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Financing Storage as a Transmission Asset: Initial Considerations for an Emerging Use Case

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Jay Barlow
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January 2026

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Pacific Northwest National Laboratory
Richland, Washington 99354

Abstract

Deploying energy storage as an electric transmission system asset is a unique use case that, despite a body of policy and regulatory support, has received little attention or investment in the United States. The benefits of using storage on the transmission system—and the remaining barriers to that use—have been explored elsewhere. This paper complements that body of research by exploring the finance implications of using energy storage as a transmission asset (SATA). Because transmission infrastructure in the U.S. is generally subject to rate-of-return regulation, in which asset owners receive both a return of their invested capital and a return on that capital, storage assets deployed for that use are not subject to market volatility and have a much lower risk profile overall. That lower risk profile would, in theory, correspond to lower interest rates and other more favorable financing terms relative to a storage project deployed in a market setting. This paper draws from corollaries in other markets to estimate the expected finance impacts of SATA projects.

Acknowledgments

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Acronyms and Abbreviations

CAISO	California Independent System Operator
FERC	Federal Energy Regulatory Commission
ISO	Independent System Operator
MISO	Midcontinent Independent System Operator
PPA	Power Purchase Agreement
SATA	Storage as a transmission asset
WACC	Weighted Average Cost of Capital

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1.0 Introduction

Expanding transmission capacity will be an important factor for enabling the energy transition. Estimates have shown that transmission build must grow between 25% and 114% to support load and clean energy growth by 2035 (Department of Energy 2023). Energy storage can play an important role in this transition by increasing the flexibility of transmission assets, extending their life, and reducing the need for additional transmission infrastructure. Since at least 2005, with the passage of the Energy Policy Act, federal policymakers have classified energy storage as an "advanced transmission technology" that can "increase the capacity, efficiency, or reliability of an existing or new transmission facility."[1] Energy storage used in this way is referred to as *storage as a transmission asset* (SATA). While only a handful of SATA projects have been built, interest in this use case is growing.

Energy storage technologies can support the transmission system in several ways. They can be directly installed in the transmission system to regulate power flows during disturbances and maintain service to customers while protecting transmission infrastructure. Other storage projects can indirectly benefit the transmission system by meeting local energy needs that would otherwise require additional transmission infrastructure (Twitchell, Bhatnagar et al. 2022). Where cost effective, energy storage alternatives can also be deployed significantly faster than transmission projects, which take several years to permit and construct.

Further, the SATA business model can be expanded by putting storage to other productive uses when not needed for supporting the transmission system. This variation, dual-use storage, allows SATA projects to participate in electricity markets when not providing transmission service, and could result in a more efficient use of energy infrastructure and lower costs for customers. In 2017, the Federal Energy Regulatory Commission (FERC) issued a policy statement expressing support for dual-use storage assets and outlining guiding principles for storage projects to be compensated with both regulated transmission revenue and market-based revenue, with the objective of reducing system costs (Federal Energy Regulatory Commission 2017).

Implementation of FERC's policy statement on dual-use storage fell to the independent system operators (ISOs), which operate the U.S. electric grid on a regional basis in much of the country. And while no ISO has yet adopted enabling regulations for dual-use storage, several have adopted policies and procedures for the inclusion of storage in transmission planning, though such projects would be limited to transmission service only.

Despite these regulatory advances, SATA deployments have been limited overall. The California Independent System Operator (CAISO) and Midcontinent Independent System Operator (MISO) both selected SATA alternatives in their 2018 and 2019 transmission plans, respectively, but since 2019, CAISO is the only region to produce transmission plan that included an analysis of SATA alternatives. There are multiple barriers that have limited adoption to date, including modeling challenges, lack of regulatory clarity and limited opportunities for revenue. Questions regarding the financing of these systems also remain for SATA (Twitchell, Bhatnagar et al. 2022).

SATA projects present unique opportunities for investors, as their status as regulated transmission assets offers effectively guaranteed revenue at favorable rates. At the same time,

[1] Energy Policy Act of 2005. Available at https://www.congress.gov/bill/109th-congress/house-bill/6.

the regulated return provides an upper limit on profit. By comparison, a market storage project might rely on contracted services or wholesale market revenues, which are generally less predictable than regulated rate-of-return revenues. This translates into higher potential profits, but also a higher degree of risk that incurs a higher cost of capital. Dual-use storage is a unique case with some time spent supporting the transmission system as SATA and some time spent participating in electricity markets. Depending on the regulatory structure, it could have guaranteed regulated revenues with market revenue in addition. Further considerations, like the ownership model and mix of debt and equity financing, impact the overall cost of capital across the three use cases. Figure 1 shows these cases on a spectrum. Because any analysis of dual-use storage is still theoretical, it is initially assumed to take on a blend of the characteristics of SATA and market storage.

Figure 1: Spectrum of storage use cases considered.

This paper summarizes financing considerations for SATA and dual-use storage, using market storage as a comparison and focusing on the cost of capital, which is a key driver of the cost of service that customers pay for. We begin by discussing some of the regulatory frameworks that influence transmission ownership and operation. Next, we illustrate how these arrangements influence the terms, structures and costs associated with SATA. We use these findings to provide examples of how changes to business and ownership models can impact the cost of potential projects through cost of capital, before concluding and identifying additional lines of research related to SATA and dual-use. We find that SATA and dual-use would likely have a lower cost of capital than market storage, which, in turn, could lead to more cost-effective outcomes.

2.0 Illustrative comparison of financing factors

This section provides an illustrative comparison of estimated capital costs for SATA, market storage, and dual-use storage. It begins by examining the two end cases (SATA and market storage) and key factors that affect the overall cost of capital. These factors include the ownership structure, the cost of debt and equity financing, and the debt-to-equity ratio in capitalization. Illustrative values for these factors are drawn from literature and combined to provide a range of estimates for the weighted average cost of capital (WACC). Dual-use storage is a special case with no direct corollaries to draw from. It is considered in its own sub-section and then its potential WACC is compared with the other cases.

2.1 Factors influencing financing for SATA

SATA consists of energy storage that provides direct support to the functioning of the electric transmission system. Though energy storage technologies differ physically and operationally from electric transmission, SATA is expected to closely resemble transmission from a regulatory and financial perspective. As there are few examples of SATA deployment to draw from, the financial factors below draw directly from the field of regulated electricity transmission.

2.1.1 Ownership structures

While there are now several different transmission ownership structures across the United States, direct utility ownership remains the dominant form. Under this model, a utility or regional grid operator develops an annual transmission plan that describes the planner's best estimate of the system investments that will meet identified needs for improving reliability, connecting new generation resources, reducing congestion, and supporting state policy goals. Selected projects are then subject to dual approval processes: state processes for siting and permitting, and FERC processes for setting a regulated rate of return on equity. Utilities sometimes collaborate to build transmission under a joint ownership structure, where costs and usage may be allocated in proportion to their ownership stake in the project, with the majority owner acting as the operator of the line. Utilities may also form joint venture transmission-only holding companies to coordinate the use of jointly owned assets.

Merchant transmission ownership is an alternative to the utility ownership model but is currently much less commonly used. Merchant transmission projects do not receive a regulated rate of return but instead are paid for and owned by third-party entities, much like independent power producers. Merchant transmission accounts for a relatively small amount of transmission overall—estimates range from 0% in the Southeast to 18.5% in Texas' system (Wu, Silverman et al. 2024)—but could play a role in expanding use of storage as a transmission asset (Robertson and Palmer 2023). Compared to utility ownership, the merchant model provides greater financing flexibility, as there are fewer regulatory requirements; however, debt and equity may come at a higher cost, as merchant transmission does not have the same revenue certainty as regulated transmission assets.

In this paper, SATA is assumed to take on the regulated utility ownership model, which represents the vast majority of transmission deployment to date. Merchant SATA models may provide an interesting exploration in future work, especially if SATA deployments begin to pursue this route. FERC's policy statement on dual-use energy storage also requires a party other than the grid operator to make decisions about the asset's market participation, suggesting that a merchant or hybrid ownership and capital structure may be needed. This paper assumes that SATA projects will be deployed as regulated assets,.

2.1.2 Debt financing

Regulated investor-owned utilities that act as transmission owners commonly raise debt financing through the issuance of corporate bonds, where the cost of debt reflects the company's overall credit rating. Because revenue is guaranteed by regulators, and risk can be spread over a company's portfolio of investments, which can include generation, transmission, and distribution infrastructure in multiple jurisdictions, utilities can generally raise relatively low-cost debt.

The SATA debt financing interest rate in this paper is assumed to range from 5.2% to 6.4%, based on a range of corporate bond rates issued by six large investor-owned utilities that disclosed yields for 8-12 year bonds in their annual filings in 2023 and 2024 (American Electric Power Company 2023, DTE Energy Company 2024, Duke Energy 2024, Exelon Corporation 2024, Nextera Energy 2024, PG&E Corporation 2024). The median of the six values is 5.4%, which is taken as the central value.[1]

2.1.3 Equity financing

The portion of a given transmission investment that is not covered by debt financing is generally covered by equity financing. FERC regulates the return on equity for most utility-owned transmission projects in the U.S. and its methodology for determining this value has evolved over the years. The method applied in a recent FERC order consisted of both a discounted cash flow model (which estimates the future value of the investments) and capital asset pricing model (which estimates the risk of the investments) to estimate a 'zone of reasonableness' for the return on equity value based on proxy companies, with the middle third of this zone taken as a 'presumptively reasonable' base range (Federal Energy Regulatory Commission 2024).

The SATA return on equity in this paper is assumed to range from 7.39% to 12.58%, corresponding to the 'zone of reasonableness' determined in the FERC order described above (Federal Energy Regulatory Commission 2024). The average of this range, 9.98%, is taken as the central value.

Several other sources provide values that are slightly higher than this central value, but still within the adopted range. Damodaran's 2024 estimate for the utility sector in general is 11.15% (Aswath Damodaran 2024). Werner and Jarvis compiled U.S. electric utility rate case data from 1980 to 2022 and found an average approved return on equity of 12.27% with a standard deviation of 2.4 percentage points (Werner and Jarvis 2024). We adopt the slightly lower range from the FERC order because of its recency and specificity to electricity transmission, though the higher values expressed in other sources can be considered by examining the high end of the FERC range.

2.1.4 Debt-to-equity ratio

The debt-to-equity ratio, or leverage ratio, for a given investment has a direct effect on the overall cost of capital. As illustrated above, equity generally has a higher rate than debt, and

[1] Throughout this paper, we identify central values as landmarks for comparison within a range. They do not always have a formal statistical significance.

therefore projects with a higher fraction of equity will generally have a higher overall cost of capital. Because this ratio has such a significant impact on capital costs, it is one of the factors considered in FERC's regulation of electric transmission rates, and FERC has a history of approving capitalization structures within a certain range.

In this paper, the equity fraction of the SATA capitalization structure is assumed to range from 40% to 60%. The lower value is supported by a 2024 annual review of 37 regulated investor-owned utilities in the U.S., which found the average capitalization structure in 2023 was 39.7% equity and 60.3% debt (Edison Electric Institute 2024). The upper value of 60% equity is supported by a 2023 FERC order upholding a 40% debt, 60% equity capitalization structure for a transmission owner, which FERC found to be within the range of previously approved capitalization structures (Federal Energy Regulatory Commission 2023). A 50% debt, 50% equity structure is taken as a central value. For a broader comparison, a review by Werner and Jarvis of U.S. regulated electric utility rate cases from 1980-2022 found an average of 45% equity, with a standard deviation of 7 percentage points (Werner and Jarvis 2024).

2.2 2.1 Factors influencing financing for market storage

Market energy storage serves as a comparison to the regulated SATA model outlined above. The envisioned market storage case draws on the analogous concept of an independent power producer, though the model of market storage is less mature.

There are two main differences between the envisioned SATA model and the market storage model. First, market storage is assumed to take on a project finance structure, whereas SATA is assumed to have a corporate utility structure. Second, market storage is expected to take in merchant or contracted revenues, whereas SATA is assumed to have a regulated return of and return on investment. These two main differences translate into differences in the cost of the capital, with the market model generally expected to have a higher cost of capital than the regulated model.

2.2.1 Ownership structure

Market storage is assumed to take on a project finance ownership structure, where the investment is held in a project company and financing is raised on the basis of the project's revenues (Groobey, Pierce et al. 2010). These revenues can be based on merchant sales into a market or contracted offtake such as a power purchase agreement or PPA (Feldman, Bolinger et al. 2020). Arrangements with higher revenue uncertainty are expected to translate into higher capital cost.

2.2.2 Debt financing

In a key difference from the regulated SATA case, market storage projects are assumed to seek debt financing in the form of loans from capital providers, rather than through issuance of bonds. In this paper, the debt interest rate is assumed to range from 6.83% to 8.0%. The lower value is the Secured Overnight Financing Rate of 4.83%[1] plus a premium of 2.0%, which was taken as representative for renewable energy projects in 2024 based on an industry expert view (Martin 2024). The higher value is used in Lazard's most recent levelized cost of storage methodology (Lazard 2024). The central value is taken to be 7%, which is used in the National Renewable

[1] As of October 24, 2024

Energy Laboratory's Annual Technology Baseline for utility-scale battery energy storage (National Renewable Energy Laboratory 2024).

2.2.3 Equity financing

The return on equity for market storage projects likely has a wide range reflecting the unique factors of each project. Estimates of the return on equity for market energy storage projects are hard to come by in the open literature. A study by the American Council on Renewable Energy (2023) surveyed after-tax returns on equity for renewable energy investment tax credit investments involving tax equity structures. The study provided two ranges: historical values from 2018-2023 ranged from 8.0% to 24.3%, with a median value of 13.0%; forward-looking expectations ranged from 6.8% to 16.0% with a median of 9.8%. Taking averages of these two sets yields a range of 7.4% to 20.15% with a central value of 11.4%, which is used in this paper.

The survey sample is assumed to include projects along the spectrum from fully contracted revenues to fully merchant revenues and the median value is assumed to be a reasonably representative central indicator for the return on equity for a market storage project. For comparison, the 2024 Annual Technology Baseline from the National Renewable Energy Laboratory returns on equity for utility-scale battery energy storage are 9.25% during operation and 11.25% during construction, assuming contracted offtake (National Renewable Energy Laboratory 2024).

2.2.4 Debt-to-equity ratio

In contrast with the envisioned SATA case, where FERC ratemaking regulates the debt-to-equity ratio, market projects can take on a wide range of debt-to-equity ratios. The equity fraction of the capitalization structure is assumed to range from 20% to 80%. The lower value is used in the National Renewable Energy Laboratory's Annual Technology Baseline for utility-scale battery energy storage (National Renewable Energy Laboratory 2024). The upper value is used in Lazard's most recent levelized cost of storage methodology (Lazard 2024). A 50% debt, 50% equity structure is taken as a central value. The wide range of equity fractions reflects the variation of risk that market projects can be exposed to; for example, projects with contracted offtake have lower revenue risk than purely merchant projects. The wide range explored here is supported by the American Council on Renewable Energy (2023) study, which found that the tax equity portion of project capitalization can range from approximately one-third to two-thirds. A review of energy projects contracted through PPAs or receiving merchant revenues saw leverages from 32-73% (Feldman, Bolinger et al. 2020).

2.3 Comparison of SATA and market storage inputs

The figures in this sub-section summarize and compare the key capital cost inputs discussed above for SATA and market storage. In all figures below, the shaded bar represents the range between the lower and upper inputs and the marker indicates the central value used for illustration.

The debt interest rate ranges reflect a strong distinction between SATA and market storage (Figure 2). Though the ranges have a similar spread, the SATA range and central value are significantly lower than that of market storage, reflecting the lower cost debt that can generally be raised through investor-owned utility bonds.

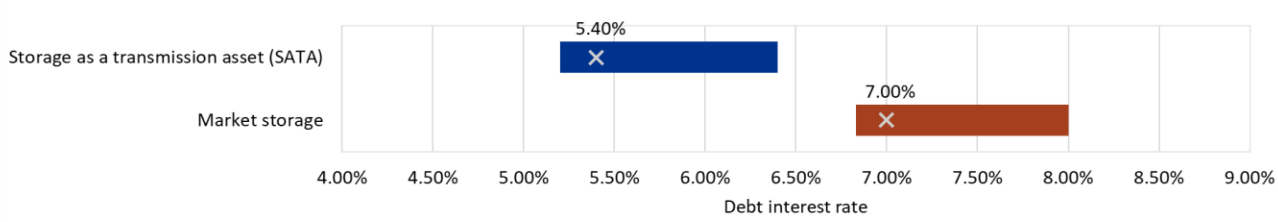

Figure 2: Comparison of debt interest rate inputs.

The return on equity ranges overlap significantly between the SATA and market storage cases (Figure 3). The central value for market storage is 1.42 percentage points higher than that of SATA. Additionally, the market storage case has a far greater spread. This reflects both that market projects can take on a wide variety of revenue arrangements and risk exposure and that FERC regulation results in a tighter range of returns on equity in the SATA case.

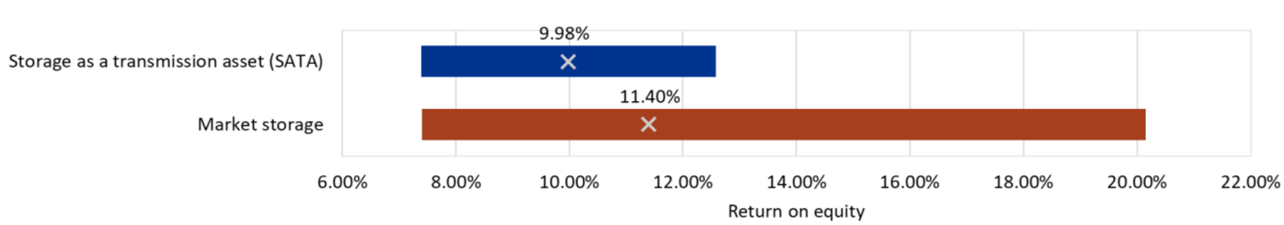

Figure 3: Comparison of return on equity inputs.

Figure 4 shows that though the central values for the equity fraction are the same between the two cases, though the market storage case has a much wider spread.

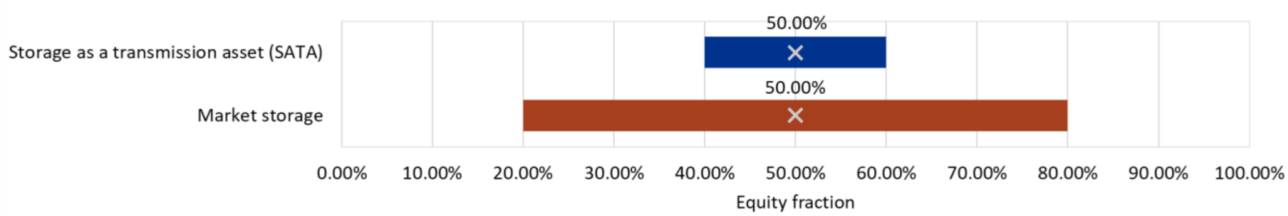

Figure 4: Comparison of equity fraction of capitalization structure inputs.

2.4 Weighted average cost of capital

Weighted average cost of capital represents the total cost of financing a project once the debt and equity rates and ratios have been set, inclusive of taxes. The inputs for the SATA and market storage cases were combined to generate a range of WACC values. The range represents a wide but reasonable spectrum of potential financing costs a SATA project could face. WACC was calculated according to the formula below, which takes into account a combined federal and state tax rate of 25.7% for consistency with other sources (National Renewable Energy Laboratory 2024, Pacific Northwest National Laboratory 2024).

$$WACC = [DebtFraction \times DebtInterestRate \times (1 - TaxRate)] + [(1 - DebtFraction) \times ReturnOnEquity] \quad (1)$$

For each case, a central WACC value and range were calculated, using the corresponding upper, lower, and central values of the inputs.

Figure 5 shows the illustrative WACC ranges for SATA and market storage. The WACC for SATA ranges from 5.27% to 9.44%, with a central value of 7.00%. The WACC for market storage ranges from 5.54% to 17.31%, with a central value of 8.30%. The central WACC value for market storage is 1.3 percentage points higher than that of SATA.

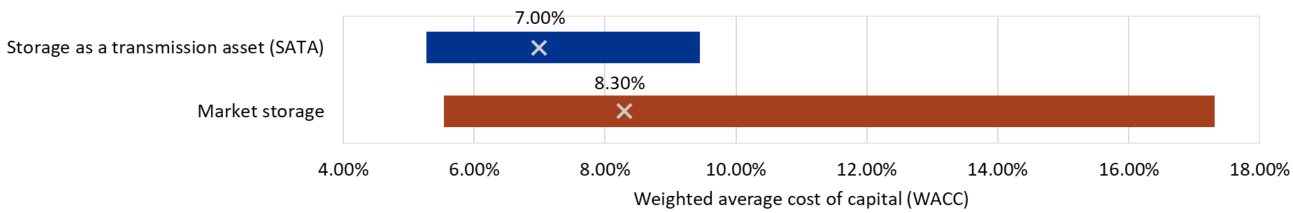

Figure 5: Comparison of WACC values.

The wide range of WACC values for market storage is a reflection of the wider ranges of its inputs for return on equity and equity fraction. These are much wider than those of the SATA case, where FERC regulation and other factors drive more consistent values. The difference between the central WACC values indicates that, when viewing through the lens of capital costs, SATA could be slightly cheaper to procure than market storage. There is significant overlap between the two WACC ranges, though, suggesting that in some cases procuring SATA and market storage could be comparable.

2.5 Dual-use storage

The dual-use case is a hypothetical case considering an energy storage asset that spends part of its time providing regulated transmission services as SATA and part of its time participating in a wholesale energy market as an energy storage asset. This raises a number of unanswered practical questions. For example, FERC's policy statement requires a dual-use asset to be operated by the grid operator in transmission mode and by the asset owner when in market mode. This suggests that merchant ownership may be viable for dual-use storage, but that question has not yet been addressed. And since no dual-use policies are in place and no dual-use projects have been built, the capital structure of any such project is still only theoretical.

Additional questions arise around revenues generated by dual-use energy storage. A critical principle of FERC's rules for storage acting as a dual-use asset is that storage owners cannot seek double recovery of the asset's cost (Federal Energy Regulatory Commission 2017). This requires deliberate usage and careful accounting of the device; it can provide multiple services and get paid for each, but it must only be paid for each one time. Furthermore, since FERC's primary objective in the dual-use policy statement was to deliver cost savings for customers, revenues must be shared with customers.

CAISO has identified three potential revenue mechanisms that could be used to ensure that dual-use storage assets are fairly compensated for their role in providing transmission and electricity market services (CAISO 2018). The first option is full market crediting, where a storage project would receive full cost recovery, and then ratepayers would be reimbursed with any market revenues that the project receives. The second option, full market retention, would see the asset recover a reduced amount of its cost through a regulated return (based on forecasts of its market revenues), and then keep any market revenues as profits. The final approach, a hybrid, would see the asset recover all project costs with a regulated return, but then split any market revenues between the project and ratepayers. These different revenue configurations would likely affect the kinds and cost of capital a project could attract.

Though CAISO did not resolve this question, the proceeding identified challenges with the first two approaches. Under the first option, full market crediting, the asset owner would have no incentive to participate in the market, since all revenues would be returned to customers, and so market participation would be unlikely. The second option, full market retention, provides a strong incentive for market participation, but transmission owners in the CAISO proceeding expressed concern with increasing the risk profile of a transmission asset, which would increase its cost of capital and therefore increase costs to customers, which would be at odds with FERC's policy statement.

The third option, which would provide full regulated recovery of a dual-use storage system's costs and then split any market revenues between customers, would maintain the potential cost-of-capital advantages of a SATA project while offering an additional revenue stream that could potentially reduce the WACC of a dual-use project below that of a SATA project.

However, since the question of revenue disposition has not yet been resolved in any region, we assume the dual-use storage case takes on capital cost inputs in between those of SATA and market storage for the purposes of initial illustration in this paper. Specifically, one half of the hypothetical asset is assumed to take on the characteristics of SATA, and the other half, market storage (Figure 6).

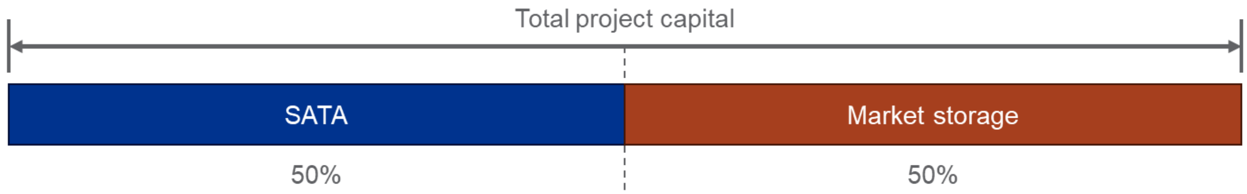

Figure 6: Capital inputs for hypothetical dual-use asset.

A range of illustrative WACC values can be generated based on this construct. The lower and upper ends of the range are calculated by taking the lower and upper values from the SATA and market storage cases above and applying them respectively to one half of the dual-use capital structure. A central WACC value is arrived at in a similar way. Because the dual-use asset is assumed to have a 50% SATA, 50% market storage structure, the effect of this exercise is equivalent to taking the simple average of those WACC values. As expected, this illustrative dual-use WACC range lies between the ranges of SATA and market storage (Figure 7).

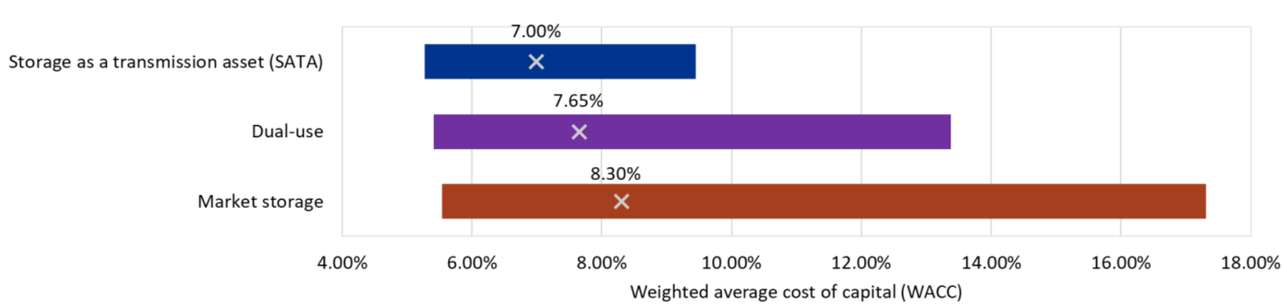

Figure 7: Comparison of WACC values, including illustrative range for dual use storage.

2.6 Discussion

The analysis presented in this paper identified relationships between the different use cases studied: storage as transmission, market storage, and dual-use storage. The findings were presented as ranges to represent how differences in capital structure, cost of debt or equity, and ownership may drive different outcomes. The conclusions should therefore be interpreted as, when all things are equal with capital structures and creditworthiness, a SATA project will likely have a lower overall cost of capital than a market storage project, and a dual-use project will lie somewhere between the two. But individual project outcomes will vary according to each one's circumstances.

For example, a utility with a higher overall risk profile would have a higher cost of equity that, depending on its capital structure, could drive its WACC for a SATA project higher than that of a market project. Pacific Gas and Electric, for instance, requested a return on equity of 12.37 percent in its most recent transmission rate case at FERC, citing its exposure to wildfire risks (Howland 2024). Conversely, a merchant developer with a strong track record and favorable contract or market conditions may be able to secure lower debt and equity costs for a market storage project that results in a WACC that is lower than that of a typical SATA project. Notably, the greater flexibility in capital structure afforded to market projects results in a much wider range of outcomes.

In the absence of real-world cases to draw from, the financial considerations for dual-use storage remain difficult to represent, and the results presented are theoretical. The first approximation used in this paper—dual-use storage as a blend between SATA and market storage—is merely an entry into the range of capital structures and costs that dual-use could adopt. One of these, wherein dual-use benefits from both regulated revenues and market revenues, could even translate into a lower cost of capital than that for SATA, though too many practical details remain unanswered to put a number on this value. Practical questions related to market participation rules, revenue sharing requirements, and transmission duty cycles would need to be resolved to facilitate a full analysis of the finance implications of a dual-use project.

This paper presented an initial analysis of financing costs and could benefit from future refinement. As no direct estimates were found for return on equity values for energy storage, the analysis borrowed from sources that looked across renewable energy technologies. Future work could survey practitioners for their estimates for energy storage, specifically. Additional input values could also enable statistical analysis of the likely ranges of WACC. Finally, there are several additional considerations that could add granularity and variation to the findings: differences between construction financing and term financing could be broken out, as is done in some sources (National Renewable Energy Laboratory 2024) and the effects of different tax equity structures could be explored. The Inflation Reduction Act of 2022 brought changes in tax credit value and monetization structures that are still being trialed in deployment and have impacts for the storage cases considered in this paper.

3.0 Conclusions and Implications

The use of energy storage as a transmission asset is an emerging business model that could improve grid outcomes and lower customer costs. Storage can be a cost-effective alternative to traditional transmission infrastructure for expanding the system and maintaining reliability, but decisions about how, where, and when to deploy storage alternatives involve complicated grid and financial modeling. Addressing the inclusion of storage in transmission planning processes has been addressed in another body of work, but the financial considerations involved in storage alternatives do not appear to have been addressed. In this paper, we explored how business models and regulatory frameworks can impact project costs through the cost of capital.

Our analysis shows that revenue models can have a small but significant impact on the cost of storage and that projects that have regulated revenues can generally access a lower cost of capital than merchant projects. These savings become more notable when allowing for a higher equity return in merchant storage case (which is likely for projects without PPA revenue or some other predictable and reliable revenue source).

In general, dual-use projects that allow for some regulated transmission revenue and additional market revenue may balance cost savings and capital efficiency most effectively. These projects may access lower cost utility debt and equity, while allowing the storage system to be utilized when they are not needed to provide transmission services. State regulators and ISO officials can keep these factors in mind while interpreting and implementing FERC’s orders regarding transmission planning and participation. As greater clarity about the operational rules for dual-use storage projects is established and revenue opportunities become clearer, the finance implications for such projects can be more definitively analyzed.

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Pacific Northwest National Laboratory

902 Battelle Boulevard
P.O. Box 999
Richland, WA 99354

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