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Waiting in Queue: A Historical Evaluation of Interconnection Policy

June 2023

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U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
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Abstract

Both states and Independent System Operators (ISO)/Regional Transmission Organizations (RTO) have struggled with long wait times in interconnection queues. As a result, numerous reforms have been proposed to expedite the connection of new resources to the grid. This paper conducts a quantitative analysis of two of these policies: one providing detailed hosting capacity information in Massachusetts, the other experimenting with cost allocation in New York. We find that both policies led to a statistically significant decrease in the times projects spend pending in interconnection queues, with New York seeing a small drop in days pending, and Massachusetts seeing a much larger one. We also include an analysis of how energy storage impacted queue time in these states. These results can help inform regulators who are weighing reforms to interconnection policies, with the goal of reducing wait times.

Acronyms and Abbreviations

CESIR	Coordinated Electric System Interconnection Review
ERCOT	Electric Reliability Council of Texas
FERC	Federal Energy Regulatory Commission
ISO	Independent System Operators
MA	Massachusetts
NEM	Net Energy Metering
NOPR	Notice of Proposed Rulemaking
NY	New York
OLS	Ordinary Least Squares
RTO	Regional Transmission Organization

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1.0 Introduction

Interconnection reviews are a necessary and critical process for adding new generators to the grid. Grid operators must review large projects before they are connected to the network in order to ensure that the project will not compromise the safety, reliability, and resiliency of the electricity system. The processing of interconnection applications, however, can be expensive and time consuming. The interconnection application itself typically includes an analysis of the feasibility of the project, the impact it will have to the network, as well as a review of the technical details of the facility to ensure it is built to adequate safety standards. These reviews can also require more detailed studies (like power flow analysis) and multiple revisions or iterations.

Processing these applications requires significant time and resources from developers, utilities, ISO/RTO staff, and state agencies. As renewable energy and energy storage installations have skyrocketed, queues for interconnection approval have grown. As Figure 1 shows, pending interconnection approvals have increased by a factor of five in the Electric Reliability Council of Texas (ERCOT), while doubling in PJM over a period of six years (PJM 2023, ERCOT 2023). Interconnection costs for generators have risen substantially and average time to interconnect has risen from 2.1 years to 3.7 years since the late 2000s (Rand, et al. 2022). The complexity around interconnection has also altered developer behavior, with many developers reporting using interconnection proceedings as a discovery process, submitting speculative projects that they may not expect to come to fruition (Penrod 2022).

Further, energy storage has become a growing component of interconnection proposals. Most interconnection processes were not designed with energy storage technologies in mind and apply many of the same standards and processes that they use for energy generators. However, energy storage provides different functionality that could potentially be leveraged to support grid outcomes and streamline interconnection approvals in some instances (IREC 2022, Gill, et al. 2022). Optimal integration of these resources will require further reforms to interconnection processes.

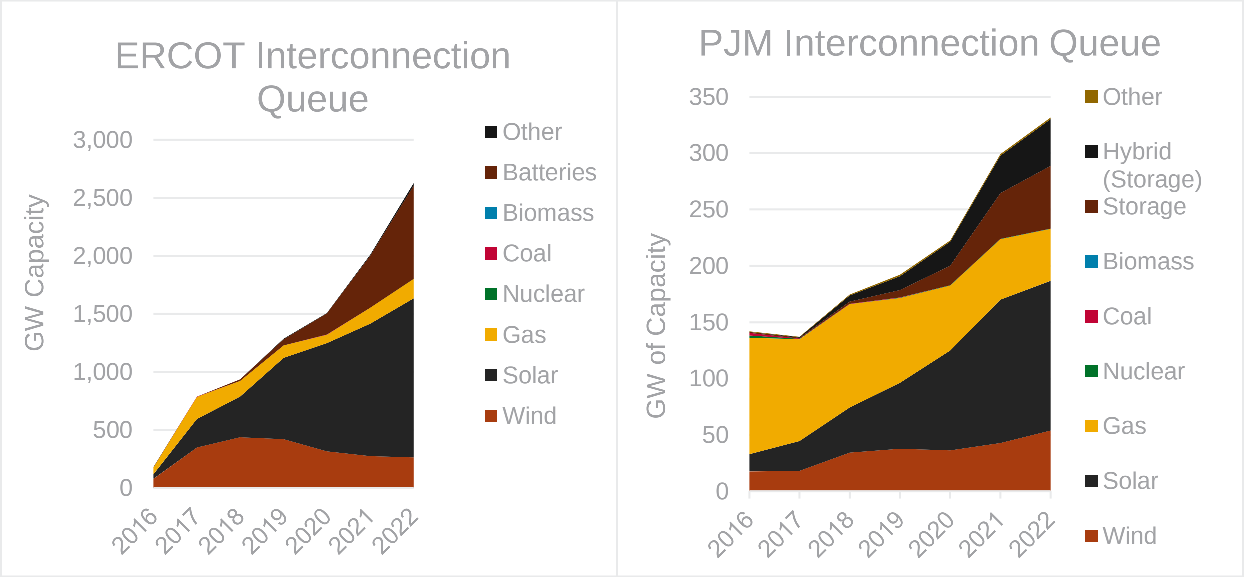

Figure 1- ERCOT and PJM Interconnection Queue Volume

As a result of these market dynamics, state regulators, ISO/RTO officials and the Federal Energy Regulatory Commission (FERC) have been experimenting with reforms to the interconnection process. PJM, for example, moved to a "first ready, first served" system in December 2022, whereby projects are reviewed and processed in clusters (Thomas 2022). This reform is designed to reduce duplication of work and allow for cost sharing between generators. Cluster studies have been shown to have a least a moderate impact on interconnection queues (Caspary, et al. 2021). Others, however, maintain that the way to tame growing interconnection queues is to implement a more holistic process that reviews hosting capacity needs on an ongoing basis and spreads the costs of upgrades across a broader group of stakeholders (Clean Energy Group 2023).

How costs are allocated throughout the interconnection process also has an impact on project outcomes. Many ISOs have historically applied traditional utility cost causation principles, which often mean the project that triggers any necessary transmission or distribution upgrades is responsible for their cost. This cost allocation technique can create free rider issues, where subsequent projects which may benefit from these upgrades are not liable for any costs associated with their installation. Clustering projects by geography can provide a natural opportunity to allocate costs more broadly to beneficiaries, but other methods for cost allocation exist as well.

State regulators have also worked to reform their interconnection processes, though the state interconnection process is generally more targeted to small, distribution-connected systems. Though large and small systems have differing technical requirements, some of the more process-focused, state-level reforms could be scaled easily towards larger systems. Additionally, some state-level reforms have been in effect for at least several years, providing sufficient time for their impact on projects to be assessed.

While some of these reforms (such as waived or reduced interconnection requirements for very small systems) are not applicable to large transmission-scale projects, others could be scaled or expanded to other areas and types of projects. Many of these policies have been in place for several years and have seen hundreds of projects complete the interconnection process under their specifications. However, their overall impact on interconnection times is untested. To that regard, we examine the effect on interconnection queue duration of two state policies designed to address some of the issues mentioned here: network hosting capacity information and cost allocation.

The remainder of this paper is structured as follows: section 2 introduces these policies and provides a brief description of how and why they were implemented. Section 3 outlines our sources of data and explains our methodological approach. Section 4 details the results of this analysis. Section 5 includes an overview of the role that energy storage has played in these policies and discuss the broader impact that these technologies could have on the interconnection process. Section 6 concludes.

2.0 Policy Background

2.1 Massachusetts

A lack of understanding of grid conditions can be a tremendous barrier for project developers and lead to inefficient deployment patterns. In an effort to combat this issue, many network operators have worked to make information on grid congestion more accessible. In 2019, Massachusetts worked to help alleviate this issue by posting regular updates on the hosting capacity of distribution feeders (Figure 2, as an example). The goal of this was to allow developers to gain a sense of the relative cost of interconnecting in different areas and direct construction towards feeders with more hosting capacity. This in turn could reduce the number of more intensive network studies and improve withdrawal rates stemming from increased cost. Massachusetts provides detailed information on project interconnection submissions and timelines allowing for detailed analysis of the policy.

While the initial order required that all utilities develop and publish these hosting capacity maps by November 2020, the commonwealth reports that all utilities began publishing hosting capacity maps by November 2019 (Commonwealth of Massachusetts 2023). Each of the state's three public utilities (National Grid, Eversource, and Unitil) publish monthly updates of hosting capacity that are publicly accessible.

A handful of similar states have worked to make hosting capacity information more accessible, and there are publicly accessible methodologies and best practices for developing hosting capacity studies. In particular, the Interstate Renewable Energy Council publishes guides on hosting capacity analysis (2017), and provides testimony to state utility commissions who are considering these sorts of reforms.

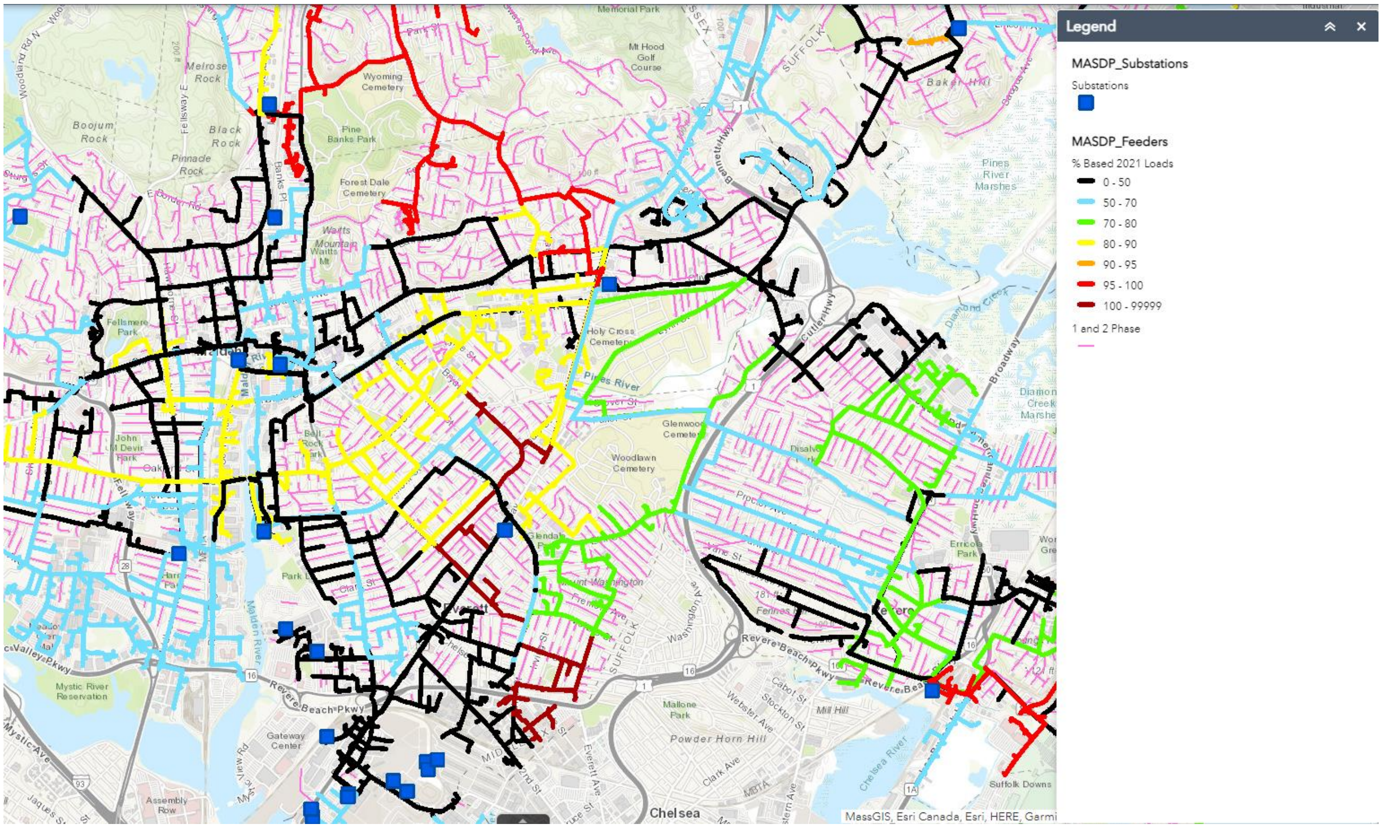

Figure 2 – Hosting capacity outside of Boston, MA (National Grid 2023)

While some DER advocates have requested that utilities tailor and automate interconnection approvals in response to grid conditions, the elimination of these information barriers alone could have an impact. With knowledge of which feeders are congested and which have additional capacity, developers can target their efforts to those projects that are least likely to run into grid issues and are easier to interconnect.

2.2 New York

While New York also uses hosting capacity analysis, they have worked to improve their interconnection by focusing on the cost allocation issue. As previously mentioned, the common “upgrader pays” model for dealing with capacity upgrades can lead to free rider issues, where subsequent projects benefit from these upgrades but pay none of the cost. The state has embarked on a detailed reform process for their cost allocation mechanisms, issuing an interim change in 2017 which requires beneficiaries to reimburse the triggering project for any marginal benefits that they incur. If for example, a new energy storage project was required to upgrade transformers, and as a result the hosting capacity on the feeder doubled, a subsequent project installed on that particular feeder would have to reimburse the triggering project owner for their share of the new hosting capacity.

In theory, this policy should help alleviate the free rider issue. Developers may be more willing to enter into an extensive review and upgrade process if there is an opportunity to receive additional revenue in the future. The state continues to make modifications to its cost allocation process, including efforts provide more cost certainty to developers. The 2017 reimbursement policy was intended to be a placeholder methodology, put in place while the state’s interconnection working group develops a more detailed one.

Cost allocation of network assets has been a particularly difficult issue for utilities at both the distribution and transmission level. Many reforms, such as FERC’s 2022 Notice of Proposed Rulemaking (NOPR), focus on planning processes (FERC 2022), and allow ISOs to proactively build network assets to meet demand. However, additional experimentation on allocating costs is likely to take place, and opportunities to empirically evaluate these forward-looking proposals are limited. New York’s policy represents an opportunity to look at the impacts that cost allocation modifications have on interconnection policies and be used to inform these processes.

3.0 Data and Methods

Both Massachusetts and New York maintain detailed information on projects seeking to connect to the electricity grid. Updates on projects seeking interconnection are published on regular intervals, and the states keep historic records on all projects that have applied for interconnection. These databases are focused on smaller systems that are generally located on the distribution system. State agencies provide information on the characteristics of the projects seeking approval (size, technology, etc.), as well as components of the interconnection request (date of submission, additional studies required, date of approval, etc.).

In order to examine the effectiveness of these programs, we utilize a number of standard regression analyses including ordinary least squares (OLS) regressions and negative binomial regressions. OLS is the most common form of regression analysis and provides a straightforward analysis of the relationship between a dependent variable and other variables. We provide post-regression analyses to ensure that our regressions do not violate the assumptions of the Gauss-Markov theorem and we have unbiased estimators. While the Gauss-Markov assumptions hold for our estimators, we note that interconnection data is not normally distributed. As many small systems are interconnected rapidly, the distribution is skewed to the left, and more closely aligns with a Poisson distribution than a normally distributed one, and the interconnection time is a count outcome. Therefore, we also provide analyses using a negative binomial regression, which accounts for the anormal distributions and overdispersion (high variance) of the data. Negative binomial regressions are frequently recommended when analyzing count variables such as these. Notably, negative binomial regressions utilize logarithmic transformation of the dependent variable, making their interpretations less straightforward.

Some projects have been listed in these interconnection queues for years, and in some cases up to a decade. By the nature of the recency of these reforms, those who entered the queue after the reforms take effect will have at most two to three years to be approved, with complicated or non-compliant projects still being listed as pending at the time of the analysis. This phenomenon would obviously skew the results. As a result, we provide an analysis of a subset in time – immediately before the policies took effect and immediately after. We divide the data into two groups, using time periods of the same length: those installed and approved immediately after the policies took effect, and those installed immediately beforehand. This allows us to see the impact on a reasonably similar set of projects.

This analysis provides a balance between more simplistic trackers often published by state agencies or industry groups (which often just measure current wait times) and more detailed causal analysis. While we control for a multitude of factors, there remains a risk of endogeneity. Future researchers and policymakers who are considering these options as potential indicators of their impacts on queue times can build on this work by expanding it to additional states or policies, or by introducing causal inference techniques such as regression discontinuity designs.

4.0 Results

4.1 Massachusetts

For Massachusetts, the OLS regression analysis (listed in Table 1) indicates that projects installed after the state published hosting capacity maps are associated with a decrease in interconnection times of approximately 100 days depending on model definition. These results account for numerous factors including the characteristics of the system (size, sector, etc.), how crowded the interconnection queue was and details of the specific interconnection request, including whether the projects required additional study and the extent to which delays on the customer side impacted the timeliness of the request.

Table 1 MA OLS results with robust standard errors from Nov 2018- June 2021, y=Days in queue

	1		2		3	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
After Map available	-107***	10.3	-95.2***	10	-96.6***	10
Expedited	-146***	13.3	-108***	11	-110***	9.83
Required Study	40.1***	14.7				
Design Capacity kW	.072**	.0297	.154***	.0497	.155***	.051
NEM	-52.4***	10.6	-19.4**	8.98		
Queue Volume	.00589***	.000802	.00603***	.000778	.00607***	.00078
Queue Count	10.3***	1	10.1***	.992	10***	.993
Queue Volume * Queue Count	-.000046***	6.4e-06	-.000047***	6.3e-06	-.000046***	6.3e-06
IC Plan Modified	79.1***	8.92	85.6***	8.88	78.5***	8.27
Withdraw Volume count	-10.6***	2.18	-11.1***	2.12	-11.2***	2.12
Withdraw Volume Capacity	.0114***	.00255	.0115***	.00246	.0115***	.00246
Withdraw Volume count * Withdraw Volume Capacity	-.000154***	.000033	-.000149***	.000032	-.000148***	.000032
Q4	37.5***	10.8	38.4***	10.3	39***	10.4
Customer delays	1.43***	.234	1.42***	.23	1.43***	.225
Sector						
Commercial						
Residential			-75.1***	9.97	-81.1***	9.89
Utility			-228**	89.3	-233**	91.4
Hybrid			-83.1***	26.6		
Has storage			33.8	22.7	-33.1***	12.2
Intercept	-607***	85.8	-556***	86.4	-551***	86.9

*** p<0.001, ** p<0.01, * p<0.05

Where variables are defined as follows:

After Map available	Dummy variable indicating whether the interconnection application was submitted before or after hosting capacity maps were available
Expedited	Dummy variable indicating whether the interconnection application received expedited status

Required Study	Dummy variable indicating whether the interconnection application required a detailed network study
Design Capacity kW	The proposed capacity of the project
NEM	Dummy variable indicating whether the interconnection application was for a net metered project
Queue Volume	The average volume of projects (in terms of total proposed capacity) in the interconnection queue
Queue Count	The average count of projects (in terms of total number of applications) in the interconnection queue
Queue Volume * Queue Count	Interaction term between queue volume and queue count
IC Plan Modified	Dummy variable indicating whether the interconnection application was modified at any point during the approval process
Withdraw Volume count	The average count of projects (in terms of total number of applications withdrawn) during project's time in the interconnection queue
Withdraw Volume Capacity	The average volume of projects (in terms of total proposed capacity) during project's time in the interconnection queue
Withdraw Volume count * Withdraw Volume Capacity	Interaction term between withdraw volume count and withdraw volume capacity
Q4	Dummy variable indicating whether an application was submitted in October, November, or December of a given year[1]
Customer delays	Total count of days in which the application was pending a response from the customer
Sector	Dummy variable indicating the sector (residential, commercial utility) of a proposed project
Hybrid	Dummy variable indicating whether the interconnection application was for a hybrid system (e.g. uses two or more energy generating or storage project).
Has storage	Dummy variable indicating whether the interconnection application included an energy storage technology

The three models above illustrate the impacts that energy storage has on interconnection delays. Model one shows the output results, without controls for energy storage. Model two introduces controls for hybrid systems and systems that have storage, while model three only controls for the presence of energy storage. Model two shows that hybrid projects without storage (e.g. solar and wind hybrids, solar and fuel cell hybrids) are in the queue for 83 days less than the average non-hybrid project, while hybrid storage projects are in queue for 49 days less than an average non-hybrid project.[2] Model three compares projects with storage to those without it. Here, projects with energy storage receive approval for interconnection 33 days earlier than those without storage, on average.

Other factors also have a marked impact on interconnection approval times. Both number of projects pending approval, as well as the total amount of capacity pending increase the average number of days to approval, while withdrawing projects from the queue reduces the total

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[1] The fourth quarter of a given year, generally sees a greater number of submissions as developers rush to claim the Investment Tax Credit for a given year

[2] The estimate for energy storage in model 2 is left in for explanatory purposes, and for consistency with the results for New York

number of days and withdrawing capacity from the queue increases time to approval.[1] Modifying the submitted plan partway through the process increases time to interconnect, as do any delays in responses from the customer. Submitting the fourth quarter of the year also adds about 40 days to the total time to approval. The final quarter of the year generally sees an increase in requests, as developers rush to complete projects so they can claim the Investment Tax Credit for the current year.

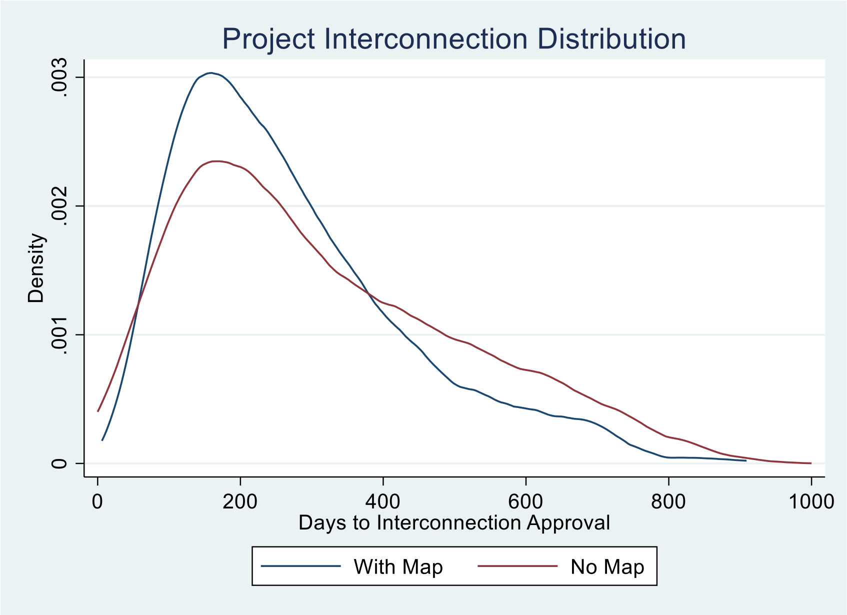

Figure 3. Kernel density for MA projects, separated by policy periods, Nov 2018- June 2021

Figure 2 provides a potentially simpler interpretation of these results. The figure shows the distribution of interconnection timelines, separated into two categories. The blue line represents projects in the analysis period that had access to the hosting capacity map, while the red represents those projects that did not. While the two periods had similar modes, the right tail is substantially fatter for projects submitted before hosting capacity maps were available. Though this analysis is not causal, it could potentially indicate that access to these details did not have a tremendous impact on approvals for a “typical” or uncomplicated project but allowed more complex projects to avoid running up against hosting capacity caps, thus moving some of the projects that would otherwise see prolonged waits for approval closer to the mode. More detailed causal analysis could help to affirm these claims with greater confidence.

We also provide two alternatively defined models for the Massachusetts policy in Table 2. These include a log transformation of the response variable, and a negative binomial regression to account for the anormal distribution of the data. These models are less straightforward to interpret and require transformation for comparison to the previous model. For the log linear transformation, we predict fitted values for the model. We find that the average project that did not have access to the map would take 362 days to reach interconnection, while one submitting for interconnection after the policy took effect would reach approval after 255 days, while controlling for the factors listed below. This difference of 107 days is very similar to the

---

[1] Queue Volume * Queue Count represents the interaction between the two variables. In these estimates, both increasing the amount of capacity in the queue and the number of projects pending increase the number of days to approval. However, these factors are related, thus the interaction term is added to show how the variables together provide an impact. A similar interaction term is included for withdrawals.

coefficients presented above in the various linear models. Likewise, the negative binomial regression sees fitted values of 349 days for projects that submitted after the map was available, and 249 for those that submitted after the map was available, a difference of 100 days. The consistency of results across these differently defined models shows indicates that the results are relatively robust despite the lack of causal analysis.

Table 2. MA Alternate model results with robust standard errors from Nov 2018- June 2021, y=Ln(Days in queue), Days in queue, respectively

	5		6	
	Log Linear Transformation		Negative Binomial Regression	
	Coefficient	Std. error	Coefficient	Std. error
After Map available	-.354***	.0375	-.34***	.0355
Expedited	-.392***	.0381		
Required Study			-.0948***	.035
Design Capacity kW	.000255**	.000118	.000242*	.000123
NEM	.0888**	.0396	.00777	.0372
Queue Volume	1.0e-05***	2.3e-06	.000031***	3.1e-06
Queue Count	.0224***	.00323	.0479***	.00285
Queue Volume * Queue Count	-8.4e-08***	1.5e-08	-2.5e-07***	1.9e-08
Withdraw Volume count			-.0529***	.00699
Withdraw Volume Capacity	-.000013***	2.8e-06	.00009***	9.8e-06
Withdraw Volume count * Withdraw Volume Capacity			-1.1e-06***	1.3e-07
Q4				
Customer delays	.00614***	.000767	.00315***	.000604
Sector				
Commercial			0	0
Residential	-.312***	.035	-.323***	.032
Utility	-.331	.217	-.389**	.182
lnalpha			-1.45	.0382
Alpha			.234	.00895
Intercept	4.27***	.229	.55*	.302

*** p<0.001, ** p<0.01, * p<0.05

4.2 New York

The process described above is repeated here to examine the impacts of the cost allocation policies in New York. Again, the dataset is split into two panels: one consisting of projects installed immediately before the policy took effect, and one with those installed afterwards. We present several models. Three models utilize OLS and are separated based on their treatment of energy storage. The final two models consist of alternatively defined models (log linear and negative binomial), which account for the count distribution of the response variable.

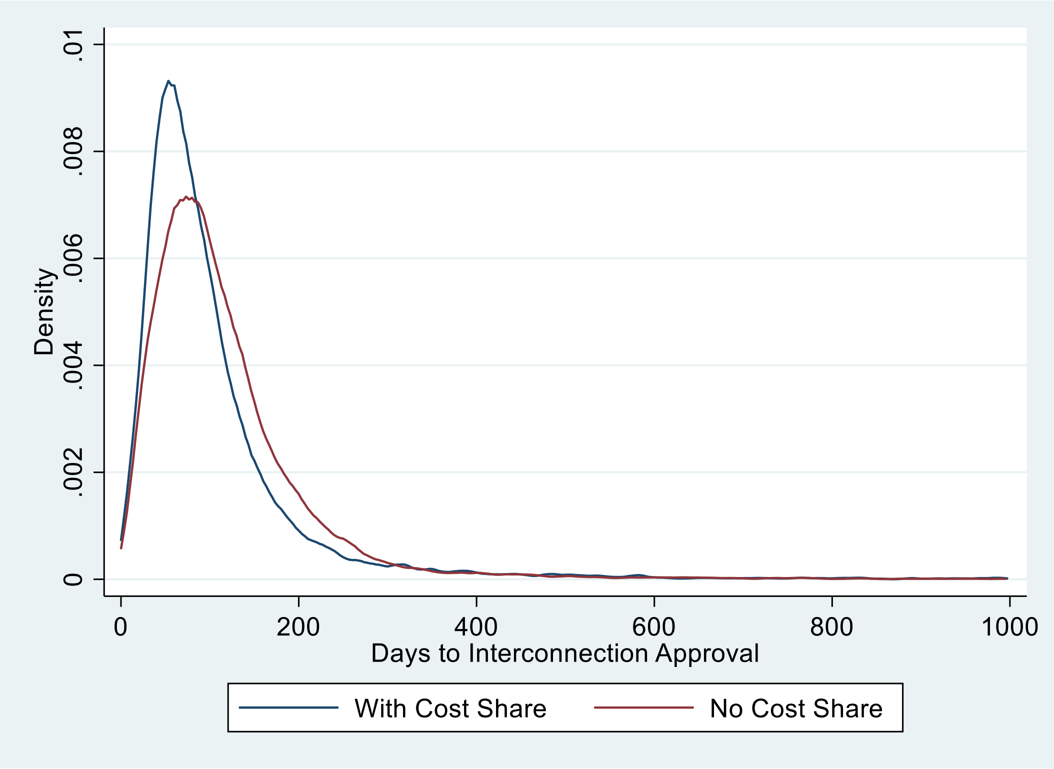

Figure 4 Kernel density for NY projects, separated by policy periods from 2015 to 2018

The OLS analysis for New York is described in Table 1Table 3. These models show that applications submitted after cost sharing was implemented have approximately 11 to 12 fewer days in the queue in comparison to applications submitted before cost sharing. While this reduction is statistically significant, it is a fairly modest reduction of duration in queue, given the average of 117 days in queue for the New York interconnection for this dataset. It is also meaningfully smaller than the results seen in Massachusetts.

Table 3 NY OLS results with robust standard errors from 2015-2018, y=Days in queue

	1		2		3	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
After cost share	-11.1***	.965	-11.3***	.965	-11.9***	.964
NEM	-73.3***	12.8	-73.9***	12.7	-73.1***	12.8
Value stack	-20.1	17.6	-17.8	17.6	-18.9	17.6
Study type						
Application review only						
Preliminary review	-20***	1.66	-21.3***	1.68	-21.5***	1.67
CESIR	217***	21.7	216***	21.7	216***	21.7
Capacity						
0-25 kW						
26-50kW	142***	10.6	143***	10.5	142***	10.6
51-499kW	297***	14.9	298***	14.9	298***	14.9
500-1999kW	581***	33.5	581***	33.5	582***	33.6
2000-4999kW	773***	35	774***	35.2	775***	35.1
5000kW or above	638***	40.8	646***	40.4	639***	40.8
Queue count	.0359***	.00457	.0358***	.00457	.0353***	.00456
Hybrid	32***	6.94			47.3***	7.14
Has storage			-21.2***	1.5	-24.2***	1.52
Intercept	140***	14.4	143***	14.4	143***	14.3

*** p<0.001, ** p<0.01, * p<0.05

Where variables are defined as follows:

Variable	Description
After cost share	Whether or not application submitted after cost share went into effect
NEM	Whether or not system is net metered
Value stack	Whether or not system is compensated via value stack methodology
Hybrid	Whether or not system contains more than one energy resource technology type
Preliminary review	Whether or not application had to go through a preliminary review after initial application review
CESIR	Whether or not application had to go through a Coordinated Electric System Interconnection Review (CESIR)
Capacity	Capacity of the proposed project in kW
Queue count	Average number of applications in the queue
Has energy storage	Whether or not system as energy storage

The biggest reduction of duration in queue is associated with projects that are net metered, likely because they are likely to be smaller residential projects that do not require as much in-depth study. It appears that more complex projects have longer duration in queue; hybrid projects add 30 to 45 days in queue and larger capacity systems add hundreds of days in queue in comparison to projects of 25kW or smaller. Projects that require an interconnection study take approximately 204 more days in queue – a substantial increase in time. Interestingly, projects with energy storage tend to reduce the duration in queue by about 21 to 24 days, though as part of a hybrid system, this reduction in duration in queue may not mitigate the added days from being a hybrid system. While this is not a large number of days, it may be that energy storage is mitigating hosting capacity issues or offering other grid benefits thereby slightly reducing the time needed to approve a project. The number of applications in the queue does not appear to have a practical effect on the duration of an application in queue.

To account for the anormal distribution of the data, we again use a negative binomial regression and log-linear transformation. These results are presented in Table 4. The log-linear model indicates that projects that submitted before the cost share took effect were approved in 142 days, on average, and those that submitted after the policy took effect were approved in 122 days (a difference of 20 days). The negative binomial model provides similar results with projects reaching interconnection approval in 124 days before cost share and 109 days for those submitted after the policy took effect (a difference of 15 days). These models show a larger gap between the two groups, though the differences between the model results are slight when considering the average time to interconnect.

Table 4 NY Alternate model results with robust standard errors from 2015-2018, y=Ln(Days in queue), Days in queue, respectively

	1		2	
	Coefficient	Std. error	Coefficient	Std. error
After cost share	-.148***	.00737	-.131***	.0074
NEM	-.207***	.038	-.396***	.0438
Value stack	.096	.0523	.0189	.0482
Study type				
Application Review Only				
Preliminary Review	-.243***	.0135	-.192***	.0134

CESIR	.532***	.0564	.298***	.0425
0-25kW				
26-50kW	.734***	.0419	.877***	.0429
51-499kW	1.34***	.0393	1.33***	.0382
500-1999kW	1.61***	.0812	1.58***	.0588
2000-4999kW	1.84***	.0928	1.7***	.0642
5000kW or above	1.73***	.144	1.57***	.0759
Queue count	.000014	.000032	.000155***	.000034
Hybrid	.435***	.0438	.483***	.0405
Has storage	-.296***	.014	-.263***	.0141
lnalpha			-.784***	.00686
alpha			.457***	.00313
Intercept	4.66***	.0541	4.93***	.0595

*** p<0.001, ** p<0.01, * p<0.05

5.0 Implications for energy storage

Energy storage represents a unique opportunity for network planning and interconnection process reform. Interconnection processes were developed before most forms of energy storage became mainstream technologies, and as a result, these process generally do not account for storage's unique capabilities (IREC 2022). The results above indicate that the policy reforms were associated with reductions in queue time, though the effect was much smaller for New York. The effect of hybrid technologies on queue duration was mixed, with Massachusetts showing decreases in queue time for hybrid projects, and New York showing increases in queue time. These hybrid projects may be seen as more technically complicated than single technology projects. However, hybrid projects that include energy storage are in some cases installed more quickly than other hybrids (i.e., NY) and more slowly than other hybrids (i.e., MA). This could indicate that regulatory bodies still view storage as an adder of technical complexity, rather than a device that can be leveraged to promote desired grid outcomes.

However, in some instances storage can be used to regulate power on the network and manage congestion (Twitchell, et al. 2022). Leveraging these capabilities represents a critical opportunity for regulators overseeing interconnection, provided that operational strategies can counterbalance some of the technical review requirements in the interconnection process. Likewise, increased hosting capacity from storage could potentially allow projects to come online with simpler analysis then would be needed for a congested network.

In recognition of these benefits, some organizations are rethinking how grid operations should consider storage projects entering interconnection queues. In the United Kingdom, for example, grid operators have introduced provisions that allow energy storage projects to be promoted in the interconnection queue, if they can help mitigate the need for additional grid infrastructure (ENA 2020). This promotion, in turn could allow for some subsequent projects to be approved more quickly and limit the need for network upgrades.

As an extension of this idea, contractual arrangements for energy storage could also be used to mitigate potential interconnection issues. One potential strategy is to pair energy operations and contractual mechanisms to ensure that storage is able to meet network demands. For example, regulators in Rhode Island have piloted arrangements where hybrid PV + storage systems could volunteer to abide by strict operating conditions in exchange for more limited interconnection costs and burdens (Gill, et al. 2022). FERC order 845 directed ISOs to adopt similar requirements, allowing generators to request interconnection approval for an amount lower than their overall nameplate capacity (FERC 2018). Such arrangements could be theoretically pooled amongst groups of developers in order to help address cost sharing issues, as well.

While at least in the states analyzed here, energy storage has not been used to address delays and complexities associated with interconnection, these emerging ideas represent potential opportunities for regulators who continue to struggle with congested interconnection queues. Leveraging new tools such as storage can help regulators achieve systemic goals, but processes must be updated to ensure these tools are utilized to the extent of their complete potential.

6.0 Conclusions and Policy Implications

Recent years have seen record numbers of energy projects seek approval to operate. In some ISOs’ interconnection queues have increased by as much as fivefold as more solar, wind, and battery projects aim to connect to the grid. This has led in turn to longer waits for interconnection approval, gaming by project developers, and swelling costs both to regulators and operators. Finding more efficient ways to bring projects online will be essential as states and countries look to meet climate goals and transition to more renewable sources of energy.

With that in mind, this paper looked at two common reforms to interconnection processes at the state level. In Massachusetts we analyze the impact of transparency on network hosting capacity, and in New York, those stemming from modifications to the cost allocation process. We use a standard ordinary least squares regression on two time restricted periods, along with log-linear transformations, and a negative binomial regression to account for the distribution of the data.

We find that both policies are associated with a decrease in the number of days a project spends pending before being interconnected. In Massachusetts a project was interconnected by an average of 107 days earlier after the hosting capacity maps were published, while in New York projects were interconnected 11 days earlier after the new cost sharing principles took effect. The more muted effect in New York could be due to lags (i.e. projects most affected may be those that come in after an upgrade is built), the stopgap nature of the policy (as the state intends to replace this with a more wholistic cost sharing mechanism), or simply a lack of impact on timelines. For both states, hybrid projects, including those with energy storage, are associated with longer approval times.

The results in Massachusetts give considerable support to the idea that information barriers are limiting the effectiveness of interconnection policy. If developers do not have a good understanding of hosting capacity, they are not able to target their efforts to uncongested areas, or size projects relative to the amount of available capacity. Industry stakeholders are increasing realizing that well-executed hosting capacity analyses are essential to the project development process (IREC 2017). These quantitative results support these findings and can be used in further analysis to explore how these reforms can lead to more efficient interconnection outcomes.

Energy storage could allow regulators to build on these benefits. Many stakeholders are currently looking to use energy storage technologies like batteries as a non-wires alternative for electricity infrastructure, both in the distribution (Peppanen, et al. 2020) and transmission sectors (Twitchell, et al. 2022). Making full use of these technologies in a cost-effective manner will require efficient deployment throughout the electricity system, which can only take place if infrastructure constraints are well known. Likewise, additional costs and delays within the interconnection process could hamper system-wide benefits. The UK is experimenting with changes to the interconnection process that other regulators could consider if they are intending to use energy storage to meet these system goals.

The cost allocation problem remains more difficult. Though New York’s experiment is associated with smaller interconnection timelines, they are an order of magnitude smaller than those seen in Massachusetts. This may be indicative that the cost allocation problem, which is a complicated free rider issue may be more difficult to resolve than information barriers. Further, the policy in New York was intended to be a temporary measure, as regulators worked to identify a more detailed cost allocation process, which could also impact the results.

As states and ISO/RTOs begin to experiment with additional interconnection reforms, analyses like these can help identify which reforms have been successful and are ripe for replication. Likewise, this analysis in many ways represents a first cut, based on statistical methods and associations. More advanced causal analysis could help illustrate these benefits with greater certainty.

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