2.5