



CLEAN ENERGY INVESTMENT LANDSCAPE:

Political and Regulatory Implications of the
2024 Elections



Columbia SIPA
Capstone Collaboration



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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

This report, prepared in collaboration with Captona and graduate students from Columbia University's School of International and Public Affairs, assesses the political and financial implications of the 2024 U.S. elections on clean energy investments—particularly in the context of the Inflation Reduction Act (IRA). The analysis is driven by growing uncertainty surrounding the implementation, interpretation, and potential rollback of IRA provisions under the current Republican-controlled executive and legislative branches.

The IRA has been transformative for the U.S. clean energy sector, offering long-term, technology-neutral tax credits and groundbreaking features like transferability, direct pay, and bonus adders. These mechanisms have reshaped capital formation and deployment across solar, wind, hydrogen, storage, carbon capture, and other low-carbon technologies. However, many of these provisions now face legal, administrative, and political vulnerabilities.

This report introduces a Vulnerability Assessment Framework to evaluate the risk of reversal or obstruction for individual IRA provisions. This framework considers:

1. Geographic distribution of IRA benefits across political districts;
2. Statutory and regulatory mechanisms available to roll back provisions;
3. Alignment of provisions with the Trump administration's priorities.

Based on this framework, the team modeled seven policy scenarios—ranging from full continuity to full repeal with retroactive clawbacks. These include scenarios such as administrative obstruction, partial or full repeal through reconciliation, and targeted rollback of key provisions like transferability and bonus adders. The impacts of each scenario were assessed using financial modeling across seven technology areas.

EXECUTIVE SUMMARY

Technology Pillar Takeaways

1. Solar

- Strengths: Most mature and widely adopted clean energy technology. Strong bipartisan investment, especially in Republican district.
- Vulnerabilities: Highly reliant on ITC and bonus adders (e.g., domestic content, energy communities). Repeal or reinterpretation of these would disproportionately affect smaller developers. Supply chain and permitting challenges persist.

2. Battery Energy Storage Systems (BESS)

- Strengths: High financial performance even under partial IRA rollbacks; benefits from tolling contracts and utility demand. Regional diversification, especially in GOP-led states.
- Vulnerabilities: Extremely sensitive to tariffs (e.g., 104% on Chinese imports). Projects may be delayed if storage cost increases aren't offset. Still reliant on federal guidance for project structuring.

3. Hydrogen

- Strengths: Benefits from bipartisan support and deep Republican-district investment, especially in Texas and Louisiana. Section 45V credit is a key enabler. Emerging offtake market in heavy-duty transport and industry.
- Vulnerabilities: High capex, long development timelines, and still-nascent offtake ecosystem. Green hydrogen especially susceptible to policy change, with credit removal significantly undermining feasibility.

4. Carbon Capture, Utilization, and Storage (CCUS)

- Strengths: 276 projects announced as of 2025; enjoys 45Q credit and some Republican backing due to alignment with industrial decarbonization.
- Vulnerabilities: Permitting bottlenecks (Class VI well delays), public opposition to pipelines, and high upfront costs make most projects unbankable without 45Q. Only a fraction of projects reach Final Investment Decision (FID).

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5. Wind (Onshore)

- Strengths: Large existing project base and some state mandates sustain deployment. Equipment orders rising for 2025+.
- Vulnerabilities: Faces exposure to IRA repeal. PTC/45Y critical to returns. Without them, projects fall below IRR thresholds. Regional saturation and grid congestion, especially in Texas, limit further growth. Admin delays to permitting compound risks.

6. Clean Fuels (Biofuels, RNG, SAF)

- Strengths: Some bipartisan appeal, embedded into industrial/agricultural infrastructure. LCFS and 45Z are key supports. Projects often resilient with layered revenue.
- Vulnerabilities: Book-and-claim accounting and lifecycle carbon modeling are politically contentious. Any delay or reinterpretation of guidance (e.g., for SAF eligibility) could reduce credit revenue and stall development.

7. Nuclear (SMRs)

- Strengths: Technologically neutral ITC offers new opportunities. Some SMR projects still supported in DOE programs.
- Vulnerabilities: NuScale's high-profile project cancellation in Idaho reflects broader challenges: cost overruns, schedule delays, and weak investor confidence. Nuclear permitting remains highly complex and politically fraught.

EXECUTIVE SUMMARY

Scenario Takeaways:

- Administrative interference (e.g., delayed guidance, restrictive interpretations) is highly likely and impactful—even in the absence of legislative action.
- Targeted repeal of transferability and bonus adders through reconciliation would have broad financial impacts, especially for smaller developers.
- Full repeal with clawbacks, though politically challenging, represents the most severe downside risk and would severely destabilize all project types.
- Scenarios preserving core credit values but limiting adders or payment methods (e.g., direct pay) reflect a plausible middle-ground with major capital formation implications.

Recommendations focus on preserving optionality, securing value early, and adapting to potential disruptions. Captona should prioritize early execution of exposed projects, document eligibility rigorously, and evaluate de-risking strategies such as hedging and staged investments. A geographic and technological diversification strategy is advised, along with the pursuit of counterparties better positioned to absorb regulatory delays or value erosion.

INTRODUCTION

INTRODUCTION

BACKGROUND

Background on the Inflation Reduction Act (IRA): The Inflation Reduction Act (IRA), signed into law in August 2022, represents the most significant climate and clean energy investment legislation in U.S. history. It provides over \$370 billion in incentives to accelerate the deployment of renewable energy, energy storage, advanced manufacturing, and decarbonization technologies. Core provisions include production and investment tax credits, new credit transferability mechanisms, and bonus adders for projects that meet prevailing wage, domestic content, and energy community criteria. These incentives are designed to transform the economics of clean energy projects while supporting U.S. energy independence, job creation, and emissions reduction targets.

SIGNIFICANCE

Significance of IRA Tax Credits in Renewable Energy Project Finance: The IRA has fundamentally reshaped the capital stack for renewable energy projects. The expansion of long-term, technology-neutral tax credits and the introduction of elective pay and transferability provisions have broadened access to capital—particularly for developers and investors previously unable to monetize tax equity. As a result, the IRA has catalyzed billions of dollars in private investment and accelerated the deployment of clean energy infrastructure. However, these provisions are now under political scrutiny in the wake of the 2024 election, introducing a new era of uncertainty for project sponsors and capital providers.

INTRODUCTION

SCOPE

Scope of Analysis: The report focuses on federal tax credit provisions related to renewable energy generation, energy storage, carbon capture, clean fuels, and emerging technologies including hydrogen and advanced nuclear. It analyzes both statutory and regulatory risks to these incentives, and examines the implications of potential changes across different technologies and geographies. It also explores the financial structures enabled by the IRA—particularly transferability—and how changes to these mechanisms could affect investment strategy. The report concludes with scenario modeling and tailored recommendations for Captona’s portfolio strategy under multiple future policy environments.

OBJECTIVES

This capstone project, conducted by graduate students at Columbia University’s School of International and Public Affairs (SIPA) in partnership with Captona, aims to evaluate the durability and investment implications of IRA provisions under the current political environment. The research is structured around three core objectives:

1. Assess the political vulnerability of key IRA provisions and associated financial mechanisms.
2. Evaluate how different scenarios—ranging from full implementation to partial repeal or administrative obstruction—may affect specific technology classes.
3. Recommend investment strategies that mitigate risk and preserve value for Captona and its partners.

INTRODUCTION

METHODOLOGY

To inform this analysis, the research team conducted expert interviews with over two dozen stakeholders from the public sector, private industry, and academia. These interviews were supplemented with proprietary modeling, legislative tracking, data from the Clean Investment Monitor and IRA Tracker, and a comprehensive review of relevant statutes, regulatory guidance, and industry publications.



POLITICAL
LANDSCAPE
ANALYSIS

POLITICAL LANDSCAPE ANALYSIS

The political landscape surrounding the Inflation Reduction Act (IRA) has grown increasingly complex following the 2024 election cycle. With the Republican Party now in control of both the executive and legislative branches, uncertainty around the implementation and durability of the IRA is a central concern for investors, developers, and policymakers alike. This section synthesizes interviews and perspectives across the private sector, public sector, and academia to assess how current dynamics may shape the future of the IRA's tax credit regime and clean energy investment more broadly.

1. Statutory vs. Regulatory Vulnerabilities

Political threats to the IRA can be categorized into two main categories: statutory and regulatory. While the IRA's core tax provisions (e.g., ITC, PTC, 45Q, 45Z) are embedded in the tax code and cannot be reversed by executive order alone, they remain vulnerable to repeal or modification through budget reconciliation.¹

Multiple academic and legal experts emphasized that while outright repeal is procedurally difficult, the reconciliation process offers a credible path for Republicans to roll back certain credits, especially if included in a broader "mega-bill" covering immigration, defense, and tax policy. However, such efforts are tempered by competing priorities and internal GOP divisions.

In contrast, regulatory components like bonus credit "adders" (e.g., domestic content, energy communities) and the transferability mechanism (Section 6418) are more politically exposed.² These provisions can be delayed, reinterpreted, or partially dismantled via administrative action. Such implementation obstruction may be the most attractive path for the Trump administration if they face congressional resistance but remain committed to gutting the legislation.



¹ Interview with energy policy expert, February 2025

² Interview with energy policy expert, February 2025

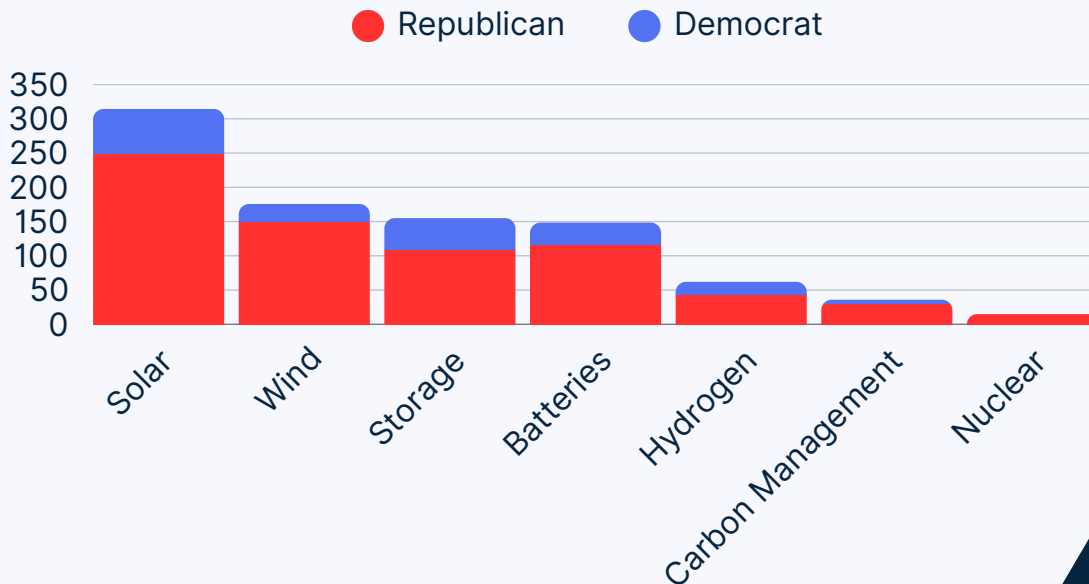
POLITICAL LANDSCAPE ANALYSIS

2. Congressional Dynamics and Bipartisan Pockets

Despite partisan hostility toward the IRA at the national level, many of its benefits are concentrated in Republican districts. Data from Rhodium Group and IRA Tracker shows a disproportionate share of clean energy manufacturing, carbon capture, and solar deployment occurring in red states.³ This geographic distribution has created bipartisan support for preserving certain credits. A March 2025 letter signed by 21 Republican members of Congress in support of IRA tax credits demonstrates emerging intra-party cleavages.⁴

House Ways and Means Committee Chair Jason Smith and members of the Energy and Commerce Committee—such as Rep. Bob Latta and Rep. Randy Weber—have historically opposed the IRA, often citing it as fiscally irresponsible or ideologically aligned with the “Green New Deal.”⁵ However, their districts include project beneficiaries, which may moderate their positions.

**Total Clean Energy Investment in the United States 2018-2024
By Political Party of District Representative (USD Billions)**



Investment Data from Rhodium Group Climate Deck (2018Q1-2024Q4)

[3] Trevor Houser, Aman Srivastava, Hannah Kulus, and Adam Ratzlaf, Clean Investment Monitor: Q4 2024 Update (Rhodium Group and MIT CEEPR, March 2025), <https://rhg.com/research/clean-investment-monitor-q4-2024-update/>.

[4] Josh Siegel, “House Republicans Push to Preserve Clean Energy Tax Breaks,” POLITICO, March 10, 2025, <https://www.politico.com/news/2025/03/10/house-republican-clean-energy-tax-breaks-00218126>.

[5] House Committee on Ways and Means, “Chairman Smith: Inflation Reduction Act Is Welfare for the Wealthy, Well-Connected,” U.S. House of Representatives, August 16, 2023, <https://waysandmeans.house.gov/2023/08/16/chairman-smith-inflation-reduction-act-is-welfare-for-the-wealthy-well-connected/>.

POLITICAL LANDSCAPE ANALYSIS

Republican Leadership in the Senate

Senate Republican Leader John Thune

South Dakota

Clean energy investment totals \$6.233 billion (equivalent to 8.29% of state GDP). Federal investment amounts to \$161.26 million or \$174.53 per capita (0.87% of state GDP).

Senate Republican Whip John Barrasso

Wyoming

The state has attracted \$17.554 billion (equivalent to 33.14% of state GDP) in clean energy investment. Federal support totals \$592.73 million or \$1009.17 per capita (4.53% of state GDP).

Senate Republican Conference Chairman Tom Cotton

Arkansas

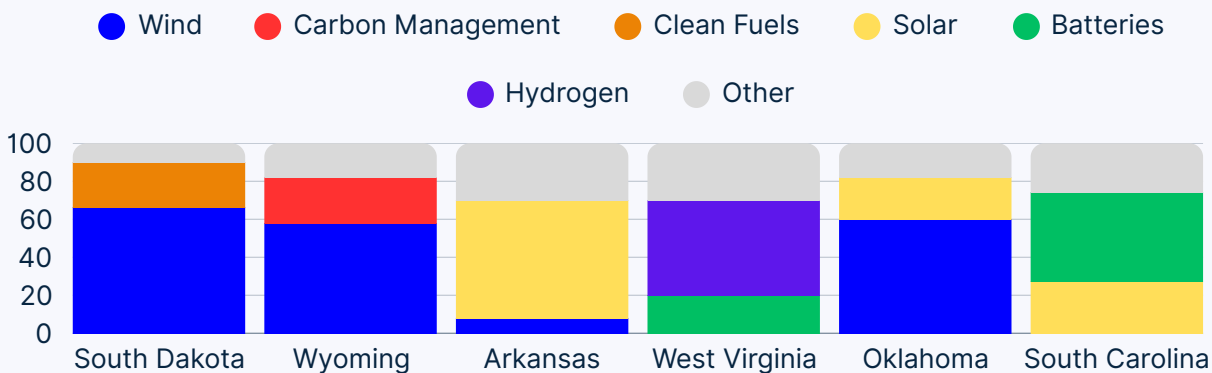
Clean energy investment stands at \$6.22 billion (equivalent to 3.30% of state GDP). Federal investment amounts to \$594.40 million, or \$192.53 per capita (1.28% of state GDP).

Senate Republican Policy Committee Chairman Shelley Moore Capito

West Virginia

The state has received \$4.228 billion (equivalent to 3.93% of state GDP) in clean energy investment. Federal investment totals \$234.95 million, or \$132.74 per capita (0.89% of state GDP).

% of State Clean Energy Investment by Technology



Investment Data from Rhodium Group Climate Deck (2018Q1-2024Q4)

POLITICAL LANDSCAPE ANALYSIS

Republican Leadership in the House

Speaker of the House Mike Johnson

Louisiana – 4th District

Clean energy investment totals \$4.205 billion, with 63% of this investment in carbon management and 28% hydrogen.

Majority Leader Steve Scalise

Louisiana – 1st District

The district has received \$4.932 billion in clean energy investment, this investment is overwhelmingly concentrated in hydrogen (98%).

Majority Whip Tom Emmer

Minnesota – 6th District

This district benefits from \$0.665 billion in clean energy investment, with 98% solar technology deployment.

Republican Conference Chairman Lisa McClain

Michigan – 9th District

Currently, there is no reported clean energy investment in this district.

Republican Policy Committee Chairman Kevin Hern

Oklahoma – 1st District

The district has secured \$0.612 billion in clean energy investment, entirely allocated to solar (100%).

Republican leaders, both in the House and Senate, represent districts and states that are significant beneficiaries of clean energy investment, underscoring their potential interest in the sector's growth. Notably, Wyoming—represented by Senate Republican Whip John Barrasso—is the nation's largest recipient of Inflation Reduction Act clean energy expenditure per capita, highlighting the critical role clean energy plays in the state's economy.

POLITICAL LANDSCAPE ANALYSIS

3. Rule of Law and Administrative Interference

Interviewees across all sectors raised concerns about whether the federal government will honor existing contracts, particularly with regard to tax credit eligibility and grant disbursements. Legal experts argue that courts would likely side with claimants in the event of clawbacks or contract breaches, but even temporary freezes can introduce enough uncertainty to delay or kill projects.

Public sector officials and academic experts emphasized that a breakdown in procedural norms—such as refusing to issue tax guidance or selectively enforcing rules—could chill investment without requiring legislative repeal. Examples include delays in permitting, rulemaking, or Treasury Department interpretation.

4. Technology Risk and Policy Salience

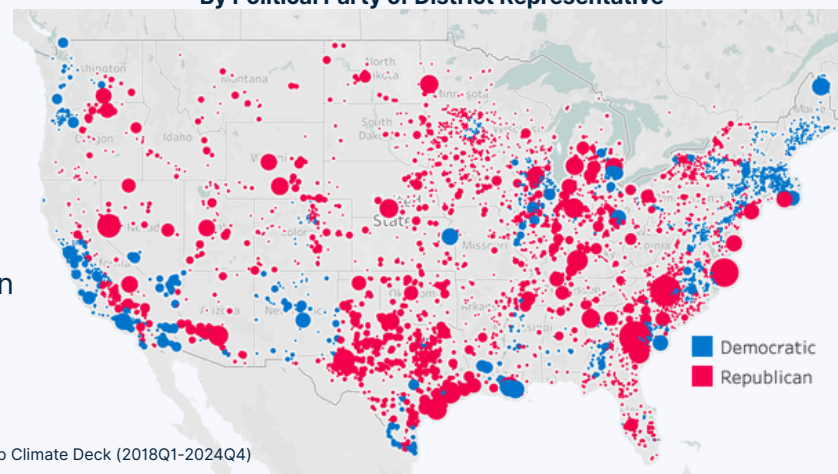
Political vulnerability varies significantly by technology. Technologies with ties to fossil fuel constituencies (carbon capture, geothermal, blue hydrogen, nuclear) are more likely to survive under a Republican administration. In contrast, EV tax credits and offshore wind are widely seen as politically vulnerable. These could serve as a political “trophy” for Republicans looking to gut the IRA, while providing cover to maintain more bipartisan provisions.

Solar and storage occupy a middle ground: while widely deployed and increasingly cost-competitive, they still depend on IRA incentives for favorable project economics, particularly at utility scale.

5. Strategic Implications for Captona

The political future of the IRA is uncertain, but not predetermined. While rollback efforts are real, they are constrained by legal mechanisms, internal Republican divisions, and the economic benefits clean energy brings to conservative districts. Captona’s investment strategy must remain agile, informed, and grounded in scenario-driven analysis to navigate this evolving political terrain.

**Total Clean Energy Investment in the United States 2018-2024
By Political Party of District Representative**



VULNERABILITY ANALYSIS

VULNERABILITY ASSESSMENT FRAMEWORK

The Inflation Reduction Act (IRA) includes a wide range of tax credits and provisions that have reshaped the renewable energy investment landscape. Under the current Trump administration, many of these measures may face heightened scrutiny, and certain provisions are vulnerable to reversal, limitation, or reinterpretation.

To help anticipate how these scenarios might unfold, we have developed a framework for assessing the specific ways in which IRA provisions could be exposed to political or administrative rollback. This framework is designed to inform strategic planning by identifying points of vulnerability—not to rank provisions by risk, but to clarify the types of scenarios in which changes could realistically occur.

Vulnerability Assessment of IRA Provisions

The framework evaluates three key dimensions of each provision:

1. First, we analyze the geographic distribution of impact by examining renewable energy investment at the congressional district level, highlighting which areas are seeing the greatest benefits from IRA tax credits. This helps illuminate the political dynamics around potential changes, especially in districts represented by policymakers with influence over IRA-related decisions.

2. Second, we examine the legal and procedural mechanisms that would be required to alter or limit each provision. This includes understanding what type of authority—legislative, regulatory, or administrative—would be needed to implement changes and how complex or feasible those processes might be.

3. Finally, we assess how the policy agenda of the Trump administration and Congress aligns with potential rollbacks. This includes analyzing public statements, proposed legislation, and expert interviews to identify which tax credits and related provisions may become targets for modification. Together, these components provide a structured approach for anticipating the types of challenges the IRA may face under the current administration.



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Statutory Provisions

The following section covers the Production Tax Credit (PTC), Investment Tax Credit (ITC), and the Credit for Carbon Oxide Sequestration (CCUS). These are statutory provisions, which, as outlined in Section III, are embedded in the tax code and cannot be reversed by executive action alone. Changes to or repeal of these provisions requires legislative action, which makes them more politically insulated than their regulatory counterparts.

Political and Economic Context

A full repeal of the IRA is considered unlikely. Many business-facing tax credits like the 45Q (carbon sequestration) and 45V (clean hydrogen) have strong bipartisan support, including among key congressional Republicans, due to the economic benefits they bring to their districts.⁶ In the letter referenced above, GOP lawmakers stated, "Both our constituencies and the energy industry alike remain concerned about disruptive changes to our nation's energy tax structure."⁷

Industry experts note that a wholesale repeal of many tax credits could be difficult. As David Victor, professor at UC San Diego, observed: "I expect that they're going to be pretty hostile, but I don't expect that the IRA is going to be repealed."⁸ In all likelihood, any changes to the IRA would be selective modifications rather than wholesale elimination. In this scenario, projects which began construction before 2025 would likely be protected, while the fate of projects starting construction after 2025 would be less certain.

Production Tax Credits (PTC)

The Clean Electricity Production Credit (45Y) is a tech-neutral tax credit introduced by the Inflation Reduction Act that replaces the Energy Production Tax Credit after 2024. This emissions-based incentive provides a base rate of 0.3 cents per kilowatt hour of electricity produced at qualified facilities. Facilities with a maximum output less than 1 megawatt automatically qualify for the higher rate of 1.5 cents per kilowatt hour, while larger facilities must meet prevailing wage and registered apprenticeship requirements to receive this enhanced rate.

[6] Carbon Direct, The Future of the IRA's Clean Energy Tax Credits, February 5, 2025, <https://www.carbon-direct.com/insights/the-future-of-the-ira-s-clean-energy-tax-credits>.

[7] Inside Climate News, "Some Republicans Defend Clean Energy Tax Credits from Trump Administration Cuts," March 10, 2025, <https://insideclimatenews.org/news/10032025/some-republicans-defend-clean-energy-tax-credits/>.

[8] E&E News by POLITICO, "What Trump's Treasury Pick Means for Clean Energy Tax Credits," November 25, 2024, <https://www.eenews.net/articles/what-trumps-treasury-pick-means-for-clean-energy-tax-credits/>.

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STATUTORY PROVISIONS

Current Status of the Tax Credits

Section 45 production tax credit and Section 48 investment tax credit were available to projects that began construction before 2025, and qualifying projects placed into service after December 31, 2024, are now eligible for the tech-neutral 45Y and 48E credits.¹¹ The final regulations for these credits were published in the Federal Register on January 15, 2025, making them subject to Congressional Review Act (CRA) procedures by the new Congress and President Trump.¹²

Vulnerability Assessment

Both credits face similar procedural vulnerabilities since they were finalized at the same time and are subject to the same CRA review period.¹³ In the following paragraphs we analyze legislative and executive action vulnerabilities separately.

a. Legislative Vulnerability

A Congressional Review Act represents the most immediate procedural threat to these tax credits. Under the CRA, final agency rules can be overturned through an expedited procedure requiring a joint resolution of disapproval by both houses of Congress and the President's signature. If such a resolution passes, the agency cannot reissue the rule "in substantially the same form" without new congressional authorization.¹⁴ Since the final regulations for 45Y and 48E were published in January 2025, the incoming 119th Congress and President Trump can overturn these regulations through the CRA procedures approximately until May 12th 2025.¹⁵

With Tax Cuts and Jobs Act provisions expiring at the end of 2025, Republicans have pointed to IRA repeal as a potential funding source for other tax priorities. Congress could use the Budget Reconciliation Process, requiring only 51 Senate votes, to repeal or amend IRA tax provisions.¹⁶ However, as noted in Section III, a group of 21 House Republicans recently signed a letter advocating to keep the clean energy tax credits from the IRA, threatening to oppose the Republican budget bill if their request is not met. The letter, organized by Rep. Andrew Garbarino (R-N.Y.), argues that clean energy is a crucial part of President Trump's "energy dominance" edict and speaks against efforts to cut the tax credits to pay for the GOP's tax-cut package. The letter calls for any changes to the IRA be done in a "targeted and pragmatic fashion" rather than through wholesale repeals. They emphasized "the importance of prioritizing energy affordability for American families and keeping on our current path to energy dominance amid efforts to repeal or reform current energy tax credits."¹⁷

[11] Utility Dive, "Treasury Finalizes Guidance for IRA's Tech-Neutral, Clean Electricity Tax Credits," January 9, 2025, [utilitydive.com](https://www.utilitydive.com).

[12] Gibson Dunn, "IRS and Treasury Issue Final Regulations for Tech-Neutral Tax Credits for Clean Energy Projects," January 14, 2025, [gibsondunn.com](https://www.gibsondunn.com).

[13] Energy Storage News, "'Phase-out of ITC/PTC in 2025 is our base case': Future of US clean energy tax credits hangs in the balance under Trump," March 20, 2025, [energy-storage.news](https://www.energy-storage.news).

[14] Crowell & Moring LLP, "Clean Energy Tax Credits and After the Election — What to Expect?" [governmentcontractslegalforum.com](https://www.governmentcontractslegalforum.com).

[15] Gibson Dunn, "IRS and Treasury Issue Final Regulations for Clean Hydrogen Tax Credits," January 9, 2025, [gibsondunn.com](https://www.gibsondunn.com).

[16] Crowell & Moring LLP, "Clean Energy Tax Credits and After the Election — What to Expect?" [governmentcontractslegalforum.com](https://www.governmentcontractslegalforum.com).

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STATUTORY PROVISIONS

The Republican signatories come from various states, including Arizona, California, Colorado, Georgia, Indiana, Iowa, Michigan, Nebraska, Nevada, New Jersey, New York, Ohio, Pennsylvania, Virginia, and Washington. Industry stakeholders, including the American Petroleum Institute and the U.S. Chamber of Commerce, have also been lobbying to spare certain IRA tax credits, specifically those relating to hydrogen and carbon capture.

b. Executive Action Vulnerability

While President Trump's executive orders signal a shift in energy policy, they don't directly impact tax credits at this time. However, Treasury Department and IRS reviews ordered by the administration could lead to proposals to rescind or revise implementing guidance.¹⁸

The executive order issued on Trump's first day in office primarily targets appropriations rather than tax credits. As industry expert Nicole Elliott noted, "The EO talks about appropriated funds and tax credits are not appropriated."¹⁹ Since the ITC and PTC are embedded in the Tax Code, executive orders cannot legally affect them. An attempt in that direction would likely face significant litigation.

Carbon Capture Credits

The Credit for Carbon Oxide Sequestration (45Q) provides financial incentives for capturing and securely storing carbon oxide emissions from industrial facilities. This credit applies to qualified carbon oxide captured at qualified facilities using carbon capture equipment, which is then either disposed of in secure geological storage, used as a tertiary injectant in enhanced oil or natural gas recovery projects and securely stored, or utilized for defined purposes.

To qualify, facilities must have begun construction before January 1, 2033, and either begin construction of carbon capture equipment before that date or include carbon capture equipment in their original facility design. Minimum capture requirements apply: direct air capture facilities must capture at least 1,000 metric tons annually, electricity generating facilities must capture at least 18,750 metric tons annually with equipment designed to capture at least 75% of the unit's baseline carbon oxide production, and other facilities must capture at least 12,500 metric tons annually.

[17] E&E News by POLITICO, "Some House Republicans Warn Against Climate Law Repeal," [eenews.net](https://www.eenews.net).

[18] Wilson Sonsini, "President Donald J. Trump's Executive Orders and Actions Regarding Clean Energy and Climate Technologies (January 2025)," [wsgr.com](https://www.wsgr.com).

[19] Thomson Reuters, "Executive Order Targets 'Green New Deal,'" January 24, 2025, [thomsonreuters.com](https://www.thomsonreuters.com).

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STATUTORY PROVISIONS

Production Tax Credits (cont'd)

The credit also includes bonuses: a 10% increase for facilities meeting domestic content requirements for steel, iron, and manufactured products, and another 10% increase for facilities located in energy communities. The credit is available for facilities placed in service after December 31, 2024, and will begin to phase out either in 2032 or when U.S. greenhouse gas emissions from electricity reach 25% of 2022 levels, whichever is later. Qualified facility owners or operators can claim credits based on kilowatt hours of clean energy generated, metric tons of carbon dioxide captured and sequestered, or kilograms of clean hydrogen produced. This credit is eligible for direct payment or transfer options, though taxpayers cannot claim both investment and production credits for the same facility.⁹

Investment Tax Credits (ITC)

The Clean Electricity Investment Credit (48E) is a tech-neutral investment tax credit introduced by the Inflation Reduction Act that replaces the Energy Investment Tax Credit after 2024. This emissions-based incentive offers a base rate of 6 percent of the qualified investment for facilities with qualified clean electricity generation and energy storage technology placed in service after December 31, 2024.

The credit can be significantly increased through several provisions: up to 5 times the base rate (reaching 30%) for facilities meeting prevailing wage and registered apprenticeship requirements, plus an additional 10% for facilities meeting domestic content requirements for steel, iron, and manufactured products, and another 10% for facilities located in energy communities.

Like the production tax credit, this credit will begin to phase out either in 2032 or when U.S. greenhouse gas emissions from electricity reach 25% of 2022 levels, whichever is later. The credit is eligible for direct payment or transfer options, which are particularly beneficial for tax-exempt organizations and government entities. However, a pre-filing registration is required for these elective payments and transfers. Taxpayers claim this credit by completing Form 3468 (Investment Credit) with their annual tax return for the first taxable year in which they report the clean energy investment credit.¹⁰

[9] Clean Electricity Production Credit, Internal Revenue Service, <https://www.irs.gov/credits-deductions/clean-electricity-production-credit>.

[10] Clean Electricity Investment Credit, Internal Revenue Service, <https://www.irs.gov/credits-deductions/clean-electricity-investment-credit>.

VULNERABILITY ANALYSIS

STATUTORY PROVISIONS

Carbon Capture Credits (cont'd)

The base credit amounts are: \$17 per metric ton for carbon oxide disposed of in secure geological storage; \$12 per metric ton for carbon oxide used as a tertiary injectant or utilized; and \$36 per metric ton for direct air capture facilities. These amounts increase by five times for facilities meeting prevailing wage and registered apprenticeship requirements. The credit is eligible for direct payment or transfer, and taxpayers claim it by completing Form 8933 with their annual tax return.²⁰

Vulnerability Assessment

45Q carbon capture credit is more resilient to potential repeal efforts due to its historical bipartisan support, including expansion during the first Trump administration through the USE IT Act in 2020.²¹ The credit's particular benefit to Republican-leaning states with fossil fuel industries and its positioning as a technology that enables continued use of traditional energy sources while reducing emissions grant it political protection that purely renewable-focused credits lack.²² Despite this relative security, 45Q is not entirely immune from scrutiny, as evidenced by the March 2025 introduction of the "45Q Repeal Act" by Representatives Scott Perry (R-PA) and Ro Khanna (D-CA), who characterize it as a "wasteful tax credit."²³

However, significant countervailing support exists from a broad coalition of over 160 companies, trade groups, and organizations that recently advocated for maintaining the credit based on its economic benefits and technological importance.²⁴ The credit's established track record since 2008, coupled with its lower political profile compared to more contentious clean energy policies, suggests that while it may face targeted modifications to refocus implementation toward fossil fuel applications, complete elimination remains unlikely under the current administration.

[20] Credit for Carbon Oxide Sequestration, Internal Revenue Service, irs.gov.

[21] U.S. Senate Committee on Environment and Public Works, "President Trump Signs Barrasso's Bipartisan Carbon Capture Bill into Law," December 28, 2020, epw.senate.gov.

[22] Carbon Direct, "The Future of the IRA's Clean Energy Tax Credits," February 5, 2025, carbon-direct.com.

[23] U.S. Representative Scott Perry, "Congressman Scott Perry Introduces the 45Q Repeal Act," March 10, 2025, perry.house.gov.

[24] Carbon Capture Coalition, "Coalition Leads National, Multi-Stakeholder Call on Congress to Maintain Critical Support for 45Q Tax Credit," January 28, 2025, carboncapturecoalition.org.

VULNERABILITY ANALYSIS

REGULATORY PROVISIONS

Regulatory Provisions

The following section covers regulatory components of the IRA. As outlined in Section III, these bonus credit "adders" such as domestic content, energy communities, and the transferability mechanism are more politically exposed. These provisions can be delayed, reinterpreted, or partially dismantled via administrative action

Category	Details
Legislative	<ul style="list-style-type: none"> • Reconciliation Bill (Statutory) • Congressional Review Act (Regulatory): Tighten or repeal qualifications for recently issued guidances
Executive	<ul style="list-style-type: none"> • Administrative Procedure Act to change regulations • Executive orders: tax credits are out of scope • Practical Interference
Upcoming Milestones	<ul style="list-style-type: none"> • CRA: estimated expiration date May 12th • Ways and Means Committee expected to markup on May 12–13th • Reconciliation Bill: GOP goal is to pass the bill before Memorial Day

[25] IRS, Notice 2025-08, irs.gov.

[26] Brookings Institution, "What Will Happen to the Inflation Reduction Act Under a Republican Trifecta?" January 15, 2025, brookings.edu.

[27] Maeve P. Carey and Christopher M. Davis, The Congressional Review Act: The Lookback Mechanism and Presidential Transitions, Congressional Research Service, July 9, 2024, fas.org.

VULNERABILITY ANALYSIS

REGULATORY PROVISIONS

Domestic Content Adder

The domestic-content bonus (up to 10 percentage points on the ITC or 10 percent on the PTC) aligns with GOP “America First” rhetoric by requiring projects to use U.S.-made steel, iron, and increasingly higher shares of domestically manufactured components, supporting broader on-shoring initiatives.²⁹ This resonates strongly with voters in key manufacturing states like Ohio, Georgia, Tennessee, and Texas, where Section 45X and 48C subsidies are stimulating significant clean-tech factory activities and investments, benefiting districts represented by Republican members.³⁰ In interviews, current and former senate staff affirmed this adder’s relative security.

However, this bonus is vulnerable because it relies on IRS guidance rather than statute, meaning the Treasury Secretary can tighten sourcing rules, thereby reducing the bonus's effective value without legislative changes.³¹ Overall, while complete repeal is unlikely due to broad political support, increased sourcing requirements or cost caps remain possible.

Energy Community Adder

The energy-community adder, an extra 10 percent (PTC) or 10 percentage (ITC) uplift for projects based in coal, oil & gas, or brownfield areas, draws Republican support because it funnels investment into shuttered-plant and mining counties in West Virginia, Kentucky, Ohio, Wyoming and Texas - places where the party’s electoral base and local job prospects overlap.³² Yet the adder is not entirely politically insulated.

Administratively, the bonus rests on an IRS guideline and an Energy Communities Map that the Treasury updates each year.³³ The current administration can freeze those annual revisions, raise the fossil-fuel employment threshold, or demand case-by-case brownfield proofs to delay deals without touching the statute. Further, while pro-coal members of the Congress champion the uplift, pro-gas conservatives regard it as place-based industrial policy, meaning the likely outcome is not a wholesale repeal but tighter eligibility criteria or a reduced bonus rate to consolidate various interest groups represented in the House.

[28] Crowell & Moring LLP, “Clean Energy Tax Credits and After the Election: What to Expect,” accessed April 24, 2025, [crowell.com](https://www.crowell.com).

[29] Plante Moran, “Inflation Reduction Act Tax Credits: A Complicated Path in 2025,” December 2024, [plantemoran.com](https://www.plantemoran.com).

[30] Bo Erickson, “Republican Lawmakers Face Clean-Energy Conundrum as They Work on Tax Bill,” Reuters, April 21, 2025, [reuters.com](https://www.reuters.com).

[31] Crowell & Moring LLP, “Clean Energy Tax Credits and After the Election – What to Expect,” accessed April 24, 2025, [crowell.com](https://www.crowell.com).

[32] Lamar Johnson, “21 House Republicans Oppose Cutting Clean Energy Credits to Pay for Tax Cuts,” Utility Dive, March 11, 2025, [utilitydive.com](https://www.utilitydive.com).

[33] “Energy Community Tax Credit Bonus,” Energy Communities, accessed April 24, 2025, [energycommunities.gov](https://www.energycommunities.gov).

VULNERABILITY ANALYSIS

REGULATORY PROVISIONS

Low-Income Community Adder

The low-income-communities adder (up to 10 or 20 percentage-points for smaller or equal to 5 MW solar or wind) is the easiest Inflation Reduction Act adder to remove in a Republican Congress or a Trump Treasury.

Over the past two years, there has been discussion about its removal. During the 2023 debt-limit debate, the House Republicans “Limit, Save, Grow Act” singled out “bonus provisions aimed at placing solar and wind facilities in low-income communities” for elimination, signaling a willingness to use the credit as a leverage while other clean-energy incentives survived.³⁴ Second, the program is a proposed regulation. Brookings lists the low-income bonus among 23 climate-related IRA rules that remain in draft form and therefore can be withdrawn or rewritten.³⁵ Reuters’ tax-policy briefing echoes this assessment, noting the rule falls in the president’s regulatory-freeze memo and within the Congressional Review Act “look-back” window.³⁶

In addition, multiple legal and policy institutions flag the credit as high-revenue, low-constituency. Crowell & Moring’s post-election risk matrix ranks the low-income bonus in its top tier of repeal items, because Congress can “drop the bonus alone, raise meaningful revenue, and touch far fewer GOP-district projects than the base ITC/PTC.”³⁷

From a procedural perspective, the credit’s mechanics make it not easily withstanding departmental struggles. Because Treasury must run a competitive allocation each year, lawmakers can: cancel the 1.8 GW programme in a FY26 budget-reconciliation bill; let a CRA vote void any final rule issued after July 2025; or direct Treasury to re-propose the rule with a trimmed cap or a state-match requirement. Each route needs a simple-majority vote, making the low-income bonus an easier target among the IRA’s three major tax-credit adders.

[34] Josh Siegel and Kelsey Tamborrino, “GOP’s Debt-Limit Plan Would Gut Biden’s Climate Law. White House’s Response: ‘Jobs,’” Politico, April 20, 2023, politico.com.

[35] Brookings Institution, “What Will Happen to the Inflation Reduction Act Under a Republican Trifecta?” Accessed April 24, 2025, brookings.edu.

[36] Maureen Leddy, “Executive Order Targets ‘Green New Deal,’” Thomson Reuters Tax & Accounting News, January 24, 2025, thomsonreuters.com.

[37] Crowell & Moring LLP, “Clean Energy Tax Credits and After the Election – What to Expect,” November 25, 2024, crowell.com.

VULNERABILITY ANALYSIS

REGULATORY PROVISIONS

Prevailing Wage and Apprenticeship

We evaluate the vulnerability of Prevailing Wage and Apprenticeship (PW&A) standards within the Inflation Reduction Act (IRA) through political and procedural lenses. While PW&A standards are politically targeted, procedural safeguards create barriers against complete repeal, making selective weakening through budget riders and CRA the more probable outcomes.

The procedural and legal pathways for repealing PW&A adder vary in complexity. While statutory repeal remains lower due to the slim Republican margin in Congress, as PW&A is codified like the domestic content adder, more plausible risks include the Congressional Review Act, which could target recent regulatory updates like the January 15, 2025 tech-neutral regulations (45Y/48E), or appropriations riders restricting implementation funds, such as those seen in recent proposals like H.R. 5894.³⁸

The Trump-era policy agenda poses an ideological challenge to PW&A standards, with explicit objectives from Trump campaign advisers to roll back Biden-era labor mandates. Actions like Trump's revocation of the Biden apprenticeship executive order and Congressional Republicans' critiques of PW&A inflating costs reinforce this stance. However, significant intra-party splits and resistance from influential groups, including NABTU and state-level Republicans benefiting from IRA investments,³⁹ limit the potential extent of repeal efforts. Market analysis, including Rabobank, further suggest that widespread bipartisan investment reduces the likelihood of a wholesale repeal, forecasting instead targeted adjustments like reductions to multipliers or extended compliance windows.⁴⁰

[38] U.S. Congress. House. H.R. 5894, 118th Congress, 1st sess., introduced October 6, 2023, congress.gov.

[39] North America's Building Trades Unions (NABTU), Issue Sheet: Inflation Reduction Act 2025, April 2025, nabtu.org.

[40] Nina Fahy, "Potential Risks to the Inflation Reduction Act Under a Second Trump Administration," Rabobank, October 14, 2024, rabobank.com.

VULNERABILITY ANALYSIS

REGULATORY PROVISIONS

Provision	Subject to CRA	Subject to APA
Transferability <u>IRS Final Regulation</u> , July 1 2024	No	Yes
Domestic Content (10%) <u>Notice 2025-08</u> , Jan 16th 2025	Yes	Yes
Energy Community (10%) <u>Notice 2024-30</u> , March 22, 2024	No	Yes
Low Income Community (10% or 20%) <u>IRS Final Regulations</u> , January 13th, 2025	Yes	Yes
Prevailing Wage (30% Base) <u>IRS Final Rule</u> , June 25th 2024	No	Yes

Summary Chart of Regulatory Vulnerabilities

VULNERABILITY ANALYSIS

FINANCIAL STRUCTURES

Direct pay provisions

The legal exposure of the IRA's two monetization tools can be grouped into the following channels, and each channel affects Section 6417 - Direct-Pay and Section 6418 - Transferability in slightly different ways.

First, statutory repeal or amendment. That is the quickest removal. A single sentence in a budget-reconciliation bill could strike Section 6417 out or confine refunds to tax-exempt entities, while the same bill could shave a percentage off transferred credits, or accelerate phase-out timetables. Speaker Mike Johnson has signalled the majority's appetite for something "between a scalpel and a sledgehammer."⁴¹

Second, appropriations riders offer little leverage because both provisions are coded as refunds in the tax code that flow automatically from Treasury's permanent Account 1324.⁴² Therefore, Congress would have to amend the Internal Revenue Code to stop the payments.

Third, regulatory restraint. The Treasury would need a reading to rewrite the the 2024 final regulations, and those rules now sit outside the 60-day Congressional Review Act window.⁴³ Last, budget reconciliation. This is the most plausible pathway: it needs only a House majority plus 51 Senate votes. But reconciliation math is complicated: in March, 2025, twenty-one House Republicans whose districts already banked IRA factories and wind farms have warned they will oppose any bill, increasing the odds that existing contracts are grandfathered.⁴⁴ Some interviewees also noted "though transferability is easier to be repealed, it does not save government money."



[41] Alex Muresianu and Peter Van Ness, "Inflation Reduction Act (IRA) Green Energy Tax Credits: Reform," Tax Foundation, March 20, 2025, taxfoundation.org.

[42] U.S. Congress. House of Representatives. Congressional Record, 117th Cong., 2nd sess., vol. 168, no. 135 (August 12, 2022), congress.gov.

[43] Crowell & Moring LLP, "Clean Energy Tax Credits and After the Election – What to Expect," December 2024, governmentcontractslegalforum.com.

[44] Josh Siegel, "House Republican Support Grows for Keeping Clean Energy Tax Breaks," Politico, March 10, 2025, politico.com.

VULNERABILITY ANALYSIS

FINANCIAL STRUCTURES

Transferability mechanisms

Interviewees are concerned that the administration's seeking to trim IRA provisions could quickly target transferability, either by imposing limits on the volume of credits transferred or by increasing compliance barriers.

From a technology standpoint, legacy technologies such as solar and wind are generally expected to withstand reductions better, as they rely less on specialized structures to attract financing. Battery Energy Storage Systems (BESS) also benefit from growing market demand but still depend on incentives to accelerate deployment.

Biogas and other alternative fuels, Green Hydrogen, and CCUS often require higher capital costs and unproven returns, making them especially reliant on flexible mechanisms like transferability to bridge financing gaps. Should transferability be weakened or repealed, these less-established pillars could see diminished investor appetite, stalling further development in emerging clean energy niches.



SCENARIO DEVELOPMENT

SCENARIO DEVELOPMENT

Scenario 1: No Change in Law or Regulations

In this scenario, the IRA remains fully intact. There are no legislative rollbacks, no regulatory changes, and informal guidance, such as bonus credits for domestic content or energy communities—remains in place. Federal agencies continue administering the law under its original structure. This scenario assumes that while the administration may not actively support the IRA, it also does not interfere with it. Implementation proceeds based on existing timelines and guidance.

Scenario 2: Partial Tax Credits Repeal

Given the current political landscape, a partial repeal of the IRA is plausible. This could involve Congress leveraging its legislative authority to selectively roll back key provisions of the act. For instance, certain clean energy tax credits and funding programs may be curtailed or eliminated, particularly those supporting emerging technologies such as green hydrogen and offshore wind. More established incentives, like those for solar and geothermal, might remain intact due to their broader political support. This reflects the administration's focus on budgetary concerns and shifting priorities. Such changes could occur within the short to medium term, depending on legislative processes and political negotiations. According to expert interviews, a partial repeal would be particularly damaging for emerging technologies like green hydrogen, which still depend heavily on stable and sustained federal incentives to remain viable.⁴⁵

Scenario 3: Full Repeal

In this scenario, Congress exercises its legislative authority to fully repeal the Inflation Reduction Act. This would involve eliminating nearly all clean energy tax credits, funding programs, and regulatory provisions outlined in the IRA. While this scenario is politically unlikely due to legal, economic, and political hurdles – mainly congressional math⁴⁶ – it remains within the realm of possibility under a unified Republican government that views the IRA as excessive spending or ideologically misaligned.

Implementation would occur over the short to medium term through legislative action, though legal battles could extend timelines. The impact would be severe: clean energy deployment would likely stall, investor confidence would collapse—particularly in long-term infrastructure plays—and companies that structured investments around IRA incentives might face insolvency risks. Such retroactive policy reversals would severely undermine the credibility of the U.S. government, where regulatory stability is essential for investor confidence.

[45] Interview, February 25, 2025.

[46] March 2025 letter to House of Representatives' Leadership, politicopro.com.

SCENARIO DEVELOPMENT

Scenario 4: Full Repeal with Retroactive Clawbacks

Several recent court cases illustrate how judges are handling the Trump administration's effort to freeze or even claw back benefits that Congress created in the Inflation Reduction Act (IRA). Although none of the rulings involves the retroactive repeal of a tax credit itself, they test how far the executive branch can go in unwinding already vested and codified incentives.

One prominent case is *New York et al. v. Trump et al.*, filed on January 28, 2025 in the District of Rhode Island.⁴⁷ A coalition of 22 states alleged that the White House and the Office of Management and Budget lacked statutory authority to order agencies to "pause" every outstanding IRA and Infrastructure Act award. The Judge issued a preliminary injunction in March, 2025 requiring the government to resume disbursements, and the First Circuit refused to uphold that order. By the time this report was finalized, the appeal was ongoing.

At the program level, environmental nonprofits scored a key win in *Climate United Fund v. Citibank & EPA*. EPA Administrator Lee Zeldin had terminated three grant agreements under the \$20 billion Greenhouse Gas Reduction Fund and told Citibank to wire the money back to the Treasury. On March 18, 2025, Judge Tanya Chutkan issued a temporary restraining order, and later a preliminary injunction, blocking both the termination and any clawbacks, calling EPA's fraud allegations "vague and unsubstantiated" and finding the agency had sidestepped the Administrative Procedure Act.⁴⁸

These orders create a procedural wall against attempts to recapture already-delivered IRA benefits. Similar doctrines used in arguments would certainly be invoked if the Executive Branch or the Congress tried to retroactively repeal tax credits and claw back amounts that investors have already claimed. While federal courts have occasionally tolerated short look-backs, Supreme Court precedent *United States v. Carlton*, 512 U.S. 26 (1994) suggests that lengthy retroactivity or wholesale decertification of credit risks violates the Fifth Amendment's due-process clause, especially when taxpayers acted in good-faith reliance on existing law.⁴⁹

These litigations signal that projects which have generated credits are on solid ground, but credits scheduled for future tax years remain exposed to statutory change. Sponsors and tax-equity investors are continuing to price "repeal risk" into forward-sale and transfer agreements, but they now treat fully vested credits much like any other settled property right.

[47] *State of New York et al. v. Trump et al.*, No. 1:25-cv-00039-JJM-PAS (D.R.I. filed January 28, 2025), rid.uscourts.gov.

[48] Nate Raymond, "US Judge Blocks Trump's EPA from Clawing Back Climate Grants," Reuters, March 19, 2025, [reuters.com](https://www.reuters.com).

[49] Hunton Andrews Kurth LLP, "Tax Reform: Is Retroactive Repeal of Tax Credits Unconstitutional?" *The Nickel Report*, February 21, 2017, [hunton.com](https://www.hunton.com).

SCENARIO DEVELOPMENT

Scenario 5: No Change in Law but Operational Interference

In this scenario, the statutory text of the Inflation Reduction Act remains intact, but the federal agencies responsible for implementation—primarily the U.S. Department of the Treasury and the Internal Revenue Service (IRS)—are directed by the administration to undermine it through administrative and procedural means. This form of operational interference does not require new legislation and can be executed quietly, making it harder to detect and challenge legally. Examples include delays in processing tax credit pre-filing claims, narrowing eligibility criteria, or introducing complex compliance requirements that make it harder for developers to meet “safe harbor” rules and other technical qualifications for incentives.

The timeline for these changes is short-term, since the administration can begin shifting priorities and interpretations through executive direction or regulatory guidance. The effects may be slower and less transparent than legislative repeal, but they can still significantly reduce the effectiveness of the IRA by injecting uncertainty, increasing transaction costs, and discouraging investment, particularly among smaller developers that are not able to claim tax credits efficiently for themselves and rely heavily on transferability to make the projects more profitable. Over time, this strategy of administrative obstruction could significantly erode the impact of the law, even in the absence of formal legislative changes.

SCENARIO DEVELOPMENT

Scenario 6: Transferability Repeal

The IRA introduced a provision allowing for the transferability of tax credits, which has significantly broadened access to capital in the clean energy space. This mechanism enables developers, particularly smaller players without large tax liabilities, to sell their credits to third parties, creating a more liquid and democratized tax equity market. It has quickly become one of the most popular features of the IRA among private sector actors, facilitating broader participation and accelerating project deployment.

While a complete repeal would be difficult given its popularity among influential stakeholders and regulatory clarity, the perceived budgetary “cost” makes it an attractive target in future budget reconciliation negotiations. Despite its relatively low real cost, provisions like transferability may be used as bargaining chips in fiscal negotiations. There is the possibility of a “repeal-and-restore” cycle where transferability is removed in early legislative drafts but reinstated later as part of a political compromise. These credits may not be the largest revenue items, but their symbolic and structural role in expanding clean energy access makes them politically sensitive.

The timeline for repeal or modification is medium-term, likely tied to broader budget negotiations or reconciliation efforts. Partial repeal—such as capping the value of transferred credits or restricting eligible technologies or participants—may be more likely than a full rollback. Repealing or limiting transferability would re-concentrate tax credit access among large institutional players, reduce market flexibility, and raise financing costs—especially for community solar, energy storage, and emerging technologies. Transferability and related adders remain exposed and fiscally tempting under a deficit-conscious administration.

SCENARIO DEVELOPMENT

Scenario 7: Adders Repeal (for each individual Adder)

Some of the most attractive features of the IRA's tax credit structure—known as “adders” or bonus credits—are based not on formal regulations (Regulation: Domestic Content, Prevailing Wage and Apprenticeship) but on guidance from Federal Agencies (Guidance: Energy Community, Low Income Community). These include the Domestic Content Bonus Credit⁵⁰ and the Energy Communities Bonus Credit⁵¹, which provide extra tax incentives for projects that use U.S.-made materials or are located in economically disadvantaged, fossil fuel-dependent regions. Unlike core IRA provisions, these adders have not gone through formal rule making—a legally binding process that requires public notice, comment, and review.⁵² Instead, they are based on agency-issued memos, FAQs, and notices, which can be modified or withdrawn quickly without public input or legislative action.

Because of this, the timeline for potential changes is short-term. The administration could alter or eliminate these bonus credits through internal agency decisions. Bonus adders tied to energy communities and domestic content are at higher risk of repeal, as they rely entirely on administrative guidance and lack the legal protection that comes with formal rulemaking.

Additionally, these incentives may be viewed by the current administration as ancillary or overly generous, making them more politically vulnerable despite their intended role in supporting just transition and domestic supply chain goals. While the base credits would remain intact, removing or weakening the adders would reduce the financial returns for many projects, especially those built around the assumption of receiving bonus incentives. This could slow domestic supply chain investment, shift project siting decisions, and weaken one of the IRA's key tools for equitable energy transition in vulnerable communities.

[50] U.S. Department of the Treasury, “U.S. Department of the Treasury Releases Guidance on Domestic Content Bonus for Clean Energy Credits,” press release, January 16, 2025, home.treasury.gov.

[51] Internal Revenue Service, “IRS Issues Guidance for Energy Communities and the Bonus Credit Program under the Inflation Reduction Act,” March 22, 2024, irs.gov.

[52] Interview, March 2025.

TECH PILLAR ASSESSMENT

TECHNOLOGY PILLAR ASSESSMENT

Financial Modeling Overview

We developed financial models to assess the impact of various IRA scenarios on 7 different technologies, with a specific focus on solar, BESS, wind and RNG - Captona's current portfolio. To account for generation seasonality, the solar and wind models are structured on a monthly and quarterly basis. Given the distinct revenue structures and regulatory environments in CAISO and ERCOT—two key electricity markets for renewables—separate models were created for wind and BESS in each market.

Technology	Model	Periodicity	Market
Solar	Utility-scale Solar	Monthly	California
Wind	Utility-scale wind	Semi-Annual	California
		Semi-Annual	Texas
CCUS	CCUS	Semi-Annual	California
Hydrogen	PEM Electrolyzer	Semi-Annual	California
RNG	Anaerobic Digestion	Annual	New York
Battery	Standalone BESS	Annual	California
		Annual	Texas
Nuclear SMR	Nuclear SMR	Annual	Texas

TECHNOLOGY PILLAR ASSESSMENT

Below are the key assumptions used across the seven models. We assume the project is currently in the development phase, with financial close set for June 30, 2025, and Commercial Operation Date (COD) on January 1, 2026. The capital structure consists solely of debt and equity. Debt sizing follows industry-standard DSCR sculpting, targeting a DSCR of 1.30x for contracted revenues and 3.00x for merchant revenues. The base interest rate for the debt is assumed to be 7%.

Project Info		
Timing		
Deal Close	date	Jun 30, 2025
Commercial Operation (COD)	date	Jan 1, 2026
Asset Life	times	25-35
Project Size	MW	100-200
Debt		
Debt Tenor	years	10
Debt Start Date	date	Jan 1, 2026
Debt End Date	date	Dec 1, 2035
Interest rate	%	7%
DSCR on Contracted Revenue	x	1.30x
DSCR on Merchant Revenue	x	3.00x

TECHNOLOGY PILLAR ASSESSMENT

To simplify the analysis, we treat tax credits (including PTC and ITC) as an additional revenue stream. These credits are incorporated into both the project cash flows and cash flows to equity when calculating Project IRR and Equity IRR. The target IRR range for the models is between 12% and 14%.

Key Metrics		Target
Debt	Min DSCR	1.3x DSCR on Contracted Cash 3.0x DSCR on Merchant Cash
	Average DSCR	
Equity	Project IRR	12% - 14%
	Equity IRR	
	Payback Period on Equity	

TECHNOLOGY PILLAR ASSESSMENT

Scenarios

Scenarios - Adders

To assess the financial resilience of our project portfolio under evolving policy conditions, we developed a set of seven policy-driven scenarios as introduced below. These scenarios reflect varying levels of uncertainty surrounding clean energy tax credits and transferability provisions introduced under the IRA. We translate these scenarios into model inputs to stress test key assumptions - particularly how tax credit proceeds may fluctuate due to the repeal of adders or the devaluation of transferability. This allows us to assess the potential decrease in realized tax credit proceeds under different regulatory conditions, particularly in cases where bonus credits are eliminated or credit transferability is restricted.

Each scenario considers two dimensions:

- Tax Credit Availability – including base or full access to Investment Tax Credit (ITC) or Production Tax Credit (PTC), as well as bonus adders such as those for domestic content, energy communities, and low-income communities. Our analysis assumes that for as long as the tax credit and adders remain intact, eligible projects will receive the full rates.
- Transferability of Tax Credits – reflecting the potential repeal or devaluation of the tax credit transfers. In our modeling, we assume that when transferability is allowed, developers can monetize tax credits at a discounted rate of \$0.90 per \$1 of ITC/PTC by selling them to third parties. However, if transferability is repealed, developers must use the credits themselves, which may delay or reduce the financial benefit due to limited tax liability or carryforward limitations. Therefore, we apply a more conservative realization rate of \$0.50 per \$1 to reflect the reduced immediate value of retained credits

TECHNOLOGY PILLAR ASSESSMENT

ITC Scenario Mapping

Most of our tech pillars (including solar, battery, RNG and nuclear) are modeled using the ITC structure under Section 48E (technology-neutral Clean Electricity ITC). For these, we define six financial modeling cases based on the composite effects of tax credit levels and transferability assumptions.

Here, Scenario 7 (Adders Repeal) results in a broad range of ITC values due to the removal of bonus incentives such as domestic content, energy communities, low-income setting, and prevailing wage and apprenticeship compliance. This creates up to ten different credit rates ranging from 6% to 60% (that is 6%, 16%, 26%, 36%, 30%, 36%, 40%, 46%, 50%, and 60%). We simplify them into three representative cases (30%, 40%, and 50%) to reflect low, base, and high credit.

Scenario	Description	Case Number	Total ITC%	Transfer Price	
#	[text]	#	%	per \$1 ITC	
1	No change	1	70%	0.9	
7	Adders Repeal	High	2	50%	0.9
		Base	3	40%	0.9
		Low	4	30%	0.9
6	Transferability Repeal	5	40%	0.5	
2345	Full Repeal Equivalent	6	0%	0.5	

We group Scenarios 2, 3, 4, and 5 together as they all result in zero effective tax credit despite differing in rationale and implications. Scenario 2 (Partial Repeal) reflects the repeal of credits for selected technologies, which we consider equivalent to Scenario 3 (Full Repeal) under each technology. A more detailed technology-level breakdown is provided in the tax credit vulnerability analysis. Scenario 4 (Full Repeal with Clawback) shares the same tax credit repeal outcome but adds the risk of retroactive recovery of previously claimed credits. In Scenario 5 (Operational Interference), credits remain legally available but cannot be realized due to operational constraints. Although transferability remains available under this scenario, it has no financial effect because the underlying credit value is zero. And, transferability repeal (Scenario 6) impacts only the monetization rate, not credit eligibility.

TECHNOLOGY PILLAR ASSESSMENT

PTC Scenario Mapping

Wind is modeled under the 45Y PTC framework instead of ITC. For wind projects, under Scenario 7 (Adders Repeal), we assume a base case includes a 10% adder for energy communities. An upside case adds an additional 10% for domestic content compliance, effectively representing Scenario 1 (No Change), where all available adders are preserved. While a downside case assumes the energy community adder is removed. Consistent with our ITC analysis, we also group Scenarios 2, 3, 4, and 5 under wind PTC, as they all result in a zero effective tax credit due to full repeal.

Green hydrogen project is modeled using the 45V PTC, with eligibility for the 45Z Clean Fuel PTC if the hydrogen is used as a transportation fuel. In Scenario 1 (No Change), the project claims 45V, which provides up to \$3.00/kg - a higher value compared to approximately \$1.00/kg under 45Z. We model Scenario 2 (Partial Credit Repeal) separately from Scenarios 3, 4, and 5, where 45V is repealed but 45Z remains. In this case, the project defaults to claiming 45Z, though the credit value is lower. In terms of Scenario 7 (Adders Repeal), since 45V does not include additional bonus adders, the only “adders” that affects the credit amount is compliance with PWA. However, the repeal of PWA would allow the project to directly claim the full \$3.00/kg credit without fulfilling labor compliance.

CCUS projects are modeled under the 45Q PTC, assuming geologic storage (non-DAC). Corresponding to our seven scenarios, the project is modeled under three different cases based on the availability of the full 45Q credit and the transferability.

Scenario	Description	PTC Price			Transfer Price	
		45Y	45V	45Q		
#	[text]	¢/kWh	\$/kgH2	\$/per metric ton CO2	per \$1 ITC	
1	No change	1.80			0.90	
7	Adders Repeal	Base	1.65	3.00	85.00	0.90
		Low	1.50			
6	Transferability Repeal	1.65	3.00	85.00	0.50	
2	Full Repeal Equivalent		1.00		0.50	
3, 4, 5		0.00	0.00	0.00		

TECHNOLOGY PILLAR ASSESSMENT

Sensitivities

Sensitivity Analysis

Given the current political uncertainty, we also performed sensitivity analyses on key variables including interest rates, tariffs, and power price forecasts. For each variable, we modeled low, base, and high cases as outlined below.

Sensitivities	unit	Low	Base	High
Interest Rate	%	6%	7%	8%
Tariffs	%	0%	25%	50%

Interest Rate

During the COVID-19 pandemic, the Federal Reserve slashed its benchmark interest rate to near-zero (0.00%–0.25%) to support the economy. In the subsequent recovery, the Fed raised rates aggressively, peaking at a 22-year high of 5.25%–5.50% by July 2023. After signs of cooling inflation, the Fed pivoted to modest easing: several late-2024 rate cuts brought the policy rate down to 4.25%–4.50% as of early 2025. According to the Fed’s March 18–19, 2025 FOMC meeting projections, the midpoint of the target federal funds rate for end-2025 is expected to be around 3.75%–4.00%.⁵³ In credit markets, investment-grade borrowing costs remain moderate. As of April 29, 2025, the ICE BofA BBB US Corporate Index Effective Yield – a benchmark for BBB-rated corporate debt – stands at approximately 5.39%.⁵⁴

Recent policy changes, including tariffs, have introduced inflationary pressures, complicating Fed's decisions. While some market participants anticipate potential rate cuts to counteract slowing growth (recession), others caution that persistent inflation caused by tariffs may necessitate maintaining or even increasing rates.

[53] Board of Governors of the Federal Reserve System, Summary of Economic Projections – March 19, 2025, [federalreserve.gov](https://www.federalreserve.gov).

[54] Federal Reserve Bank of St. Louis, "ICE BofA BBB US Corporate Index Effective Yield," FRED, accessed April 29, 2025, fred.stlouisfed.org.

TECHNOLOGY PILLAR ASSESSMENT

To reflect current macroeconomic uncertainties, our financial models incorporate a range of interest rate scenarios based on market conditions and internal guidance.

- **Low Case – 6%:** Assumes a more dovish monetary environment in which inflation is brought under control, enabling the Federal Reserve to pursue additional rate cuts and ease financial conditions.
- **Base Case – 7%:** Based on Captona’s internal estimates, this scenario assumes the Fed gradually lowers the federal funds rate in line with projections, while borrowing costs remain elevated due to credit spreads and project-specific risk.
- **High Case – 10%:** Reflects a tightening environment in which persistent inflation—possibly driven by renewed tariffs—forces the Fed to maintain or raise interest rates further, resulting in significantly higher financing costs.

TECHNOLOGY PILLAR ASSESSMENT

Sensitivities

Tariffs

The U.S. has recently imposed significant tariffs on imported solar panels, wind turbine components, and battery storage systems, particularly targeting imports from China and Southeast Asia. These tariffs, some exceeding 300%, are a response to concerns over trade practices and have escalated under the current administration. As a result, the cost of renewable energy projects is expected to rise, with estimates suggesting that a 25% tariff on imports could raise the cost of building onshore wind turbines by 10% and renewable energy overall by 7%.⁵⁵

To assess the potential financial impact of these tariffs, our models incorporate three scenarios:

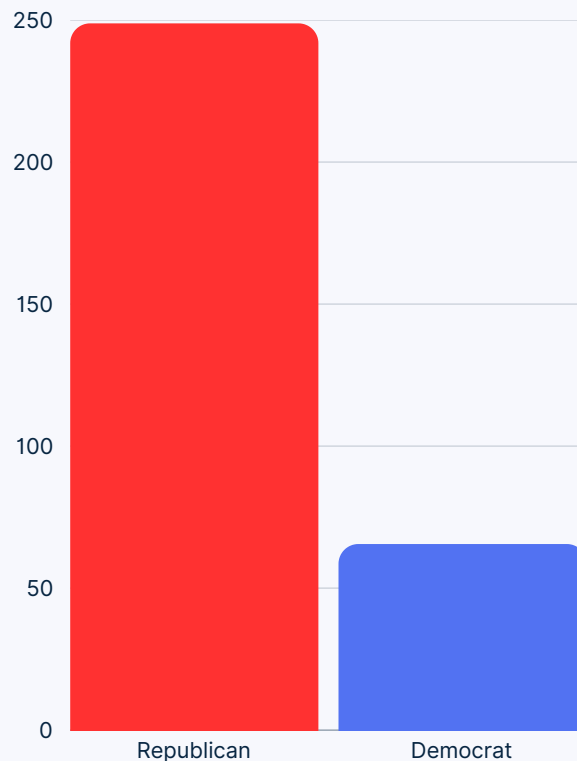
- **Low Case – 0% Tariff Impact:** Assumes no additional tariffs, reflecting a stable trade environment.
- **Base Case – 25% Tariff Impact:** This represents slightly increased tariff levels, leading to moderate increases in capital expenditures.
- **High Case – 50% Tariff Impact:** Considers a scenario where tariffs double, significantly escalating project costs and potentially affecting project viability.

[55] Kathryn Krawczyk, "What Trump's Tariffs Mean for the Energy Transition," April 4, 2025.

SOLAR ASSESSMENT

TECH PILLAR: SOLAR

Solar remains the dominant and most mature renewable energy technology in the U.S. energy transition landscape. The sector has benefited significantly from federal Investment Tax Credits (ITC), bonus adders, and new transferability rules under the IRA, which have catalyzed record-breaking growth in both utility-scale and distributed solar deployment. Installed solar capacity has expanded rapidly across the country—including in traditionally conservative districts—helping to create bipartisan political momentum behind continued solar support. As shown in the bar graph, capital investment in solar projects is nearly four times greater in Republican congressional districts than Democratic districts.



Total Solar Energy Investment, Billions USD, Q1 2018 - Q4 2024
(by Party of District Representative)

Investment Data from Rhodium Group Climate Deck (2018Q1-2024Q4)

Despite this momentum, solar remains highly sensitive to federal incentives, especially for utility-scale projects. Our expert interviews confirm that the ITC and its related bonus structures are critical to financial viability. Without these supports, many projects would be delayed, downsized, or rendered uneconomical—particularly in high interest rate environments or regions facing permitting and interconnection delays.

TECH PILLAR: SOLAR

From a policy risk perspective, solar is not the most politically vulnerable technology, but it is not immune. While the core ITC is widely supported and legally embedded in the tax code, associated adders and transferability provisions are more vulnerable. Their repeal or reinterpretation could undermine project economics and limit access to capital, particularly for smaller or community-scale developers. Additionally, solar project developers face non-legislative headwinds including ongoing supply chain constraints, persistent trade tensions, and grid congestion in high-demand interconnection zones.

That said, solar also enjoys significant tailwinds. The demand from AI and data center growth, continued price declines in PV technology, and increasing state-level mandates ensure a robust long-term growth outlook. Solar's political viability is cushioned by its wide adoption in red states and its growing role in powering U.S.-based manufacturing and industrial sectors. Accordingly, while IRA-related uncertainty may introduce short-term friction, solar remains a resilient pillar across the scenarios we've identified.

Policy Analysis

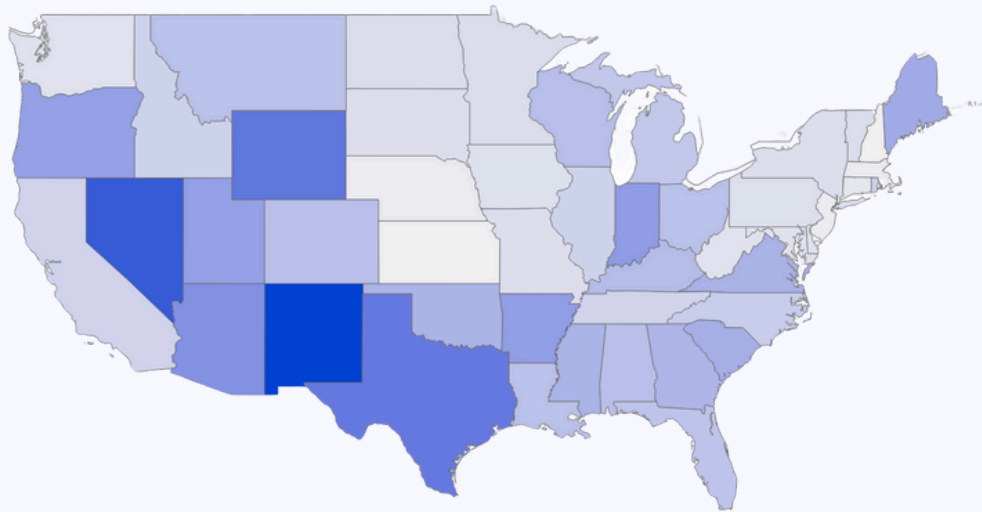
Solar energy policy remains at the center of the IRA's clean energy incentives, but its future under the current political landscape is mixed. On one hand, the core Investment Tax Credit (ITC) and new tech-neutral provisions like Section 48E are legally embedded in the tax code and broadly supported across party lines—particularly due to the widespread benefits in Republican districts.

According to data from the Clean Investment Monitor and Rhodium Group, capital investment in solar has flowed disproportionately into GOP-held districts, helping insulate the sector from wholesale repeal. As shown in the heat map on the next page, capital expenditures in solar projects represent a substantial piece of the economy in conservative states.

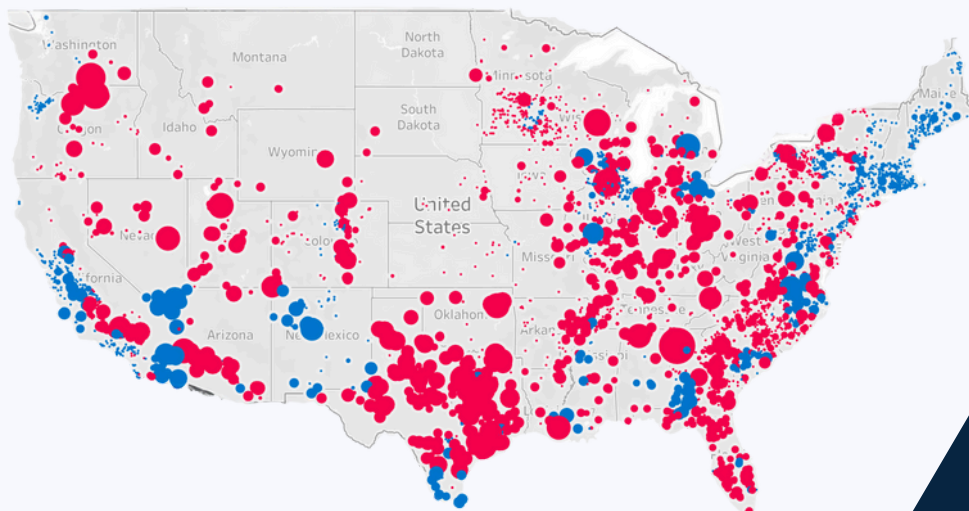
TECH PILLAR: SOLAR

To give an idea of the scale relative to the size of each state's economy, the following heat map shows total solar investment between 2018-2024 as a percent of annual GDP for each state. In New Mexico, for example, solar investment is equivalent to about five percent of the state's GDP. For states like Texas, Nevada and Wyoming solar investment is as large as between three and four percent of their state GDP.

Total Solar Energy Investment, Q1 2018 - Q4 2024 as % of State GDP



The heat map below gives a visual representation of the size and location of solar investments throughout the country, where red dots are in Republican congressional districts and blue dots are in Democratic districts.



TECH PILLAR: SOLAR

Nonetheless, solar remains vulnerable at the margins. Bonus adders such as the domestic content and energy community credits are not enshrined in statute but rely on agency-issued guidance. These adders are politically exposed and could be delayed, scaled back, or revoked by the executive branch without congressional action. Additionally, the popular transferability mechanism (Section 6418), which has expanded solar access for smaller developers, may be curtailed during future budget reconciliation negotiations. While less likely to be repealed entirely, it could be capped or limited by eligibility rules that reduce its practical utility.

From a regional perspective, the sector's broad footprint in conservative districts offers some protection, particularly in states like Texas, North Carolina, and Georgia—each of which has attracted substantial utility-scale solar investment. This bipartisan economic benefit has led 21 House Republicans to publicly support preserving clean energy tax credits in a March 2025 letter to House leadership, signaling fractures within the GOP on IRA repeal.

While the prospect of full repeal is remote, operational interference is a likelier threat. Delays in Treasury rulemaking, backlogs in pre-filing registration for elective pay, or narrowed eligibility criteria for ITC compliance could have an outsized impact—especially for smaller developers operating on tight capital timelines.

In sum, solar is not the most politically vulnerable technology under the IRA, but it is not immune. It faces indirect risks via targeted rollbacks to transferability and adders, as well as procedural interference that may undermine confidence in timely tax credit realization. Captona should monitor regulatory guidance closely, prioritize geographies with strong state-level policy support, and structure deals to lock in current ITC benefits wherever possible.



TECH PILLAR: SOLAR

Technology specific assumptions

We have developed a monthly model based on the assumptions from one of Captona's existing projects, detailed in the table below. This solar project, located in California, has a total capacity of 10 MW. It is backed by a 20-year Power Purchase Agreement (PPA), ensuring a fixed price of \$120/MWh for 100% of its generation. Additionally, the project includes a 10-year Resource Adequacy contract, covering 85% of the available capacity. The project also benefits from a 10-year contracted Renewable Energy Credit (REC) at \$30/MWh for its generation.

Contracted Revenues		
PPA		
PPA Price	\$/MWh	120
Annual PPA Price Escalation	%	0%
PPA Term	years	20
REC Contract		
Contracted REC Price	\$/MWh	30
Annual REC Price Escalation	%	0%
Contracted REC Term	years	10
Resource Adequacy		
Contracted Capacity Price	\$/MW - Month	2000
Annual Price Escalation (%)	%	0%
Available Capacity %	%	85%
Contracted Capacity Term	years	10

TECH PILLAR: SOLAR

Financial Analysis

After the contract expires, the project will sell electricity on the merchant market, with an expected price of \$75/MWh. Additionally, the project will sell merchant REC at \$5/MWh and merchant Capacity at \$2500/MW per month.

Uncontracted Revenues		
Merchant Electricity		
Merchant Price (COD Year)	\$/MWh	75
Annual Price Escalation	%	2.50%
REC Contract		
REC Price Merchant	\$/MWh	5
Annual REC Price Escalator	%	0%
Merchant Capacity		
Contracted Capacity Price	\$/MW - Month	2500
Capacity Price Escalation	%	0%
Capacity %	%	85%
Capacity Term (Years)	years	25

The assumptions for operational cost and capital expenditure are as follows.

TECH PILLAR: SOLAR

Financial Analysis

The assumptions for operational cost and capital expenditure are as follows.

CapEX		
EPC	\$/W	1.3
Development Fee	\$/W	0.4
Interconnection	\$/W	0.1
Working Capital	\$/W	0.01
Transaction Costs	\$/W	0.08
Acquisition Cost	\$/W	0.15
Add'l Eligible Costs	\$/W	0
Add'l Ineligible Costs	\$/W	0
Total Cap.EX (without Tariffs)	\$M	20.45
% Tariffs	\$/W	0%
Total Cap.Ex	\$M	20.45

TECH PILLAR: SOLAR

Operational Cost					
Sensitivities	\$/MW p.a.	\$M p.a.	Escalator	Start Year	End Year
Contracted O&M	10,000	0.1	2.00%	1	35
Inverter Replacement 1	7,500	0.08	0.00%	12	14
Inverter Replacement 2	7,500	0.08	0.00%	22	24
Insurance	3,800	0.04	0.00%	1	35
Lease	10,000	0.1	0.00%	1	35
Variable O&M	2,000	0.02	2.00%	1	35
Asset Management	7,500	0.08	2.00%	1	35
Accounting Expense	1,000	0.01	0.00%	1	35
Customer Acquisition	5,000	0.05	0.00%	1	35
Property Taxes	17,500	0.18	0.00%	1	35
Decommissioning Expe	200	0	0.00%	1	35
Contingency Expense	1,000	0.01	0.00%	1	35
O&M Contingency	0	0	0.00%	1	35

TECH PILLAR: SOLAR

2. Result of sensitivity and scenario analysis

2.1. Base Case

For the base case scenario, we assume there is 0% of tariffs in place and 7% interest rate for the debt to align with the current situation. As for the tax credit assumption, we assume we can secure 40% of total ITC%, and get 90 cents out of 1 dollar through tax credit transfer. (Same for the other technologies) As for now, the unlevered project IRR is 9.29% and levered equity IRR is 10.08%, both within the reasonable range.

<u>Solar</u>	live
Case	Base
Debt Size	7.79
Average DSCR	1.30x
Min DSCR	1.30x
Leverage	38.11%
Project IRR	9.29%
Equity IRR	10.08%
Payback Period of Equity	13.73

TECH PILLAR: SOLAR

2.2. Scenario Analysis

Using the DSCR sculpting method, both the average and minimum DSCR requirements are met under all scenarios, with a consistent leverage ratio of 38.11%. The repeal of the IRA would have a significant impact on equity return metrics. If the IRA is fully repealed, the project IRR decreases to 5.06%. Since the project IRR is below the current borrowing cost of 7%, the equity IRR falls even further to 4.69% after leveraging. In the case of a repeal of transferability, where we assume a discount in the transfer price from 0.9 to 0.5, the project IRR decreases to 7.04%, and the equity IRR drops to 6.99%. If the IRA adders are all repealed, meaning the project would only qualify for the base 30% rate, the project IRR drops to 7.92%, equity IRR drops to 8.13%

<u>Solar</u>	1	2	3	4	5	6
Case	No change	Adders Repeal - High	Adders Repeal - Base	Adders Repeal - Low	Transferability Repeal	Full Repeal
Debt Size	7.39	7.79	7.79	7.79	7.79	7.79
Average DSCR	1.37x	1.30x	1.30x	1.30x	1.30x	1.30x
Min DSCR	1.37x	1.30x	1.30x	1.30x	1.30x	1.30x
Leverage	36.14%	38.11%	38.11%	38.11%	38.11%	38.11%
Project IRR	16.21%	11.01%	9.29%	7.92%	7.04%	5.06%
Equity IRR	27.98%	13.00%	10.08%	8.13%	6.99%	4.69%
Payback Period of Equity	3.69	11.84	13.73	15.26	16.28	20.34

TECH PILLAR: SOLAR

2.3. Sensitivity Analysis, Interest Rate & Tariffs

Interest rate changes have minimal effect on the project's unlevered IRR, which stays constant across sensitivities of different interest rates. However, when tariffs drive CapEx increases above 15%, the unlevered IRR falls below 8%. With a 50% CapEx increase and 10% interest rate, the project IRR declines to 5.10%. For equity IRR, when the project IRR falls below the borrowing cost, leverage amplifies the downside, further reducing returns. With a 50% increase in CapEx and a 10% interest rate, the equity IRR drops to 4.98%.

Tariffs/ Interest Rate	Project IRR			Equity IRR		
	0%	25%	50%	0%	25%	50%
6%				10.58%	6.98%	4.91%
7%	9.29%	6.82%	5.10%	10.41%	6.96%	4.93%
10%				10.07%	6.92%	4.98%

2.4 Worst Case Scenario

In the worst-case scenario, steep tariffs drive a 50% increase in CapEx, while inflation-induced rate hikes push the interest rate to 10%. Even with a 70% ITC in place, the project becomes unattractive, as the equity IRR falls below the cost of borrowing. If the IRA is also partially or fully repealed, the project IRR drops further, rendering the investment financially unviable.

Raise by 30%	No change	Adders Repeal			Transferability Repeal	Full Repeal
		High	Base	Low		
Project IRR	10.04%	6.34%	5.10%	4.09%	3.43%	1.92%
Equity IRR	9.89%	5.60%	4.33%	3.33%	2.68%	1.24%
Payback Period of Equity	13.20	18.43	21.32	23.37	25.49	30.72

TECH PILLAR: SOLAR

3. Takeaway and Mitigation strategies

3.1 Takeaway

If the Transferability provisions and bonus adders under the IRA are repealed, both project and equity IRRs fall below the typical 8% return threshold for solar projects. In the event of a full repeal, the project IRR declines to 5.06% and the equity IRR drops further to 4.69%, making the project unattractive to equity investors given the current risk profile and interest rate environment. Ongoing uncertainty around tariffs and interest rates adds further pressure—a 15% CapEx increase from tariffs alone would push the project IRR below 8%. If interest rates rise to combat inflation, the higher cost of debt will erode equity returns. In the worst-case scenario, with debt rates reaching 10% and CapEx increasing by 50%, the project would become financially unviable.

3.2 Mitigation strategies

The project owner may transfer some of the risk to the off-taker by negotiating a higher contracted PPA price to improve project returns, especially amid heightened policy uncertainty. While a partial or full repeal of the IRA—such as the loss of ITC/PTC or bonus adders—would not qualify as a Force Majeure event, or automatically trigger a Change-in-Law termination under standard PPA terms, it may prompt the parties to engage in good-faith renegotiation to rebalance project economics. Legal remedies are limited in such cases, making commercial negotiation the most practical path forward. As demonstrated in the sensitivity analysis below, increasing the base-case PPA price by 30% lifts both project and equity IRRs above the 10% threshold even when adders are repealed. If the PPA price is increased by 50%, project, and equity IRRs are above 10% in most scenarios—except under a full IRA repeal.

Raise by 30%	No change	Adders Repeal			Transferrability Repeal	Full Repeal
		High	Base	Low		
Project IRR	20.99%	14.52%	12.36%	10.64%	9.53%	7.07%
Equity IRR	42.41%	23.26%	16.21%	12.46%	10.52%	7.03%
Payback Period of Equity	2.41	5.73	10.00	11.26	12.55	15.66

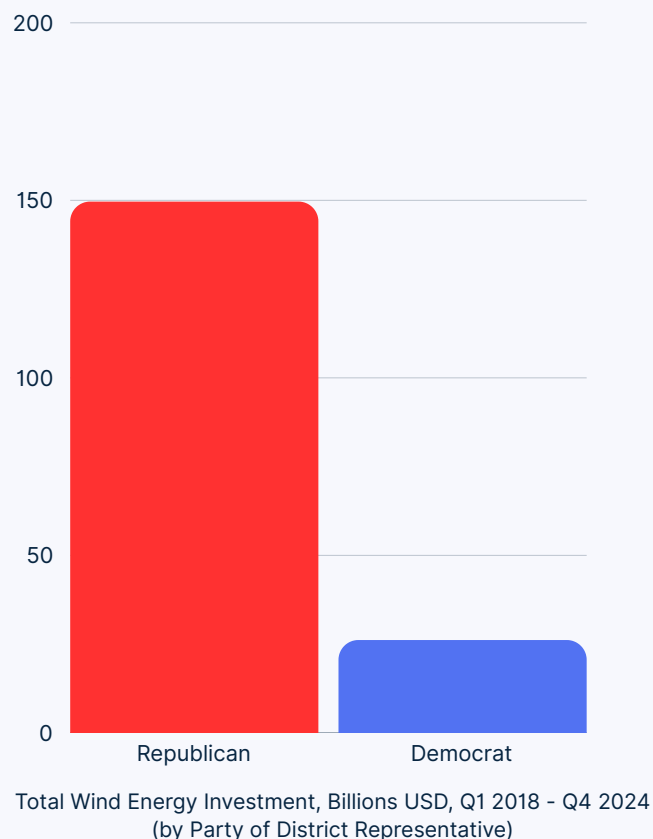
Raise by 50%	No change	Adders Repeal			Transferrability Repeal	Full Repeal
		High	Base	Low		
Project IRR	25.79%	18.13%	15.54%	13.48%	12.14%	9.20%
Equity IRR	56.41%	40.10%	29.59%	19.81%	15.87%	10.05%
Payback Period of Equity	1.76	2.65	4.18	7.58	10.93	13.18

WIND ASSESSMENT

TECH PILLAR: WIND

Despite tax credits and support for new renewable energy deployment, last year 2024, onshore wind saw its fourth straight year of declining capacity additions.⁵⁶ While tax credits through the IRA have revived interest in the sector, the regions where the tax credits have the most value are those where wind already has a high share of generation, meaning transmission congestion can hold back new construction. Recently, particularly 2023-2024, the onshore wind market in the U.S. added only 7 GW, the lowest level of new capacity since 2017, reflecting multiple factors such as inflation, supply chain constraints, increased interest rates, and legislative uncertainties. However, the industry registered a notable 130% increase in equipment orders from 2022 to 2023, although 80% of these orders target deliveries in 2025 or later.⁵⁷

Market participants are also witnessing a regional shift as grid congestion and high wind penetration in Texas and the Plains prompt new projects to focus on the West, Midwest, and Southeast, where transmission upgrades and advanced turbine technologies are broadening onshore wind's geographic reach. The impact of the Administration's Jan. 20 Memorandum on these processes is unclear but could significantly impact many development-stage projects and the valuation of development project portfolios.⁵⁸



Investment Data from Rhodium Group Climate Deck (2018Q1-2024Q4)

[56] BloombergNEF and Business Council for Sustainable Energy, 2025 Sustainable Energy in America Factbook, February 2025, bcse.org.

[57] Wood Mackenzie and American Clean Power Association, U.S. Wind Energy Monitor: 2023 Year in Review – Executive Summary, Q1 2024, cleanpower.org.

[58] Charles River Associates, "Risks to Onshore and Offshore Wind Projects from New US Administration Orders," CRA Energy Insights, February 2025, crai.com.

TECH PILLAR: WIND

The latter is often important because many early-stage wind projects are sold during the development process and often again when projects reach financial close or start operations. Almost 70% of all wind-specific imports that are tracked through trade codes came from Mexico, Germany, Spain, and India, with the remaining imports mostly from Canada and various countries in Europe and Asia.⁵⁹

Policy Analysis

Congress is moving ahead with a budget-reconciliation bill that would scrap the Inflation Reduction Act's clean-energy tax title, including the on-shore wind production-tax credit (45), the technology-neutral 45Y credit that is due to replace it in 2025⁶⁰, and the 10 % manufacturing credit for towers⁶¹, blades and nacelles⁶² (45X). House leaders set an aggressive schedule to pass the package before the August recess, even after 21 Republican lawmakers warned their party that a blanket repeal would "disrupt capital already committed to wind projects."⁶³

On-shore wind depends more heavily on those credits than any other mature renewable technology. Berkeley Lab's latest Land-Based Wind Market Report shows that projects finished in 2022–23 cost roughly \$37–\$42 per MWh before incentives⁶⁴; the PTC, currently worth about \$29 per MWh⁶⁵, covers forty-plus percent of first-decade revenue⁶⁶, while bonus adders and 45X shave a few extra dollars off the levelized cost. Strip the credits away and new turbines must clear \$60–70 per MWh, significantly above recent gas-fired or solar PPA prices in most U.S. markets.⁶⁷

On the market side, developers and investors are already treating that policy risk as real. In some ways, the effect of repeal is priced in. Wood Mackenzie cut its 2025–29 onshore wind build forecast by almost half after the reconciliation outline appeared, citing "restricted subsidy visibility and higher borrowing costs."⁶⁸ Separately, clean-energy executives told Utility Dive that scores of wind projects have paused because January's executive order freezing IRA disbursements made it impossible to close tax-equity deals.⁶⁹

[59] Ryan H. Wiser et al., Land-Based Wind Market Report: 2024 Edition, Lawrence Berkeley National Laboratory, August 2024, emp.lbl.gov.

[60] Nico Portuondo, "Republican Bill Would Phase Out Wind, Solar Credits," E&E News, April 10, 2025, eenews.net.

[61] Caitlin Oprysko, "Ford Seeks Help to Save IRA Tax Credits," Politico, March 26, 2025, politico.com.

[62] Nico Portuondo and Meredith Lee Hill, "House GOP Looks to Make Progress on Reconciliation This Week," E&E News, February 3, 2025, eenews.net.

[63] Lamar Johnson, "21 House Republicans Oppose Cutting Clean Energy Credits to Pay for Tax Cuts," Utility Dive, March 11, 2025, utilitydive.com.

[64] Ryan Wiser et al., Land-Based Wind Market Report: 2024 Edition – Executive Summary, Lawrence Berkeley National Laboratory, August 2024, emp.lbl.gov.

[65] U.S. Department of the Treasury and Internal Revenue Service, "Credit for Renewable Electricity Production and Publication of Inflation Adjustment Factor and Reference Price for Calendar Year 2024," Federal Register, July 11, 2024, federalregister.gov.

[66] From interview.

[67] Lazard, Lazard's Levelized Cost of Energy+ (LCOE+)—June 2024, June 2024, lazard.com.

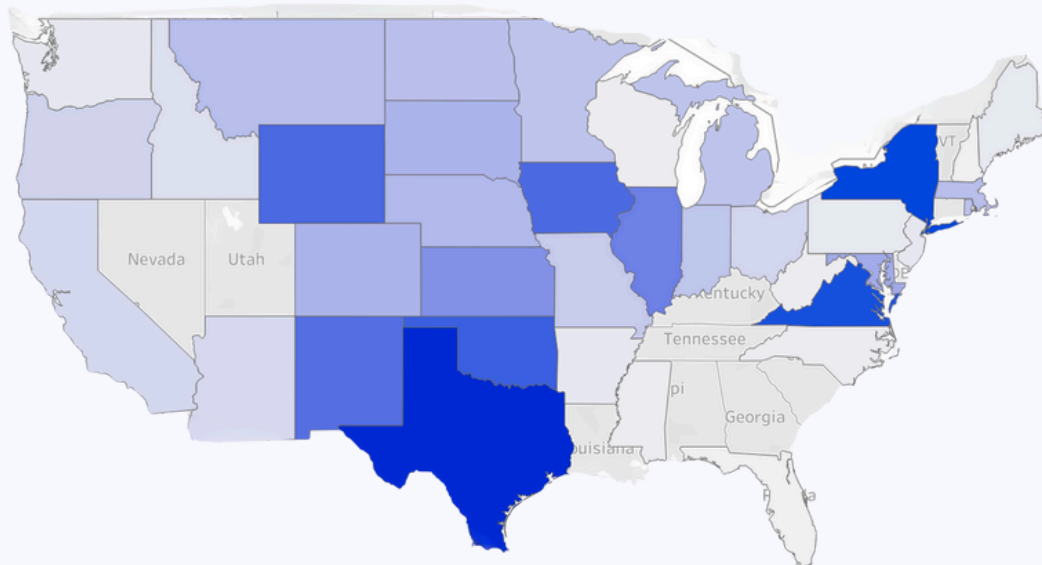
[68] Nichola Groom, "Wood Mackenzie Cuts 5-Year US Wind Energy Outlook 40% on Trump Policies," Reuters, April 8, 2025, reuters.com.

[69] Lamar Johnson, "IRA Funding Freeze Has Put 'Many' Clean Energy Projects on Pause," Utility Dive, March 7, 2025, utilitydive.com.

TECH PILLAR: WIND

The supply-chain side is just as exposed. Most factory expansions for U.S. blades and towers were announced on the back of 45X started in 2023, but industry press reports indicate that several of those investments are now “on ice” pending Senate action.⁷⁰ Even some Republican senators from wind-heavy states have asked their leadership to keep at least the 45 and 45X credits intact, underscoring how much local manufacturing and construction employment rides on them.⁷¹

Total Wind Energy Investment, Q1 2018 - Q4 2024 by State



Investment Data from Rhodium Group Climate Deck (2018Q1-2024Q4)

If the House language became law unchanged, analysts expect annual U.S. on-shore wind additions to fall from the 11–15 GW range Wood Mac had pencilled in⁷² to roughly 5–7 GW after 2026, with the Midwest interior retaining only the very best Class I and Class II sites.⁷³ Corporate buyers have shown preference toward solar-plus-storage for fixed-price supply.⁷⁴ At the current pace, many domestic component plants would never break ground. For now, the constructions are done for “safe-harbour” the pre-repeal credit, shifting pipelines toward states with strong renewable-portfolio standards, and structuring 24/7 green-energy contracts that do not rely on the wind PTC and instead blend solar, wind and storage.⁷⁵

[70] Jeff St. John, “Trump Freezes Inflation Reduction Act and Infrastructure–Law Funding,” Canary Media, January 21, 2025, canarymedia.com.

[71] Nichola Groom, “Four Republican US Senators Back Biden-Era Energy Tax Credits,” Reuters, April 10, 2025, reuters.com.

[72] Eduardo Garcia, “US Wind Rebounds to Set Up Stronger Mid-Term Outlook,” Reuters, April 4, 2024, reuters.com.

[73] Nichola Groom, “Wood Mackenzie Cuts 5-Year US Wind Energy Outlook 40% on Trump Policies,” Reuters, April 8, 2025, reuters.com. (Note: This is a repeat of [68], but fine to list again if cited twice.)

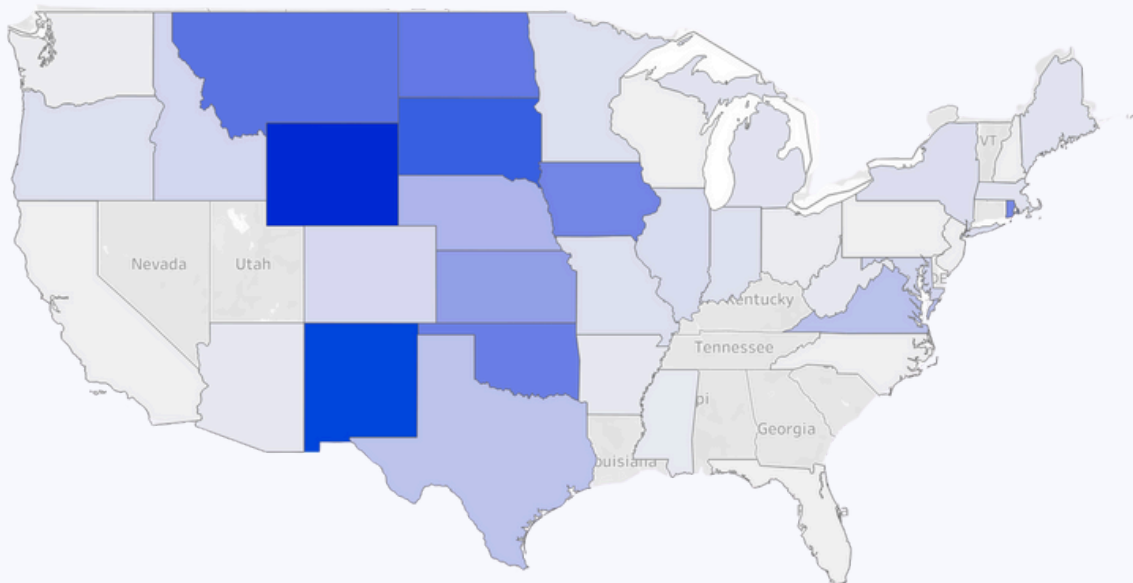
[74] Diana DiGangi, “Solar and Battery Storage Will Lead New Generation in 2025: EIA,” Utility Dive, February 24, 2025, utilitydive.com.

[75] Ibid. (same as [74], citing DiGangi in Utility Dive).

TECH PILLAR: WIND

Perhaps no other established clean-energy technology has as much at stake in the reconciliation fight as on-shore wind. The PTC and its successor credits are woven directly into the project revenue stack. After taking them away, the sector reverts from the market-leading to almost marginal. Unless the Senate pares the House draft back, or state-level requirements and corporate premiums rise enough to close a widening cost gap, the post-2025 construction of U.S. onshore wind will slow dramatically, with ripple effects on jobs, manufacturing, and the nation's overall decarbonisation pathway.

Total Wind Energy Investment, Q1 2018 - Q4 2024 as % of State GDP



Investment Data from Rhodium Group Climate Deck (2018Q1-2024Q4)

TECH PILLAR: WIND

Financial Analysis

1. Technology specific assumptions

We have developed semiannual model based on assumptions from Berkeley Lab⁷⁶, DOE⁷⁷, and EIA.⁷⁸ We modeled onshore wind projects in Texas and California. Both of which are wind farms with a plant capacity of 102MW (30 turbines with 3.4MW capacity each). It is backed by 10 year PPAs after its COD and followed by merchant sale. The price is \$40 per MWh for Texas and \$50 per MWh for California, with an escalation of 2%. After the PPA ended, the project will sell electricity into the merchant market, with an expected price of \$47.8 for Texas and \$60.95 for California for the remaining 20 years of the project life.

Generation		CAISO	ERCOT	Revenue		CAISO	ERCOT
Nameplate Capacity	MW/turbines	3.4	3.4	Merchant Price	\$/MWh	50	40
Number of Turbines	Number	30.0	30.0	Volume	%	100%	100%
Average Plant Capacity	MW	102.0	102.0	Annual Inflation	%	2%	2%
Capacity Factor	%	30%	34%	Operational Cost		CAISO	ERCOT
Degradation	% p.a.	1.60%	1.60%	Fixed OpEx	\$/MWh	14	10
				Annual Escalator	%	2%	2%

Capex		CAISO	ERCOT
Total Cap.Ex (without Tariffs)	\$/MW	156.06	139.74
% Tariffs	\$/W	0%	0%
Total Cap.Ex	\$/M	156.06	139.74

[76] Ryan H. Wiser et al., Land-Based Wind Market Report: 2024 Edition – Executive Summary, Lawrence Berkeley National Laboratory, August 2024, emp.lbl.gov.

[77] U.S. Department of Energy, "Land-Based Wind Market Report," energy.gov, accessed April 2025.

[78] U.S. Energy Information Administration, Capital Cost and Performance Characteristics for Utility-Scale Electric Generating Plants, Annual Energy Outlook 2025, eia.gov.

TECH PILLAR: WIND

2. Result of Sensitivity Analysis

2.1 Base Case

For the base case scenario, we assume there is 0% of tariffs in place and 7% interest rate for the debt to align with the current situation. As for the tax credit assumption, we assume to gain 2.9 cents/kWh, and get 90 cents out of 1 dollar through tax credit transfer. For ERCOT, the unlevered project IRR is 9.91% and levered equity IRR is 10.82%, both within the reasonable range. For ERCOT, the unlevered project IRR is 9.13% and levered equity IRR is 9.61%, both within the reasonable range. For a project with the same scale, the onshore wind project in ERCOT has higher project IRR and equity IRR.

2.2 Scenario Analysis

For CAISO, using the DSCR sculpting method, both the average and minimum DSCR requirements are met under all scenarios, with a consistent leverage ratio of 33.76%. The repeal of the IRA would have a significant impact on equity return metrics. If the IRA is fully repealed, the project IRR decreases to 5.65%. Since the project IRR is below the current borrowing cost of 7%, the equity IRR falls even further to 5.44% after leveraging. In the case of a repeal of transferability, where we assume a discount in the transfer price from 0.9 to 0.5, the project IRR decreases to 7.30%, and the equity IRR drops to 7.36%. If the IRA adders are all repealed, meaning the project would only qualify for the base 30% rate, the project IRR drops to 8.43%. The equity IRR is 8.74%.

TECH PILLAR: WIND

For ERCOT, using the DSCR sculpting method, both the average and minimum DSCR requirements are met under all scenarios, with a consistent leverage ratio of 35.86%. The repeal of the IRA would have a significant impact on equity return metrics. If the IRA is fully repealed, the project IRR decreases to 4.32%. Since the project IRR is below the current borrowing cost of 7%, the equity IRR falls even further to 3.81% after leveraging. In the case of a repeal of transferability, where we assume a discount in the transfer price from 0.9 to 0.5, the project IRR decreases to 6.69%, and the equity IRR drops to 6.61%. If the IRA adders are all repealed, meaning the project would only qualify for the base 30% rate, the project IRR drops to 8.35%. The equity IRR is 8.72%.

For both CAISO and ERCOT, interest rate change has minimal effect on the project IRR, which stays constant across sensitivities of different interest rates. However, when tariffs drive up the project CapEx by 10%, the project IRR drops to 7.92% and 7.95

% for projects in CAISO and ERCOT, making it financially unviable. Similarly, for equity IRR, the increase in interest rates have minimal impact on the equity IRR across sensitivities of different interest rates. For equity investors, the project is still viable when the project's CapEx increases by 15% and interest rate is equal to or under 4% and when the project CapEx increases by 10% and interest rate is equal or under 7%

CAISO Case	No change	Adders Repeal			Transferability Repeal	Full Repeal
		High	Base	Low		
Project IRR	9.38%	9.85%	9.38%	8.81%	6.94%	4.32%
Equity IRR	10.10%	10.73%	10.10%	9.33%	6.93%	3.81%
Payback Period of Equity	9.7	9.59	9.7	10.32	13.48	19.38

TECH PILLAR: WIND

ERCOT Case	No change	Adders Repeal			Transferability Repeal	Full Repeal
		High	Base	Low		
Project IRR	9.38%	9.85%	9.38%	8.81%	6.94%	4.32%
Equity IRR	10.10%	10.73%	10.10%	9.33%	6.93%	3.81%
Payback Period of Equity	9.7	9.59	9.7	10.32	13.48	19.38

2.3 Worst Case Scenario

In the worst-case scenario, steep tariffs drive a 50% increase in CapEx, while inflation-induced rate hikes push the interest rate to 10%. The project IRR falls below the cost of borrowing in all scenarios, regardless of change in IRA.

	Project IRR			Equity IRR		
	0%	25%	50%	0%	25%	50%
6%	9.38%	6.21%	4.02%	10.46%	6.26%	3.72%
7%				10.10%	6.06%	3.58%
10%				9.22%	5.55%	3.25%

	Project IRR			Equity IRR		
	0%	25%	50%	0%	25%	50%
6%	9.13%	6.43%	4.53%	9.88%	6.5%	4.35%
7%				9.61%	6.35%	4.24%
10%				8.96%	5.95%	3.96%

TECH PILLAR: WIND

3. Takeaway and Mitigation strategies

3.1 Takeaway

If transferability is repealed or if there is a full repeal of the IRA. Equity IRR will fall below 10%, a typical return threshold for wind projects. In the event of full repeal, the project IRR and equity IRR drops to 5.65% and 5.95% respectively for CAISO and 4.32% and 4.39% respectively for ERCOT, making the project unattractive to equity investors given the current risk profile and interest rate environment. Ongoing uncertainty around tariffs and interest rates adds further pressure, a 15% CapEx increase from tariffs alone would push the project IRR below 8%. If interest rates rise to combat inflation, the higher cost of debt will erode equity returns.

3.2 Mitigation strategies

The project owner may transfer some of the risk to the off-taker by negotiating a higher contracted PPA price to improve project returns, especially amid heightened policy uncertainty. While a partial or full repeal of the IRA—such as the loss of ITC/PTC or bonus adders—would not qualify as a Force Majeure event, or automatically trigger a Change-in-Law termination under standard PPA terms, it may prompt the parties to engage in good-faith renegotiation to rebalance project economics. Legal remedies are limited in such cases, making commercial negotiation the most practical path forward.

BESS ASSESSMENT

TECH PILLAR: BESS

The energy storage market was experiencing significant cost reductions and growth before the 2024 election. By December 2024, turnkey energy storage system prices had fallen 40% to \$165/kWh globally, marking the most significant drop since BNEF's survey began in 2017. The price range was \$58/kWh to \$370/kWh, with China's four-hour systems setting the lowest prices, averaging below \$100/kWh for the first time. Global stationary energy storage deployment was expected to reach nearly 200 gigawatt-hours in 2025, rising 14% to set another record for annual global installations.

Tolling agreements have emerged as a significant market trend in the energy storage sector, offering a risk-mitigation strategy for asset owners while creating opportunities for specialized operators. These agreements allow asset owners to lease their battery storage systems to third-party operators in return for fixed revenues, effectively shielding owners from merchant revenue risks while lowering their cost of capital.

Globally, two key drivers behind this trend are power price volatility in deregulated markets like Australia and Texas, where software companies often serve as operators, and utilities' growing interest in procuring energy storage capacity in regulated US markets outside of Texas.

With 3,685 megawatts of energy storage capacity already under tolling agreements in Arizona, California, and Texas as of early 2025, BNEF expects this trend to accelerate, driven by "continued power price volatility, a growing number of energy storage mandates, and load growth," though deployment rates will vary based on regional power mix, market structures, and policy frameworks.⁷⁹

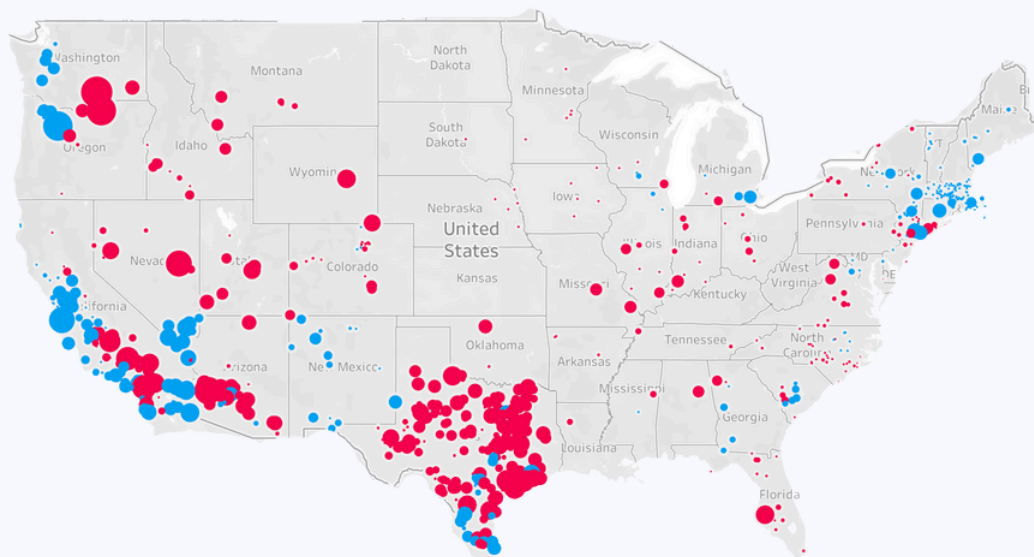


[79] BloombergNEF, Isshu Kikuma, "Energy Storage Tolling: A Primer," March 17, 2025.

TECH PILLAR: BESS

Policy Analysis

The energy storage market has proven highly vulnerable to political changes, especially U.S. trade policies.⁸⁰ 104% tariffs on imports from China, imposed by the administration on April 9, 2025, pushed battery storage costs back to 2023 levels.⁸¹ The total import tariff on Chinese lithium-ion batteries reached 114.9%, over 10 times the tariff during the Biden administration. This tariff is set to rise further in 2026 when additional Section 301 tariffs come into force.⁸²



Investment Data from Rhodium Group Climate Deck (2018Q1-2024Q4)

These higher costs and policy uncertainty will likely suppress demand for U.S. battery storage projects in the near term and delay most projects already in the pipeline. BNEF's analysis shows it may take another five years for U.S. four-hour turnkey system costs to return to 2024 levels if the new tariffs remain in place.⁸³ The U.S. market is particularly vulnerable because of its heavy reliance on imports — China represented 70% of U.S. lithium-ion battery imports in 2024. Even imports from other countries, such as South Korea and Japan, have become more expensive due to reciprocal tariffs announced on April 2, 2025.⁸⁴

[80] BloombergNEF, Yayoi Sekine, "Energy Storage: 10 Things to Watch in 2025," January 15, 2025.

[81] BloombergNEF Shorts, "Trump's 104% China Tariffs Send Battery Cost Back to 2023: React," April 9, 2025.

[82] White & Case, "United States Finalizes Section 301 Tariff Increases on Imports from China," May 2025.

[83] BloombergNEF Shorts, "Trump's 104% China Tariffs Send Battery Cost Back to 2023: React," April 9, 2025. (Note: this is a repeat of [81] but can be listed again if cited separately.)

[84] Argus Media, "US Battery Costs Face Sharp Rise on Tariffs," April 3, 2025.

TECH PILLAR: BESS

The majority of investment in BESS is flowing to Republican-controlled states, as illustrated in as shown in the graphs below, based on Rhodium Group and IRA Tracker data sets. Total facility CAPEX shows Republican states receiving approximately \$100,000 in BESS investment compared to just \$43,000 for Democratic states. This pattern is mirrored in battery production investment, where Republican states attract \$115,000 versus \$32,000 for Democratic states. The geographic distribution map confirms this disparity, revealing concentrated investment clusters across Republican strongholds in Texas and the southern United States, while Democratic investments appear primarily limited to coastal regions in California, Washington, and the Northeast. This significant imbalance demonstrates the current political landscape of energy storage development across the country.

**Total Battery Production Investment, Billions USD, Q1 2018 - Q4 2024
(by Party of District Representative)**



**Total Battery Storage Investment, Billions USD, Q1 2018 - Q4 2024
(by Party of District Representative)**



Investment Data from Rhodium Group Climate Deck (2018Q1-2024Q4)

TECH PILLAR: BESS

Financial Analysis

1. Technology specific assumptions

The Opex, Capex, and Generation info in two BESS models are developed based on assumptions from the Lazard LCOE 2024 report, as outlined in the table.⁸⁵ For CAISO, a 100 MW / 400 MWh BESS is used to meet resource adequacy requirements. In ERCOT, the model uses a 100 MW / 200 MWh BESS. All assumptions are using the average of the cost and performance ranges provided in the report. The total CapEx for the CAISO system is estimated at \$116.5 million—nearly twice that of the ERCOT system, which is approximately \$59 million.

Generation		CAISO	ERCOT
Battery Power Capacity	MW, AC	100.0	100.0
Storage duration	Hrs/cycle	4.0	2.0
Nameplate Capacity	MWh	400.0	200.0
Round-trip efficiency	%	90%	90%
Cycles per year	Cycles p.a.	365.0	365.0
Availability	MW	100%	100%
Annual Generation	MWh p.a.	131,400.0	65,700.0
Degradation	% p.a.	2.6%	2.6%

Operational Cost		CAISO	ERCOT
Charging Cost	\$/MWh	51.00	64.00
Annual Escalator	%	1.97%	1.97%
Storage O&M	\$/kwh	5.25	5.35
Annual Escalator	%	2.50%	2.50%
Augmentation Costs	\$M	x	x
Warrenty Expense % of Cap.Ex	%	1.00%	1.00%
Extended Warranty Start	year	3.00	3.00

Capex		CAISO	ERCOT
Initial Capital Cost - DC	\$/kWh	221.00	220.50
Initial Capital Cost - AC	\$/kW	45.00	45.00
EPC Costs	\$/kWh	69.50	73.50
Total Cap.Ex (without Tariffs)	\$/kWh	116.50	59.00
% Tariffs	\$/W	0%	0%
Total Cap.Ex	\$M	116.50	59.00

TECH PILLAR: BESS

The number for Revenue stream is provided by our client. For the CAISO model, the project is assumed to receive a 10-year Resource Adequacy (RA) payment of \$7/kW-month from the CPUC, contingent on demonstrating sufficient capacity to meet peak demand plus a planning reserve margin. In parallel, the project participates in energy arbitrage, earning merchant revenue at \$15/kW-month with a 2% annual escalation.

Revenues - CAISO		
Resource Adequacy		
RA Contract Price	\$/kW-month	7
Annual RA Price Escalation	%	2%
Volumes	%	100%
RA Term	years	10
Energy Arbitrage		
Annual Price Escalation	%	2%
Volumes	%	100%
Merchant price	\$/kW-month	15

For the ERCOT model, the project secures a full tolling agreement at \$7/KW-month with 2% annual escalation at the first 7 years. After the tolling agreement expires, the project will engage in energy arbitrage, earning merchant revenue at \$15/KW-month with 2% annual escalation for the following 13 years.

Revenues - ERCOT		
Full Tolling		
Tolling Contract Price	\$/kW-month	7
Annual Contract Price Escalation	%	2%
Volumes	%	100%
Term	years	7
Energy Arbitrage		
Annual Price Escalation	%	2%
Volumes	%	100%
Merchant price	\$/kW-month	15
RA Term	years	13

TECH PILLAR: BESS

2. Result of Sensitivity Analysis

2.1 Base Case

Under the base case scenario, the CAISO BESS achieves approximately 10% higher project IRR compared to the ERCOT BESS, with project IRRs of 21.97% and 14.42% respectively. Due to a higher leverage ratio, the equity IRR for the CAISO BESS can reach as high as 46.34%.

2.2 Scenario Analysis

As shown in the table below, the BESS projects still demonstrate solid financial performance even under a full repeal of the IRA. In Scenario 6, the project IRR is 13.05% in the CAISO market and 9.48% in the ERCOT market. With leverage, the equity IRR increases to 16.98% for CAISO and 9.91% for ERCOT. In most cases, even when the transferability and adders are repealed, the project IRR and Equity IRR remain high above 10%.

CAISO Case	No change	Adders Repeal			Transferability Repeal	Full Repeal
		High	Base	Low		
Project IRR	34.05%	25.27%	21.97%	19.19%	17.33%	13.05%
Equity IRR	68.70%	63.65%	46.34%	34.32%	27.89%	16.98%
Payback Period of Equity	1.98	1.35	2.31	3.37	4.99	6.64

ERCOT Case	No change	Adders Repeal			Transferability Repeal	Full Repeal
		High	Base	Low		
Project IRR	20.95%	16.19%	14.42%	12.92%	11.89%	9.48%
Equity IRR	29.83%	19.58%	16.66%	14.43%	13.01%	9.91%
Payback Period of Equity	4.67	9.27	9.68	10.11	11.14	12.27

TECH PILLAR: BESS

2.3 Sensitivity Analysis

Interest Rate and Tariffs - CAISO

Project IRR is highly sensitive to tariff-induced CapEx increases. Starting at 21.97% with no tariffs, the IRR declines progressively as tariffs increase. At a 25% CapEx increase, the IRR drops to 16.50%, and at 50%, it falls sharply to 12.71%, indicating significant erosion of project profitability due to rising capital costs. However, project IRR remains above 10% even when Tariffs increase CapEx by 50%. On the Equity IRR side, both interest rate and tariff increases compound the negative impact. With 0% tariffs, the equity IRR holds at 46.34%, thanks to the benefits of leverage. But with the increase of tariffs and interest rates, the equity IRR can drop to as low as 13.90%. Importantly, despite the compounding effect of higher interest rates and tariffs, the Equity IRR stays well above the 10% investment threshold in all cases, suggesting that the project remains financially viable even under stress.

Tariffs/Interest Rate	Project IRR			Equity IRR		
	0%	25%	50%	0%	25%	50%
6%				51.83%	26.56%	16.91%
7%	21.97%	16.50%	12.71%	46.34%	24.75%	16.00%
10%				35.70%	20.81%	13.90%

Power Price - CAISO

The project's returns are highly sensitive to merchant power price fluctuations. At the base case of \$15/MWh, the project achieves a 21.97% IRR, with equity returns reaching 46.34%. If power prices drop to \$10/MWh, the project IRR falls to 12.19%, and equity IRR declines sharply to 16.27%, substantially reducing returns. On the other hand, a price increase to \$20/MWh boosts project and equity IRRs to 30.53% and 91.52%, respectively, greatly enhancing profitability. However, as more batteries are deployed and the CAISO duck curve continues to flatten, downward pressure on merchant prices may become a prevailing trend.

Power Price	Project IRR	Equity IRR
10	12.19%	16.27%
15	21.97%	46.34%
20	30.53%	91.52%

TECH PILLAR: BESS

Interest Rate and Tariffs - ERCOT

The sensitivity analysis shows that while project IRR remains unaffected by changes in interest rates, it declines sharply as tariffs increase and drive up CapEx. Under the base case with no tariffs, the project IRR holds steady at 14.42%, but a 50% increase in CapEx due to tariffs reduces the project IRR to 7.95%, nearly cutting it in half. However, the project IRR remains high above 8% even when the CapEx raises by 35%. On the equity side, rising interest rates further exacerbate the impact of higher CapEx. Equity IRR declines steadily as both tariffs and borrowing costs increase; in the worst-case scenario, with a 50% CapEx increase and a 10% interest rate, the equity IRR falls to just 7.65%, below the 10% return threshold. However, with the benefit of leverage, the equity IRR remains above 10% in most scenarios, indicating that the ERCOT BESS project remains relatively resilient under the current market environment.

Tariffs/Interest Rate	Project IRR			Equity IRR		
	0%	25%	50%	0%	25%	50%
6%	14.42%	10.57%	7.95%	17.16%	11.51%	8.24%
7%				16.66%	11.26%	8.07%
10%				15.49%	10.63%	7.65%

Power Price - ERCOT

The ERCOT BESS project demonstrates similar sensitivity to changes in merchant power prices. At the base case of \$15/MWh, the project IRR is 14.42% and the equity IRR is 16.66%, suggesting a reasonable return under current assumptions. However, if prices fall to \$10/MWh, the project IRR declines to 9.11%, and the equity IRR drops to 9.58%, both falling below the 10% return thresholds and raising concerns over investment attractiveness. In contrast, if prices rise to \$20/MWh, returns improve to 17.88% project IRR and 22.10% equity IRR, enhancing financial viability.

Power Price	Project IRR	Equity IRR
10	9.11%	9.58%
15	14.42%	16.66%
20	17.88%	22.10%

TECH PILLAR: BESS

3. Takeaways

The CAISO and ERCOT BESS projects remain financially sound under current policy conditions, but are not immune to downside risks. If the Transferability provisions and bonus adders under the IRA are repealed, returns will be meaningfully reduced. In the worst-case scenario where IRA is fully repealed, the CAISO project IRR drops from base case of 21.97% to 13.05%, and the equity IRR declines from 46.34% to 16.98%. For ERCOT, the impact is more severe, with project IRR falling to 9.48% and equity IRR to just 9.91%, approaching the minimum threshold for acceptable equity returns.

Further compounding the risk are potential tariff-related CapEx increases and rising interest rates. A 50% increase in CapEx driven by tariffs would cut the CAISO project IRR to 12.71% and the ERCOT IRR to 7.95%. On the equity side, the dual effect of higher debt costs and CapEx can depress returns significantly. In the ERCOT market, equity IRR drops to 7.65% under the most adverse case—50% CapEx increase and 10% interest rate—rendering the project unattractive to many investors.

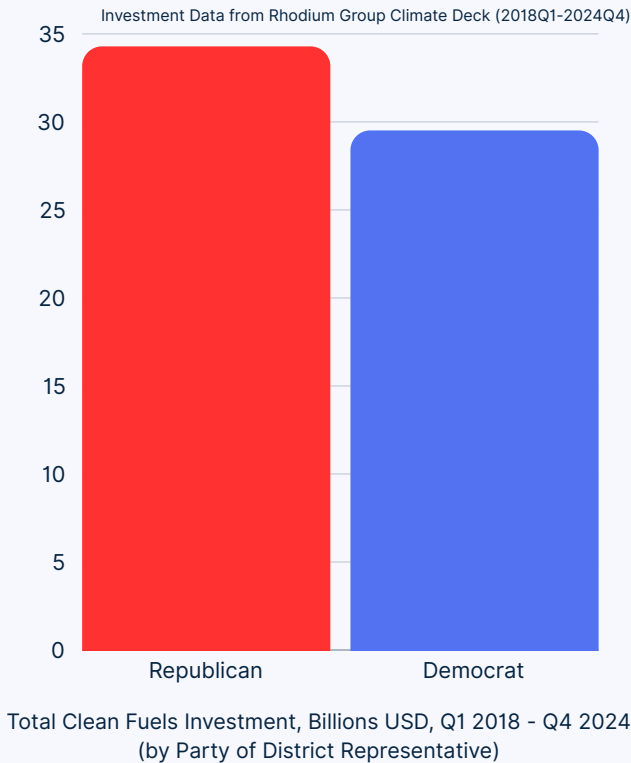
Nevertheless, thanks to favorable leverage structures, both CAISO and ERCOT BESS projects maintain equity IRRs above 10% in most scenarios, even under policy rollback and macroeconomic headwinds. This suggests that the BESS project, in particular the BESS project in CAISO, remains relatively resilient, while ERCOT's financial viability becomes more marginal in high-risk conditions.

CLEAN FUELS ASSESSMENT

TECH PILLAR: CLEAN FUELS

The U.S. clean fuels sector—including Renewable Natural Gas (RNG), Sustainable Aviation Fuel (SAF)⁸⁶, and renewable diesel⁸⁷—is experiencing robust growth momentum.⁸⁸ Expansion is driven by corporate net-zero commitments, rising demand in Low Carbon Fuel Standard (LCFS) states⁸⁹, and the forthcoming launch of the Section 45Z Clean Fuel Production Credit.⁹⁰ However, the sector also faces structural challenges, including cost pressures, supply chain bottlenecks, feedstock constraints, and land-use debates.⁹¹

Clean Fuels and Biofuels in Dataset
Sustainable Aviation Fuel
Waste Biomass
Refining and Natural Gas Processing
Ethanol
Landfill Gas
Municipal Solid Waste



[86] U.S. Department of Energy, Pathways to Commercial Liftoff: Sustainable Aviation Fuel, by Campbell Howe et al., November 2024, liff-off.energy.gov.
 [87] Clean Fuels Alliance America, "Clean Fuels Celebrates Conference in Important Market," Clean Fuels Conference 2025, January 21, 2025, cleanfuelsconference.org.
 [88] BloombergNEF and Business Council for Sustainable Energy, 2025 Sustainable Energy in America Factbook, February 2025, bcse.org.
 [89] California Air Resources Board, Low Carbon Fuel Standard (LCFS) Guidance 19-05: Reporting and Recordkeeping for Natural Gas and Book-and-Claim Accounting for Biomethane, revised October 2019, arb.ca.gov.
 [90] Growth Energy, "Growth Energy to U.S. Treasury: Unleash American Biofuels," April 10, 2025, growthenergy.org.
 [91] P6 Technologies, "Top Renewable Fuels Trends to Watch Out in 2025," March 26, 2025, p6technologies.com.

TECH PILLAR: CLEAN FUELS

Renewable Natural Gas (RNG) remains the most commercially mature clean fuel pathway, with over 400 operational projects nationwide as of September 2024.⁹² Produced from organic waste streams such as landfills, dairy farms, and wastewater treatment facilities⁹³, RNG is fully compatible with existing natural gas infrastructure and continues to see strong demand from utilities.⁹⁴ While most U.S. states host RNG projects, significant untapped potential remains. Waste from landfills and wastewater facilities represents the third-largest source of U.S. methane emissions, much of which remains uncaptured and unutilized.⁹⁵ Nationally, only a small fraction of landfills—approximately 55 out of 283 privately owned sites—currently upgrade captured biogas into RNG.⁹⁶

- **State-level studies reinforce this potential for growth:** For example, a Michigan Public Service Commission study found that municipal waste facilities could feasibly produce enough RNG to replace 8% of the state’s current fossil gas consumption.⁹⁷
- **Nationally,** Deloitte estimates that RNG from waste streams could displace around 4.4% of total U.S. fossil gas demand and up to 16.5% of core customer gas consumption if fully developed. Even under more conservative assumptions, RNG could serve a meaningful share of residential, commercial, industrial, and transportation fuel needs over the next decade.⁹⁸

However, RNG growth is increasingly constrained by limited supplies of economically viable feedstocks and rising competition for organic waste⁹⁹, and higher capital cost due to rising equipment, labor, and material costs.¹⁰⁰ The Section 45Z Clean Fuel Production Credit is expected to help offset these challenges by enhancing project returns.¹⁰¹ Long-term RNG expansion will depend on expanded policy support, improved feedstock access, and infrastructure improvements.¹⁰² Despite these hurdles, RNG’s strong commercial track record, bipartisan political support, and integration into corporate decarbonization strategies¹⁰³ position it as a critical pillar of the U.S. clean fuels transition.

[92] Coalition for Renewable Natural Gas, “North American RNG Surpasses 400 Operational Facilities,” Biomass Magazine, September 10, 2024, biomassmagazine.com.

[93] U.S. Environmental Protection Agency, “Renewable Natural Gas,” Landfill Methane Outreach Program, last updated January 29, 2025, epa.gov.

[94] Daniel Bolgren, Kate Hardin, and Carolyn Amon, “A Ripe Time for Municipal Gas and Waste Renewable Natural Gas Partnerships,” Deloitte Insights, January 25, 2024, deloitte.com.

[95–98] Ibid. (same Deloitte source cited multiple times).

[99] Wei Zhang and Li Chen, “Advancements in Renewable Natural Gas Production: A Comprehensive Review,” Renewable Energy Advances 1, no. 1 (January 2024): 1–15, sciencedirect.com.

[100] Michelle Meisels and Misha Nikulin, “2025 Engineering and Construction Industry Outlook,” Deloitte Insights, November 2024, deloitte.com.

[101] World Resources Institute, “7 Things to Know About Renewable Natural Gas,” December 18, 2020, wri.org.

[102] Ibid. (same WRI source, second mention).

[103] Enchanted Rock, “Enchanted Rock and U.S. Energy Partner to Provide Back-Up Power for Microsoft Data Center for Grid Outages,” December 12, 2023, enchantedrock.com.

TECH PILLAR: CLEAN FUELS

Sustainable Aviation Fuel (SAF) presents a high-growth opportunity¹⁰⁴ within the U.S. clean fuels sector, driven by regulatory mandates, corporate decarbonization targets, and new federal incentives. The Section 45Z Clean Fuel Production Credit, offering up to \$1.75 per gallon¹⁰⁵ for low-carbon fuels starting in 2025, is expected to significantly improve SAF project economics.¹⁰⁶ Demand growth is being fueled by multiple factors, including California’s forthcoming SAF blending mandate¹⁰⁷ and corporate offtake agreements like United Airlines’ 5 billion-gallon SAF commitment.¹⁰⁸

Despite policy support, SAF supply remains highly constrained. As of August 2024, U.S. SAF production reached only 16.5 million gallons from only 4 commercial projects¹⁰⁹, meeting a small fraction of U.S. aviation fuel demand.¹¹⁰ The Biden administration’s SAF Grand Challenge targets scaling production to 3 billion gallons annually by 2030¹¹¹, but achieving this goal will require rapid technology deployment and feedstock expansion.¹¹² Emerging production technologies—such as Alcohol-to-Jet (ATJ)—are expected to improve scalability and reduce production costs.¹¹³ However high capital costs¹¹⁴ and lengthy certification processes (e.g., ATJ certification can take 3-5 years¹¹⁵) could delay project returns.

Renewable diesel has also achieved significant commercial scale,¹¹⁶ particularly in California, where favorable carbon intensity (CI) scoring under the LCFS has driven adoption¹¹⁷. Several conventional oil refineries are planning to convert to renewable diesel production facilities, creating a bridge to broader clean fuel usage.¹¹⁸ The Section 45Z Clean Fuel Production Credit, offering up to \$1/gallon for low-emission fuels starting in 2025¹¹⁹, which, when layered with LCFS credits, can enhance project economics. However, regulatory volatility has introduced near-term risk, in February 2025, California’s proposed LCFS amendments were disapproved¹²⁰, causing LCFS credit prices to \$60/metric ton¹²¹, from a \$75/metric ton. This decline could temporarily dampen project returns, particularly for projects heavily reliant on LCFS stacking.

[104] McKinsey & Company, “How the Aviation Industry Could Help Scale Sustainable Fuel Production,” June 16, 2023, mckinsey.com.
 [105] U.S. Department of Energy, “Clean Fuel Production Credit,” Alternative Fuels Data Center, last updated January 2025, afdc.energy.gov.
 [106] ResourceWise, “45Z in Focus: Frequently Asked Questions,” ResourceWise Environmental Blog, February 21, 2025, resourcewise.com.
 [107] California Air Resources Board, “CARB and Nation’s Leading Airlines Announce Landmark Partnership for a Sustainable Aviation Future,” October 30, 2024, arb.ca.gov.
 [108] United Airlines, “Sustainable Aviation Fuel,” accessed April 24, 2025, united.com.
 [109] U.S. Department of Energy, Pathways to Commercial Liftoff: Sustainable Aviation Fuel, November 2024. (Repeat of citation [86], but fine to list again if cited separately.)
 [110] U.S. Government Accountability Office, Sustainable Aviation Fuel: Agencies Should Track Progress Toward Ambitious Federal Goals, GAO-23-105300, March 23, 2023, gao.gov.
 [111] U.S. White House, “Fact Sheet: Biden Administration Advances the Future of Sustainable Fuels in American Aviation,” September 9, 2021, whitehouse.gov.
 [112] U.S. Department of Energy, Sustainable Aviation Fuel Grand Challenge Roadmap: Flight Plan for Sustainable Aviation Fuel, September 2022, energy.gov.
 [113] Ibid. (same as [112]).
 [114] World Economic Forum, Financing Sustainable Aviation Fuels: Accelerating the Transition to Net-Zero Aviation, 2025, weforum.org.
 [115] John A. Smith and Jane B. Doe, “Innovations in Renewable Energy Technologies: A Comprehensive Review,” Journal of Renewable Energy Research 12, no. 3 (March 2024): 123–145, sciencedirect.com.
 [116] Maria Gerweni, Todd Hubbs, Scott Irwin, and Steven Ramsey, “Updated Estimates of the Production Capacity of U.S. Renewable Diesel Plants Through 2026,” farmdoc daily (14):202, November 6, 2024, farmdocdaily.illinois.edu.
 [117] Danny Cullenward, California’s Low Carbon Fuel Standard, Kleinman Center for Energy Policy, University of Pennsylvania, October 2024, kleinmanenergy.upenn.edu.
 [118] Melody M. Bomgardner, “California Refiners Shift Production to Renewable Diesel,” Chemical & Engineering News 98, no. 32 (August 19, 2020), cen.acs.org.
 [119] Nicholas E. Buffie, The Section 45Z Clean Fuel Production Credit, CRS Report No. IF12502, February 18, 2025, crsreports.congress.gov.
 [120] California Air Resources Board, Information Regarding Low Carbon Fuel Standard Regulation Updates, February 18, 2025, arb.ca.gov.
 [121] Mehr Imran, “Regulatory Setback: California LCFS Amendments Disapproved,” ClearBlue Markets, February 21, 2025, clearbluemarkets.com.

TECH PILLAR: CLEAN FUELS

Despite these challenges, renewable diesel remains a compelling near-term opportunity for clean energy investors. Its commercial maturity, eligibility for stacked incentives, and compatibility with existing transportation and logistics infrastructure position it as a scalable pathway for decarbonizing hard-to-electrify sectors. Investors can mitigate policy risks by prioritizing LCFS-compliant markets, leveraging early access to 45Z benefits, and advocating for long-term stability of state and federal credit frameworks.

Across all clean fuels pathways, inflationary pressures have raised project costs since 2022 (IEA, 2024), while policy uncertainty following the 2024 election adds additional headwinds. The Section 45Z Clean Fuel Production Credit, layered with LCFS and other state incentives, offers a major catalyst for clean fuel project deployment if preserved. However, a Republican-led Congress in 2026 could seek to modify or rollback 45Z, mirroring risks faced by other energy credits like 45Q. Early safe-harboring and strategic project selection will be essential to securing long-term value in the evolving clean fuels landscape.

Policy Analysis

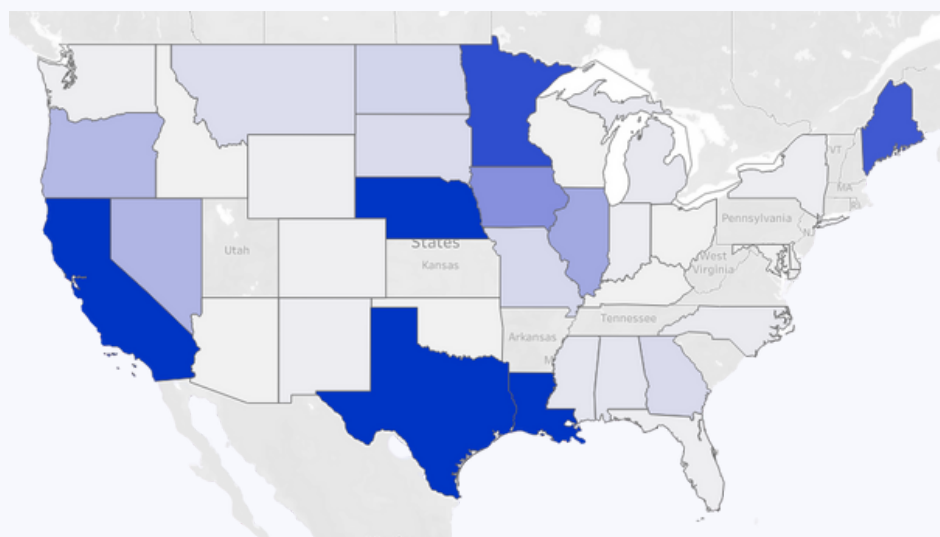
The Section 45Z Clean Fuel Production Credit, offering up to \$1.75/gallon for SAF and \$1/gallon for clean fuel from 2025 to 2027, supports much of the growth trajectory for Renewable Natural Gas (RNG), Sustainable Aviation Fuel (SAF), and renewable diesel, and is widely seen as politically durable but not immune to modification. Based on expert interviews, there is strong consensus that major IRA tax credits like 45Z are deeply embedded in the tax code, making full repeal unlikely. However, experts warn that budget negotiations—particularly if federal deficits widen—could lead to efforts to cap credit values, shorten eligibility timelines, or tighten qualification rules. A Republican-led Congress in 2026 might target 45Z for rollbacks, particularly if budget deficits grow, mirroring risks seen with 45Q.

TECH PILLAR: CLEAN FUELS

Beyond legislative risks, the implementation of 45Z faces operational hurdles that could undermine its effectiveness for clean fuels deployment. Permitting delays, regulatory bottlenecks, and inflationary pressures are major threats to deployment. Interviews highlighted that regulatory discretion, such as delays in Treasury guidance or EPA permitting for infrastructure projects, could slow project timelines even if 45Z remains intact. This mirrors risks seen in the CCUS and hydrogen sectors.

Nonetheless, clean fuels maintain structural advantages that strengthen their political resilience relative to other technologies. SAF, renewable diesel, and RNG align with energy security narratives, agricultural sector priorities, and rural economic development goals—appealing to both Republican and Democratic constituencies. Additionally, technologies that leverage existing infrastructure (e.g., RNG into natural gas pipelines, renewable diesel into trucking fleets) are less politically polarizing than projects requiring major new infrastructure. Moving forward, investors should prioritize safe-harboring eligible projects by the end of 2025 to lock in 45Z credits, diversify geographically into LCFS states like California, Oregon, and Washington, and actively monitor federal rulemaking to manage credit realization risks in an increasingly complex political and regulatory environment. Finally, investors should prioritize partnering with RNG developers to secure offtake agreements early and focus on projects that utilize lower-cost, readily available feedstocks—such as landfill gas or wastewater biogas—to reduce exposure to supply chain volatility and feedstock competition.

Total Clean Fuels Investment, Q1 2018 - Q4 2024 by State



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Financial Analysis

1. Technology specific assumptions

This model evaluates the financial viability of an Anaerobic Digestion & Upgrading-based Renewable Natural Gas (RNG) project located in New York, targeting pipeline-quality RNG production. The project achieves commercial operation by the end of 2025 and assumes an operational life of 20 years. The total capital expenditure for the project is estimated at \$29.58 million, based on an adjusted interpolation of data from the NREL report.¹²²

Generation		
Waste Intake	<i>ton/year</i>	109,500.0
Waste - Fertilizer Yield	%	40%
Waste - RNG Conversion	<i>m³/ton</i>	75.0
HHV	<i>MJ/m³</i>	37.2
Conversion Factor	<i>MJ/MMBtu</i>	1,055.1
RNG Yield	<i>MMBtu/ton</i>	2.64
Annual RNG Production	<i>MMBtu/year</i>	289,561.73

The facility is assumed to process 109,500 tons of organic waste annually, with 70% of the intake converted into solid organic fertilizer. For the remaining organic fraction, a waste-to-biogas yield of 75 m³ per ton is assumed, aligning with the Global Methane Initiative estimate that mixed food waste typically yields 75 to 200 m³ per ton, depending on feedstock composition and digestion conditions.¹²³ The biogas is modeled with a higher heating value (HHV) of 37.2 MJ/m³, based on EPA's data which notes that Southern California Gas Company's Rule 30 specifies a minimum heating value requirement of 990 Btu/scf (approximately 37.2 MJ/m³) for pipeline-quality gas.¹²⁴ Using these assumptions, the resulting renewable natural gas (RNG) yield is calculated at approximately 2.64 MMBtu per ton of organic waste processed. This leads to an estimated annual RNG production of about 289,562 MMBtu for the facility.

[122] Danielle Sandor, Darlene Steward, and Jordan Cox, Comparison of Select Food Waste Utilization Options: Anaerobic Digestion and Composting, National Renewable Energy Laboratory (NREL), 2022, nrel.gov.

[123] Global Methane Initiative, Overview of Anaerobic Digestion for Municipal Solid Waste, October 2016, globalmethane.org.

[124] U.S. Environmental Protection Agency, An Overview of Renewable Natural Gas from Biogas, July 2020, epa.gov.

TECH PILLAR: CLEAN FUELS

The offtake price for renewable natural gas (RNG) is assumed to be \$0.25/m³ under a 20-year contract period covering the whole project lifetime, based on default inputs from the Renewable Natural Gas Financial Model Template (v2.00) developed by eFinancialModels.¹²⁵ Using a higher heating value (HHV) of 37.2 MJ/m³, this converts to approximately \$7.09/MMBtu, applying the standard conversion factor of 1,055.1 MJ/MMBtu. This price reflects pipeline-quality RNG and aligns with current market ranges for contracted offtake. The project assumes fertilizer sales at \$40.00 per ton¹²⁶ and tipping fees at \$56.40 per ton¹²⁷. Both revenue streams are projected to escalate at an annual rate of 1.5%.

Additional revenues are derived from environmental credits. On the one hand, RINs can generate additional revenue for an RNG project because producers earn RINs when they produce renewable fuel, and they can sell these RINs to obligated parties who need them to meet regulatory requirements. D3 RINs are for cellulosic biofuel, which includes renewable natural gas (RNG) produced from organic waste like food scraps, manure, and landfill gas. D3 RINs are valued here at \$2.64/RIN, based on the January–February 2025 average of Q-RIN and unverified trades reported by the EPA.¹²⁸ This translates to approximately \$0.20/MMBtu using the EPA's standard energy equivalence factor.¹²⁹

Revenue		
RNG Sales		
Offtake Price	\$/m ³	0.25
	\$/MMBtu	7.09
Offtake Period	year	20
Environmental Credits		
D3 RIN	\$/RIN	2.6
D3 RIN	\$/MMBtu	0.2
LCFS Price	\$/ton CO ₂	60.0
Conversion Factor	MJ/MMBtu	1,055.1
CI Reduction	gCO ₂ e/MJ	80.0
Annual Inflation	%	4.0%
Other Sales		
Fertilizers Sale	\$/ton	40.0
Tipping Fee	\$/ton	56.4
Escalation	%	0.0%

[125] eFinancialModels, Renewable Natural Gas (RNG) Financial Model Template, Version 2.00, accessed March 30, 2025, efinancialmodels.com.

[126] eFinancialModels, Renewable Natural Gas (RNG) Financial Model Template, Version 2.00. (Second citation if cited separately.)

[127] NYSERDA, Benefit-Cost Analysis of Potential Food Waste Diversion Legislation, New York State Energy Research and Development Authority, 2017, p. 15.

[128] U.S. Environmental Protection Agency, "RIN Trades and Price Information," last modified April 27, 2025, epa.gov.

[129] U.S. Securities and Exchange Commission, Exhibit 10.22: Transaction Confirmation between Trillium Transportation Fuels, LLC and GSF Energy, L.L.C., August 24, 2018, sec.gov.

TECH PILLAR: CLEAN FUELS

On the other hand, a food scraps-to-RNG project in New York can qualify for California LCFS credits by injecting RNG into a common carrier pipeline connected to California and following the book-and-claim system. Through a "book-and-claim" accounting system, renewable natural gas (RNG) produced from food waste can achieve CI values as low as $-79.91 \text{ gCO}_2\text{e/MJ}$.¹³⁰ Based on a current LCFS credit price of \$60 per ton of CO_2 and using a conversion factor of 1,055.1 MJ per MMBtu, the project's credit revenues are calculated with an assumed annual price escalation of 4.0% - As looking ahead, tightening CI reduction targets could drive LCFS credit prices into the \$100–\$140 per ton CO_2 range over the next decade, as projected in the December 2024 Navius Research report.¹³¹ However, LCFS revenues are considered only in the sensitivity analysis and are excluded from the base case, as they are relatively high and could distort a more conservative baseline projection.

On the cost side, fixed operating and maintenance (O&M) costs are set at 4% of capital expenditures, with an additional 1% for warranty and insurance. Variable O&M includes \$1.69/ton for waste hauling, \$8.00/MMBtu for biogas capture¹³², and upgrading, and \$2.50/MMBtu for pipeline injection.¹³³ Utility costs are driven by electricity consumption of 28 kWh per MMBtu of RNG produced, with electricity priced at \$0.15/kWh, yielding a per-MMBtu electricity cost of \$4.14. A supplemental 5% natural gas input is priced at \$0.38/MMBtu.¹³⁴

Cost		
Fixed O&M		
Operating Costs	%	4.00%
Warranty & Insurance	%	1.00%
Variable O&M		
Hauling Cost	\$/ton	1.69
Biogas capture and upgrading cost	\$/MMBtu	8.0
Pipeline Injection	\$/MMBtu	2.50
Utility Cost		
Electricity Consumption	kWh/MMBtu	28.0
Electricity Price	\$/kWh	0.15
Electricity Cost (per MMBtu)	\$/MMBtu	4.14
Natural Gas (5%)	\$/MMBtu	0.38

[130] Nathalie Hoffman, "Second Food Scraps-to-RNG Project Certified Under California LCFS GREET 3.0," BioCycle, April 19, 2021, biocycle.net.

[131] Navius Research, California LCFS Price Trends: December 2024 Update, January 2025, naviusresearch.com.

[132] Guidehouse, Economic Analysis of the US Renewable Natural Gas Industry, 2020.

[133] U.S. Environmental Protection Agency, LFG Energy Project Development Handbook, Chapter 4: "Project Economics and Financing," 2017, p. 8, epa.gov.

[134] NYSERDA, Potential of Renewable Natural Gas in New York State, 2019.

TECH PILLAR: CLEAN FUELS

2. Scenario and Sensitivity Analysis

2.1 Base Case

Based on our assumptions of no tariff and a 7% interest rate, **Table XX** shows that while the repeal of ITC adders and transferability provisions would erode returns, the project remains fundamentally resilient under current financing assumptions. Using Case 3 as a base case (40% ITC), the project achieves a Project IRR of 18.52%, an Equity IRR of 23.22%, and a 4-year equity payback period, while maintaining a debt sizing of \$15.97M and 1.30x average DSCR.

The model output also shows that even under a full repeal of IRA incentives (0% ITC), the project still delivers an Equity IRR of 17.74% and a Project IRR of 12.29%, which meets the target IRR range of 12–14%. However, the payback period significantly extends to 9 years, highlighting reduced attractiveness compared to the base case.

Case Number		1	2	3	4	5	6
Case Name		No change	Adders Repeal (High)	Adders Repeal (Base)	Adders Repeal (Low)	Transferability Repeal	Full Repeal Equivalent
ITC %	\$/kgH2	70.00%	50.00%	40.00%	30.00%	40.00%	0.00%
Transfer Price	per \$1 PTC	0.90	0.90	0.90	0.90	0.50	0.50
Debt Size	\$M	7.99	13.31	15.97	18.64	15.97	21.78
Average DSCR	x	1.30x	1.30x	1.30x	1.30x	1.30x	1.30x
Min DSCR	x	1.30x	1.30x	1.30x	1.30x	1.30x	1.30x
Unlevered IRR	%	25.75%	20.62%	18.52%	16.67%	15.39%	12.29%
Levered IRR	%	19.64%	21.81%	23.22%	24.98%	16.21%	17.74%
Payback Period of Equity	years	5.00	4.00	4.00	4.00	9.00	9.00

TECH PILLAR: CLEAN FUELS

2.2 Sensitivity Analysis

The sensitivity analysis was conducted to stress test the project economics under varying tariff levels (0%, 25%, 50%) and interest rates (6%, 7%, 10%). The focus is primarily on the Base Case (Case 3) and selected downside cases (Case 4, 5, and 6).

Under the Adders Repeal Base Case (Case 3), with a 25% tariff, the project maintains a Project IRR of 14.05%, remaining above the minimum viability threshold. However, under a 50% tariff, Project IRR declines to 10.86%, falling slightly below the 12–14% target range and indicating sensitivity to extreme tariff scenarios. Increasing the interest rate from 7% to 10% leads to a 2–3 percentage point reduction in Equity IRR across all cases. When both tariff and interest rate are high, even with 40% ITC and transferability preserved (Case 3), the Equity IRR drops to 11.33%, falling slightly below the target threshold.

Tariff	r	Project IRR			Equity IRR		
		0%	25%	50%	0%	25%	50%
Case 3	6%	18.52%	14.05%	10.86%	23.22%	19.97%	14.54%
	7%				23.22%	19.97%	13.53%
	10%				23.22%	17.53%	11.33%
Case 4	6%	16.67%	12.42%	9.38%	24.98%	19.20%	11.49%
	7%				24.98%	17.50%	10.75%
	10%				24.98%	14.13%	9.10%
Case 5	6%	15.39%	11.29%	8.36%	16.21%	13.42%	9.64%
	7%				16.21%	13.42%	9.05%
	10%				16.21%	12.08%	7.68%
Case 6	6%	12.29%	8.58%	5.90%	19.74%	10.10%	5.86%
	7%				17.74%	9.44%	5.48%
	10%				14.01%	7.95%	4.60%

TECH PILLAR: CLEAN FUELS

Similarly, under a 50% tariff, Project IRRs decline across downside cases: 9.38% with lower adders, 8.36% without transferability, and 5.90% under a full repeal scenario. Notably, without a 50% tariff, the project generally remains financially acceptable across all cases except full repeal scenario (Case 6), where even a 25% tariff causes a material deterioration, with both Equity IRR and Project IRR falling more than 10% below baseline levels.

On the other hand, even if the IRA is fully repealed (Case 6), the project remains financially viable as long as tariffs stay at zero, delivering a Project IRR at 12.29% and equity IRR between 14.01% and 19.74%, which is within a reasonable investment range.

While not detailed in the table above, stress-testing results for Case 1 (No Change) and Case 2 (Adders Repeal - High) confirm that the project consistently meets or exceeds the target IRR ($\geq 12\%$) across all tested tariff and interest rate combinations, reflecting strong resilience even under stressed conditions.

Overall, the project remains robust with moderate tariff and interest rate increases. However, under high tariff scenarios (50%), returns deteriorate significantly, especially when combined with baseline or reduced availability of tax credits or transferability provisions, highlighting the project's vulnerability to extreme policy risks.

2.3 Sensitivity Analysis - LCFS

Without including LCFS revenues in the initial analysis, the base case assumptions provided conservative estimates. However, when accounting for LCFS revenue as an additional offset — assuming the project secures LCFS eligibility through pipeline delivery into California — the project remains financially resilient even under extreme downside assumptions (50% tariff and 10% interest rate).

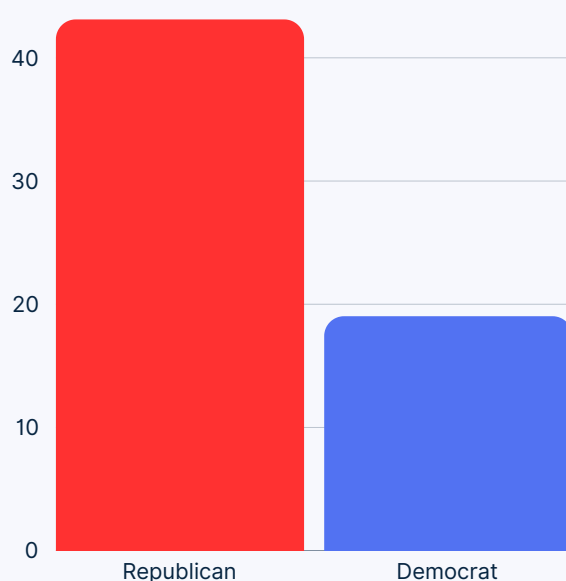
As shown in the updated outputs, most cases continue to meet or exceed our IRR requirements once LCFS revenue is factored in. Even under a full repeal scenario (0% ITC, no transferability), the project achieves a Project IRR of 11.41% and an Equity IRR of 12.25%, which, although slightly below ideal targets, is a robust outcome under such extreme conditions (high tariffs, high interest rates, and no tax incentives — a highly unlikely combination).

HYDROGEN ASSESSMENT

TECH PILLAR: HYDROGEN

Low-carbon hydrogen has garnered significant attention as a tool for decarbonization, though its role in the global energy transition remains comparatively modest. While electrification and renewables have taken center stage, hydrogen attracted only around \$10 billion in investment—less than the \$11 billion funneled into carbon capture and storage (CCS), a necessary technology for producing blue and turquoise hydrogen.¹³⁵ The International Energy Agency (IEA)¹³⁶ estimates hydrogen will contribute just 4% toward emissions reductions by 2050, while IRENA offers a more optimistic 12%.¹³⁷

50 — Total Hydrogen Investment, Billions USD, Q1 2018 - Q4 2024
(by Party of District Representative)



Investment Data from Rhodium Group Climate Deck (2018Q1-2024Q4)

Still, the reality remains that 88% of current hydrogen production—83.5 million metric tons—is derived from fossil fuels without CCS, and only 100,000 metric tons are produced via electrolysis, underscoring the tiny market share of green hydrogen.¹³⁸ Although roughly 600 low-carbon hydrogen projects are now operational, they represent only 0.7% of global hydrogen output with a combined capacity of 750,000 metric tons annually.¹³⁹ Many major economies have published national hydrogen strategies, yet practical use cases remain confined mostly to hydrocarbon-linked industries. Of the anticipated 51 million metric tons of new demand from emerging sectors, 43% of low-carbon hydrogen projects currently lack offtake agreements, raising concerns about future demand.¹⁴⁰ In 2023, global spending on green hydrogen supply projects under construction totaled USD 3.5 billion, with around 80% directed toward electrolysis facilities and the rest toward projects incorporating carbon capture, utilisation and storage (CCUS).¹⁴¹ Investment in electrolyzers rose by more than 350% from 2022, primarily for industrial and refining applications, while infrastructure spending remained comparatively low.¹⁴² North America led investment in CCUS-equipped hydrogen projects.

[135] Nane Sönnichsen, Low-Carbon Hydrogen: Trend Report, Hamburg: Statista, 2024.

[136] International Energy Agency, Global Hydrogen Review 2024: Hydrogen Demand, Paris: IEA, 2024.

[137] International Renewable Energy Agency, "Global Hydrogen Trade," IRENA, accessed April 11, 2025.

[138–141] Ibid. (multiple repeated citations to Sönnichsen, Low-Carbon Hydrogen: Trend Report, Statista, 2024).

[142] International Energy Agency, "Investment, Finance and Innovation," in Global Hydrogen Review 2024, Paris: IEA, 2024.

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Despite growing green hydrogen momentum, the ratio of green to blue/turquoise hydrogen capacity additions was 1.7 to 1.1 in 2024, and is projected to reach 34.6 million tons to 12.4 million tons, respectively, by 2030.¹⁴³ However, blue and turquoise projects still dominate in feasibility stages, largely because they can leverage existing fossil fuel infrastructure. Energy inefficiency, competition for renewables, and financing difficulties—exacerbated by interest rate hikes that raised U.S. LCOH—have stalled progress and hydrogen demand remains largely speculative.¹⁴⁴ Outside refining and chemical sectors, no major end-use market has solidified.

Policy Analysis

Industry experts caution that the hydrogen sector—particularly green hydrogen—is unlikely to be commercially viable in the near term without substantial government support and public subsidies. Countries such as China and Oman, for instance, have implemented comprehensive national strategies to promote hydrogen as a decarbonization tool.^{145,146}

In the United States, the Inflation Reduction Act currently provides significant financial incentives through Section 45Z (Clean Fuel Production Credit) and Section 45V (Clean Hydrogen Production Credit), which are instrumental in supporting the development of green hydrogen and some industry experts are concerned that hydrogen projects will become unviable without public support.

Unlike more mature technologies such as solar, green hydrogen lacks the extensive coalitions and lobbying infrastructure that can help secure long-term policy backing. This makes the sector particularly vulnerable to political shifts.



[143] International Energy Agency, "Investment, Finance and Innovation," in *Global Hydrogen Review 2024*, Paris: IEA, 2024.

[144–145] Nane Sönnichsen, *Low-Carbon Hydrogen: Trend Report*, Hamburg: Statista, 2024. (Additional repeated citations.)

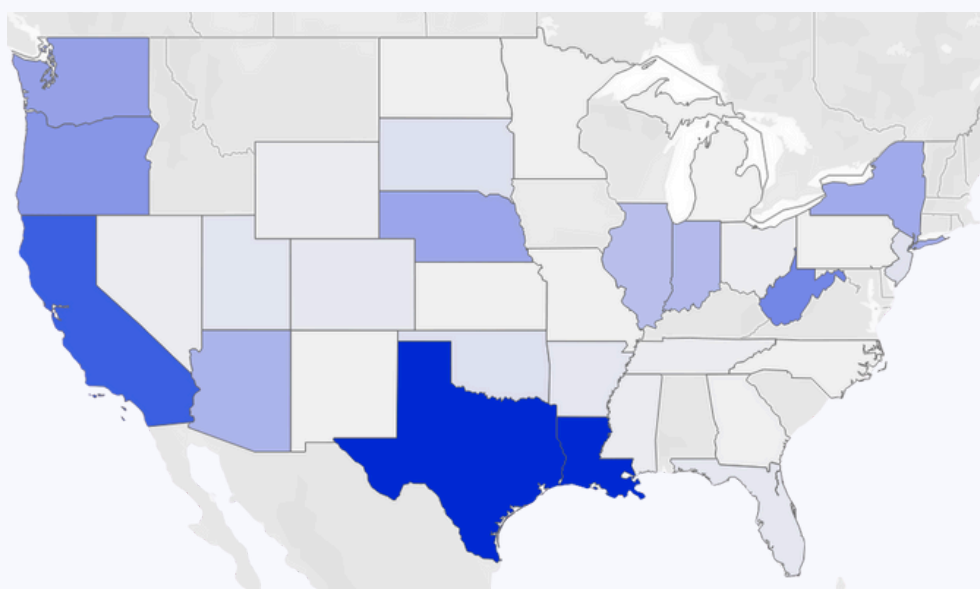
[146] International Energy Agency, *Renewable Hydrogen from Oman: A Producer Economy in Transition*, January 2023.

TECH PILLAR: HYDROGEN

Nevertheless, some lawmakers—including Republican representatives from states benefiting from IRA-related hydrogen investments—have opposed efforts to eliminate these programs, including grants and tax credits.¹⁴⁷ In addition, the network of federally funded hydrogen hubs established under the Biden administration may be at risk of defunding or elimination under the current conservative leadership.¹⁴⁸

The current administration is expected to favor blue and grey hydrogen technologies over green hydrogen. These forms of hydrogen production—derived from fossil fuels and often paired with carbon capture—are more closely aligned with the interests and infrastructure of the oil and gas industry, which has historically enjoyed stronger support from Republican policymakers and is favored by the Trump administration. However, it is important to note that many hydrogen-related investments have been heavily concentrated in Republican-controlled districts. Total hydrogen investment between Q1 2018 - Q4 2024 in Republican districts amounts to \$43.115 billion, compared to \$19.028 billion in Democratic districts. Furthermore, two Republican-led states—Louisiana and Texas—account for a combined 74% of national hydrogen investment, with \$23.256 billion and \$22.674 billion respectively.

Total Hydrogen Energy Investment, Q1 2018 - Q4 2024 by State



Investment Data from Rhodium Group Climate Deck (2018Q1-2024Q4)

[147] Lara Pierpoint and Thomas Koch Blank, *China's Green Hydrogen: Entering a New Era*, RMI, October 18, 2023.

[148] Christa Marshall, "Republican Lawmakers Urge DOE to Save California Hydrogen Hub," *E&E News*, April 9, 2025.

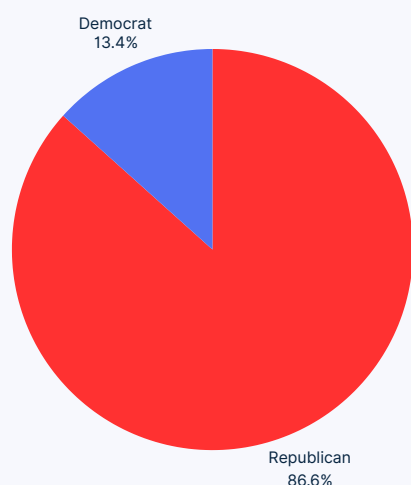
TECH PILLAR: HYDROGEN

The same trend is evident in the development of PEM (proton exchange membrane) hydrogen technology, which is Captona's area of focus. There are currently 19 PEM hydrogen projects located in Republican districts, representing \$4.83 billion in investment. In contrast, Democratic districts account for only \$0.745 billion in PEM hydrogen investments. In February, more than 110 companies and trade groups—including some from the oil and gas sector—signed a letter addressed to Republican leaders urging them to preserve the Section 45V hydrogen production credit.¹⁴⁹

Some experts we consulted with expressed concern that emerging technologies like green hydrogen may face greater political risk due to their nascent status. Conversely, others argued that well-established technologies such as solar and wind may be vulnerable to subsidy rollbacks under the rationale that they are already competitive and no longer in need of federal support. While the trajectory of conservative policymaking on hydrogen remains uncertain, it is evident that Republican-led states and districts stand to lose the most from any disruption to the expanding hydrogen sector.

PEM Investment by Party of District Representative

Investment Data from Rhodium Group Climate Deck (2018Q1-2024Q4)



PEM Investment in Republican Districts (Millions USD)

Company	State	Total Facility CAPEX
Air Products, Massena	NY	500
APEX, Plug Power	TX	658
Constellation	NY	16
Florida Power and Light	FL	69
Gevo, Zero6	SD	28
MMEX	TX	173
New Fortress Energy	TX	387
New Jersey Natural Gas	NJ	249
NovoHydrogen	OR	1769
Plug Power	TX	159
Plug Power	NY	704
Plug Power	TN	88
Plug Power GA	GA	20
Plug Power, GA Pilot	GA	7

[149] Sophia Schmidt, "MACH2 Hydrogen Hub Funding Could Be on the Chopping Block, According to a Report," The Allegheny Front, April 14, 2025.

TECH PILLAR: HYDROGEN

Financial Analysis

We build a semi-annual model for a green hydrogen production facility utilizing Proton Exchange Membrane (PEM) electrolyzer technology. The plant is assumed to be located in California, a state at the forefront of hydrogen adoption due to its aggressive decarbonization targets, established Low Carbon Fuel Standard (LCFS) program, and incentives for zero-emission vehicles. California's significant investment in hydrogen fueling infrastructure, paired with growing demand from the heavy-duty transportation sector, particularly trucking, makes it an ideal location for offtake. The project is designed to operate on a semi-annual financial modeling cycle to better reflect cash flow variations across the year.

1. Technology specific assumptions

Key assumptions for this model are grounded in publicly available benchmarks, as illustrated in the tables. The facility is assumed to have the total capacity of 100 MW, operating at a 55% capacity factor¹⁵⁰ and 54.3 kWh/kgH₂ system efficiency¹⁵¹, with an assumed asset life of 20 years. The hydrogen project CAPEX is assumed to be \$200 million, based on a \$2,000/kW capital cost benchmark referenced from IEA¹⁵² and DOE reports.¹⁵³

Generation		
Nameplate Capacity	MW	100.0
Capacity Factor	%	55%
System Efficiency	kWh/kgH ₂	54.3

Operational Cost		
Electricity Cost		
Net Electricity Cost	\$/MWh	48.0
Electricity Consumption	KWh/kgH ₂	54.3
Water Cost		
Process Water Cost	\$/kgH ₂	0.005
O&M		
O&M - fixed	%	5.0%
Warranty & Insurance	%	1.0%
Escalation	%	1.0%
Annual Inflation	%	2.0%

[150] Lazard, Lazard's Levelized Cost of Energy+, v.18.0, June 2024, p. 47, lazard.com.

[151] U.S. Energy Information Administration, Assumptions to the Annual Energy Outlook 2025: Hydrogen Market Module, April 2025, p. 7, eia.gov.

[152] International Energy Agency, Global Hydrogen Review 2024, Paris: IEA, 2024, iea.org.

[153] U.S. Department of Energy, Clean Hydrogen Production Cost: PEM Electrolyzer, DOE Hydrogen and Fuel Cell Technologies Office, 2024, hydrogen.energy.gov.

TECH PILLAR: HYDROGEN

This revenue model assumes that hydrogen will be used to replace diesel in California’s heavy-duty trucking sector, positioning trucking fleets as the primary offtakers. The revenue model assumes two distinct sales phases: a contracted offtake period and an uncontracted sales period. During the first 15 years, hydrogen is sold under a long-term offtake agreement at \$4.20/kg, with a 2.0% annual price escalator. This price reflects the baseline willingness to pay by fleet operators when no LCFS or federal tax credits are monetized by the producer, as outlined in the DOE’s Pathways to Commercial Liftoff: Clean Hydrogen report.¹⁵⁴ Following the offtake period, hydrogen is sold at a merchant price of \$4.00/kg over a 10-year term.¹⁵⁵

During the whole period, the producer is assumed to claim LCFS credits directly. With a carbon intensity (CI) reduction of 100 gCO₂e/MJ - based on CA-GREET3.0 values for ultra-low sulfur diesel (ULSD) at 100.45 gCO₂e/MJ and green hydrogen from electrolysis at near-zero CI.¹⁵⁶ LCFS revenue is estimated at \$1.59/kg of hydrogen, using a current \$60/ton CO₂ credit price and higher heating value (HHV) assumptions. An annual LCFS price escalation of 4.5% is assumed, acknowledging that policy-driven tightening of CI reduction targets could push credit prices into the \$100–\$140/ton CO₂ range over the coming decade, as projected in the December 2024 Navius Research report.¹⁵⁷

Operational costs including electricity input is priced at \$48/MWh¹⁵⁸ with a consumption of 54.3 kWh/kgH₂¹⁵⁹, and water cost is \$0.005/kgH₂.¹⁶⁰ Fixed O&M is set at 5.0%¹⁶¹, and insurance and warranty at 1.0%¹⁶², based on EIA, DOE and Lazard figures. Escalation and inflation rates are both set at 2.0%.

Revenue		
Offtake Revenue		
Offtake Price	\$/kg	3.6
Offtake Period		15.0
Annual Inflation	%	2.0%
Merchant Revenue		
Merchant Price	\$/kg	4.5
Merchant Period		5.0
Annual Inflation	%	2.0%
LCFS		
LCFS Price	\$/ton CO ₂	60.0
HHV	MJ/kg	120.0
CI Reduction	gCO ₂ e/MJ	100.0
LCFS Revenue	\$/kgH ₂	0.7
Annual Inflation	%	4.0%

[154] U.S. Department of Energy, Pathways to Commercial Liftoff: Clean Hydrogen, March 2023, p. 31, liftoff.energy.gov.

[155] National Renewable Energy Laboratory (NREL), “Decarbonizing Medium- & Heavy-Duty On-Road Vehicles: Zero-Emission Vehicles Cost Analysis,” February 28, 2022, govinfo.gov.

[156] California Air Resources Board, Low Carbon Fuel Standard: CA-GREET3.0 Lookup Table Pathways Technical Support Documentation, March 6, 2023, arb.ca.gov.

[157] Navius Research, California LCFS Price Trends: December 2024 Update, January 2025, naviusresearch.com.

[158] Lazard, Lazard’s Levelized Cost of Energy+, v.18.0, June 2024. (Also previously cited at [150], [167], and [170]—multiple repeats noted.)

[159] U.S. Energy Information Administration, Assumptions to the Annual Energy Outlook 2025: Hydrogen Market Module, April 2025, p. 7, eia.gov.

[160] Lazard, Lazard’s Levelized Cost of Energy+, v.18.0, June 2024.

[161] U.S. Department of Energy, Clean Hydrogen Production Cost Estimate Using PEM Electrolysis: 2023 Year-End Update, January 2024, hydrogen.energy.gov.

[162] Lazard, Lazard’s Levelized Cost of Energy+, v.18.0, June 2024.

TECH PILLAR: HYDROGEN

2. Scenario and Sensitivity Analysis

2.1 Scenario Analysis

Assuming a 7% interest rate and no tariff, our hydrogen project demonstrates limited financial viability across all four modeled policy scenarios. Even under the most favorable case (Case 1), the project struggles to meet our target equity IRR of 12–14%, delivering a levered IRR of only 9.90% and an equity payback period of 7.5 years. This already signals marginal attractiveness from an investment perspective.

The project's heavy dependence on the 45V Production Tax Credit (PTC) becomes even more apparent in Case 3, where 45V is repealed and replaced with the 45Z PTC. In this scenario, the project becomes economically unviable, with an unlevered IRR of -0.60% and an equity IRR of -1.12%, failing to return the invested capital. The situation worsens under Case 4: Full IRA Repeal, where IRRs drop to -4.97% (project level) and -5.61% (equity level), making development financially imprudent.

Case Number		1	2	3	4
Case Name		No Change	Transferability Repeal	45v Replaced by 45z	Full Repeal
PTC Price	\$/kgH2	3.00	3.00	1.00	-
Transfer Price	per \$1 PTC	0.90	0.50	0.90	0.50
Debt Size	\$M	15.44	15.44	15.44	15.44
Average DSCR	x	1.30x	1.30x	1.30x	1.30x
Min DSCR	x	1.30x	1.30x	1.30x	1.30x
Unlevered IRR	%	9.68%	2.67%	-0.60%	-4.97%
Levered IRR	%	9.90%	2.33%	-1.12%	-5.61%
Payback Period of Equity	years	7.50	15.00	20.50	20.50

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Case 2, which models a repeal of the transferability provision (reducing the PTC monetization rate from \$0.90 to \$0.50 per \$1 of PTC), significantly reduces project economics as well. Despite maintaining the \$3.00/kgH₂ 45V PTC, the levered IRR drops to just 2.33%, and payback extends to 15 years.

These results highlight the policy-sensitive nature of green hydrogen investments in the current U.S. context. Even moderate changes in IRA, such as limiting transferability or partial PTC repeal, introduce significant downside risk. The long equity payback periods in unfavorable scenarios (15–20.5 years) further reduce the project's attractiveness, especially in a volatile policy environment. Given this profile, investors face heightened regulatory, credit, and policy risk, which would demand either government-backed contracts or robust offtake agreements to mitigate uncertainty.

2.2 Sensitivity Analysis

The sensitivity analysis above illustrates that tariffs have a more pronounced impact on project returns than interest rates. For example, under Case 1, while changes in interest rates from 6% to 10% cause modest reductions in both project and equity IRRs, the introduction of a 25% or 50% tariff sharply erodes returns, pushing equity IRR below 2.4% and even into negative territory.

Even with full PTC support (Case 1), the project becomes non-viable under a 50% tariff, regardless of the financing cost. This underscores the exposure of green hydrogen projects to trade and procurement-related risks, particularly if electrolyzer's equipment or key components are subject to import tariffs. If we assume a 10% minimum equity IRR threshold, the project is only viable under a narrow set of conditions - specifically, a 6% interest rate, no tariff, and unchanged IRA provisions. This highlights the fragility of financial viability even under relatively optimistic market conditions.

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Our sensitivity analysis under Scenario 2 (where the 45V PTC remains, but transferability is repealed) further reveals the vulnerability of the project to tariff exposure. In this scenario, equity IRR drops to 2.33% even before applying any tariff or interest rate stress — already well below the investment threshold. When we apply a 25% or 50% tariff, the project becomes deeply unviable, with equity IRRs plunging to -4.36% and as low as -13.80%, depending on financing costs. Notably, the impact of tariff increases far outweighs that of rising interest rates, which only shift returns by ~20 basis points. This shows that even a modest policy rollback of losing the ability to transfer PTCs at full value, severely undermines project economics. When combined with additional commercial risks like tariffs, financial viability collapses across all financing conditions, including a favorable 6% interest rate.

	r	Project IRR			Equity IRR		
Tariff		0%	25%	50%	0%	25%	50%
No Change	6%	9.68%	2.38%	-5.31%	10.00%	2.36%	-4.59%
	7%				9.90%	2.36%	-4.55%
	10%				9.64%	2.35%	-4.43%
Transferability Repeal	6%	2.67%	-4.29%	-15.40%	2.40%	-4.36%	-13.80%
	7%				2.33%	-4.36%	-13.77%
	10%				2.16%	-4.36%	-13.68%

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2.3 Breakeven Analysis

To further assess the financial feasibility of the hydrogen project under different policy scenarios, we analyzed how combinations of hydrogen offtake price (Base: \$3.60/kg), electricity cost (Base: \$48/MWh), and CAPEX (Base: \$200M) influence the project's equity IRR. Our objective was to identify the minimum threshold values across these variables that would enable the project to achieve an project IRR of approximately 10%, which we consider the target return benchmark for investment viability.

Case 2	Hydrogen Offtake Price (\$/kg)					
Electricity Cost (\$/MWh)	2.7%	3.6	4.0	4.4	4.8	5.2
	48.0	2.7%	5.9%	8.8%	11.5%	14.1%
	43.0	5.4%	8.2%	10.9%	13.4%	15.9%
	38.0	7.7%	10.3%	12.8%	15.3%	17.6%
	34.0	9.4%	11.9%	14.3%	16.7%	19.0%
	29.0	11.3%	13.7%	16.0%	18.3%	20.6%
Capex (\$M)	2.7%	3.6	4.0	4.4	4.8	5.2
	200.0	2.7%	5.9%	8.8%	11.5%	14.1%
	180.0	5.6%	8.8%	11.8%	14.6%	17.4%
	170.0	7.2%	10.4%	13.5%	16.4%	19.2%
	160.0	8.9%	12.2%	15.3%	18.3%	21.3%
	150.0	10.7%	14.1%	17.3%	20.5%	23.5%
	140.0	12.7%	16.2%	19.6%	22.9%	26.1%
	130.0	14.9%	18.6%	22.1%	25.6%	29.0%

Case 2 (Transferability Repeal): baseline project IRR is 2.7%.

A hydrogen sale price of at least \$4.40/kg is required to reach a 10% project IRR, assuming moderate improvements in either electricity cost or CAPEX. Lower offtake prices fail to produce acceptable returns under most cost assumptions. At an offtake price of \$4.40/kg, electricity cost must be reduced to \$43/MWh or below if CAPEX remained at \$200M. While if electricity costs remain unchanged at \$48/MWh, then the total CAPEX must be reduced to approximately \$180M or lower to meet the 10% project IRR threshold at a \$4.40/kg hydrogen price.

Case 3 (45v Replaced by 45z): baseline project IRR is -0.6%.

A hydrogen sale price of at least \$4.80/kg is required to reach a 10% project IRR in this case, assuming moderate reduction in either electricity cost or CAPEX. Lower offtake prices such as \$4.40/kg may still lead to acceptable returns, but only under simultaneously favorable cost assumptions. In most cases, prices below \$4.80/kg result in IRRs below the 10% target.

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At an offtake price of \$4.80/kg, electricity cost must be reduced to \$43/MWh or below. While at the baseline electricity cost of \$48/MWh, even \$4.80/kg results in only 8.4% IRR, well below the investment threshold. If electricity costs remain unchanged at \$48/MWh, then the total CAPEX must be reduced to approximately \$180M or lower to meet the 10% project IRR threshold at a \$4.80/kg hydrogen price. At the base CAPEX of \$200M, the project IRR remains stuck below 9%.

Case 4 (Full Repeal):
baseline equity IRR is -5.0%.

Under the most constrained case, with the removal of both the tax credits and transferability, the project requires stacking multiple favorable inputs to reach the 10% target and remains highly sensitive to both price and cost assumptions.

A hydrogen sale price of at least \$5.20/kg is required to reach a 10% project IRR in a full repeal scenario, assuming moderate improvements in either electricity cost or CAPEX. Lower offtake prices such as \$4.80/kg may still lead to acceptable returns, but only under simultaneously aggressive reductions in both cost components.

Case 3	Hydrogen Offtake Price (\$/kg)					
	-0.6%	3.6	4.0	4.4	4.8	5.2
Electricity Cost (\$/MWh)	48.0	-0.6%	2.6%	5.6%	8.4%	11.0%
	43.0	2.3%	5.2%	7.9%	10.4%	12.9%
	38.0	4.8%	7.4%	9.9%	12.3%	14.7%
	34.0	6.5%	9.0%	11.4%	13.7%	16.0%
	29.0	8.5%	10.8%	13.2%	15.4%	17.7%
		-0.6%	3.6	4.0	4.4	4.8
Capex (\$M)	200.0	-0.6%	2.6%	5.6%	8.4%	11.0%
	180.0	2.1%	5.4%	8.4%	11.2%	14.0%
	170.0	3.5%	6.8%	9.9%	12.8%	15.7%
	160.0	5.1%	8.4%	11.5%	14.6%	17.5%
	150.0	6.7%	10.1%	13.3%	16.5%	19.5%
	140.0	8.4%	11.9%	15.3%	18.6%	21.8%
	130.0	10.3%	14.0%	17.5%	21.0%	24.4%

TECH PILLAR: HYDROGEN

Case 4	Hydrogen Offtake Price (\$/kg)					
Electricity Cost (\$/MWh)	-5.0%	3.6	4.0	4.4	4.8	5.2
	48.0	-5.0%	-1.8%	1.2%	4.0%	6.6%
	43.0	-1.8%	1.0%	3.6%	6.2%	8.6%
	38.0	0.8%	3.3%	5.7%	8.1%	10.4%
	34.0	2.6%	5.0%	7.3%	9.6%	11.8%
	29.0	4.6%	6.9%	9.1%	11.3%	13.5%
Capex (\$M)	-5.0%	3.6	4.0	4.4	4.8	5.2
	200.0	-5.0%	-1.8%	1.2%	4.0%	6.6%
	180.0	-2.5%	0.6%	3.6%	6.4%	9.2%
	170.0	-1.3%	1.9%	4.9%	7.8%	10.6%
	160.0	-0.0%	3.2%	6.3%	9.2%	12.1%
	150.0	1.3%	4.6%	7.7%	10.8%	13.8%
	140.0	2.7%	6.1%	9.3%	12.5%	15.7%
	130.0	4.2%	7.7%	11.1%	14.4%	17.7%

At an offtake price of \$5.20/kg, electricity cost must be reduced to \$38/MWh or below for the project to generate a 10% IRR. At the baseline electricity cost of \$48/MWh, even \$5.20/kg only yields an IRR of 6.34%, far below the required return for investors.

If electricity costs remain unchanged at \$48/MWh, then the total CAPEX must be reduced to approximately \$170M or lower to meet the 12% IRR threshold at a \$5.20/kg hydrogen price. At the base CAPEX of \$200M, equity IRR remains constrained to just 6.34% even under this elevated hydrogen price.

The below summary table provides a clear reference point for negotiating with offtakers and EPC contractors, setting commercial targets that align with financial viability under different policy frameworks.

Variable	Case 2 (Transferability Repeal)	Case 3 (45V Replaced by 45Z)	Case 4 (Full IRA Repeal)
Hydrogen Offtake Price	≥ \$4.40/kg	≥ \$4.80/kg	≥ \$5.20/kg
Electricity Cost	≤ \$43/MWh (if CAPEX = \$200M)	≤ \$43/MWh (if CAPEX = \$200M)	≤ \$38/MWh (if CAPEX = \$200M)
CAPEX	≤ \$180M (if Elec. = \$48/MWh)	≤ \$180M (if Elec. = \$48/MWh)	≤ \$170M (if Elec. = \$48/MWh)

TECH PILLAR: HYDROGEN

3. Takeaway and Mitigation strategies

Green hydrogen is highly sensitive to any potential changes in IRA tax credits provisions, a point consistently reinforced through both our modeling and expert interviews. As the industry is still in its early stages, the removal or weakening of tax credits - even marginally - has a disproportionate negative impact on project returns. Moreover, the project is highly reliant on the 45V tax credit; switching to the 45Z credit as an alternative still results in substantial reductions in profitability.

Without mass manufacturing to drive down electrolyzer capital costs, tax credits are essential to achieving financial viability, and tariff increases are particularly damaging to project economics.

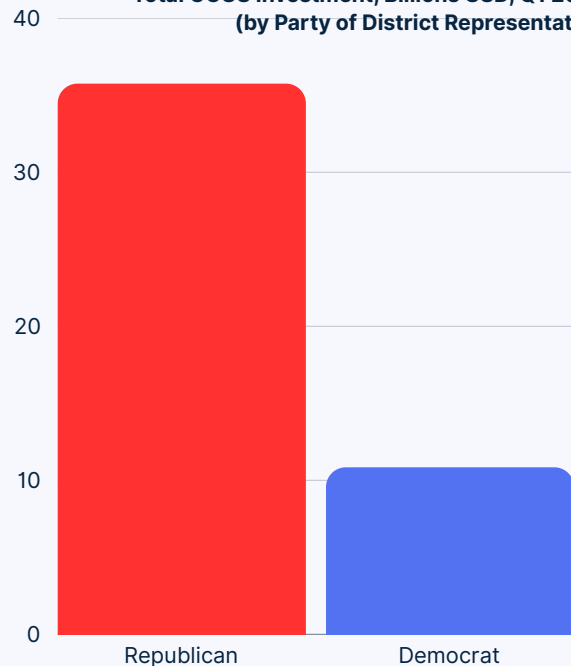
However, in our model, we assume an offtake price of \$3.60/kg and a merchant sale price of \$4.50/kg, which we view as conservative. One of our interviews indicated that some projects under development are modeling around \$5.00/kg for offtake agreements. With this in mind, our breakeven analysis also shows that an offtake price at around \$5/kg, combined with lower electricity costs and capex, will significantly improve project feasibility.

CCUS ASSESSMENT

TECH PILLAR: CCUS

The U.S. Carbon Capture, Utilization, and Storage (CCUS) sector has experienced a significant surge in project announcements following the passage of the Inflation Reduction Act (IRA) in August 2022. Between August 2022 and July 2023 alone, over 50 new capture, storage, and integrated capture and permanent storage projects were announced, surpassing the 39 projects announced during the entire year of 2022.¹⁶³ Throughout 2023, the momentum continued, with a total of 154 carbon capture, removal, reuse, and storage projects announced across the United States.¹⁶⁴ As of early 2025, the number of announced CCUS projects has risen to 276, representing a combined capture capacity of nearly 200 million metric tons of CO₂ per year.¹⁶⁵ The majority of these projects focus on Natural Gas Combined Cycle (NGCC) power plants, ethanol production facilities, and hydrogen production hubs, reflecting the growing role of CCUS in decarbonizing both the power and industrial sectors.¹⁶⁶

**Total CCUS Investment, Billions USD, Q1 2018 - Q4 2024
(by Party of District Representative)**



Investment Data from Rhodium Group Climate Deck (2018Q1-2024Q4)

CCUS in Dataset
Direct Air Capture
CCS
Coal with CCS
NG w/ CCS
NG w/ CCUS
Carbon Storage

[163] Eliza Sheff and Darryle Ulama, "From Act to Action: How the Inflation Reduction Act Is Accelerating Decarbonization in the United States with Carbon Capture and Storage," Clean Air Task Force, August 18, 2023, catf.us.

[164] Carbon Capture Coalition, 2025 Federal Policy Blueprint, February 2025, carboncapturecoalition.org.

[165] Ibid. (same as [164]).

[166] Eli Bashevkin, Theresa Christian, Jonathan Chung, William Dean, Andrew Gilbert, Katelyn O'Dell, and Chris Wu, Portfolio Insights: Carbon Capture in the Power Sector, U.S. Department of Energy, Office of Clean Energy Demonstrations, April 2024, energy.gov.

TECH PILLAR: CCUS

However, despite the increase in project announcements, this momentum, persistency a gap exists between announced projects and those reaching Final Investment Decision (FID); the International Energy Agency (IEA) reports that only about 20% of global capture capacity announced for 2030 is either operational or has reached FID, with permitting delays, infrastructure bottlenecks, and market uncertainties cited as key obstacles.¹⁶⁷ This trend is mirrored in the United States, where, despite leading the world in CCUS project announcements and investment, the majority of projects remain in early development stages, with only a small fraction advancing to Final Investment Decision (FID) due to persistent regulatory and financial barriers.¹⁶⁸ While the American framework for carbon management is among the most ambitious globally, significant challenges continue to threaten commercialization.¹⁶⁹

Project economics are closely tied to the availability of the Section 45Q tax credit, which offers up to \$85 per ton of CO₂ captured for industrial projects.¹⁷⁰ Analysis by the Rhodium Group indicates 62-70% of projected CCUS deployment through 2030 depends on access to the enhanced 45Q credit structure.¹⁷¹ Without it, most projects would not meet minimum return thresholds.¹⁷² This substantial increase from previous credit levels has dramatically improved the financial viability of CCUS projects and catalyzed new investment.¹⁷³

Permitting remains a significant bottleneck for U.S. carbon storage projects. As of early 2025, the U.S. Environmental Protection Agency (EPA) had issued only a handful (11) of Class VI permits—the type required for long-term geologic CO₂ storage—despite dozens of applications pending review, highlighting the slow pace of federal regulatory processes.¹⁷⁴ At the same time, local opposition to carbon dioxide pipelines is intensifying, particularly in states like Iowa and South Dakota, where legal challenges, new legislation, and community protests have caused major delays for critical infrastructure.¹⁷⁵ These permitting hurdles and public resistance can create substantial obstacles for the timely deployment of CCUS projects.

[167] International Energy Agency, “Carbon Capture, Utilisation and Storage,” accessed April 24, 2025, [iea.org](https://www.iea.org).

[168] Carbon Capture Coalition, 2025 Federal Policy Blueprint, February 2025, carboncapturecoalition.org.

[169] *Ibid.*

[170] Matt Bright, “The Inflation Reduction Act Creates a Whole New Market for Carbon Capture,” Clean Air Task Force, August 22, 2022, [catf.us](https://www.catf.us).

[171] Ben King, Whitney Jones, John Larsen, and Galen Bower, “Opportunities for Advancing Industrial Carbon Capture,” Rhodium Group, September 10, 2020, [rhg.com](https://rhodiumgroup.com).

[172] Matt Bright, “The Inflation Reduction Act Creates a Whole New Market for Carbon Capture,” Clean Air Task Force, August 22, 2022, [catf.us](https://www.catf.us).

[173] Carbon Capture Coalition, Primer: 45Q Tax Credit for Carbon Capture Projects, September 2023, carboncapturecoalition.org.

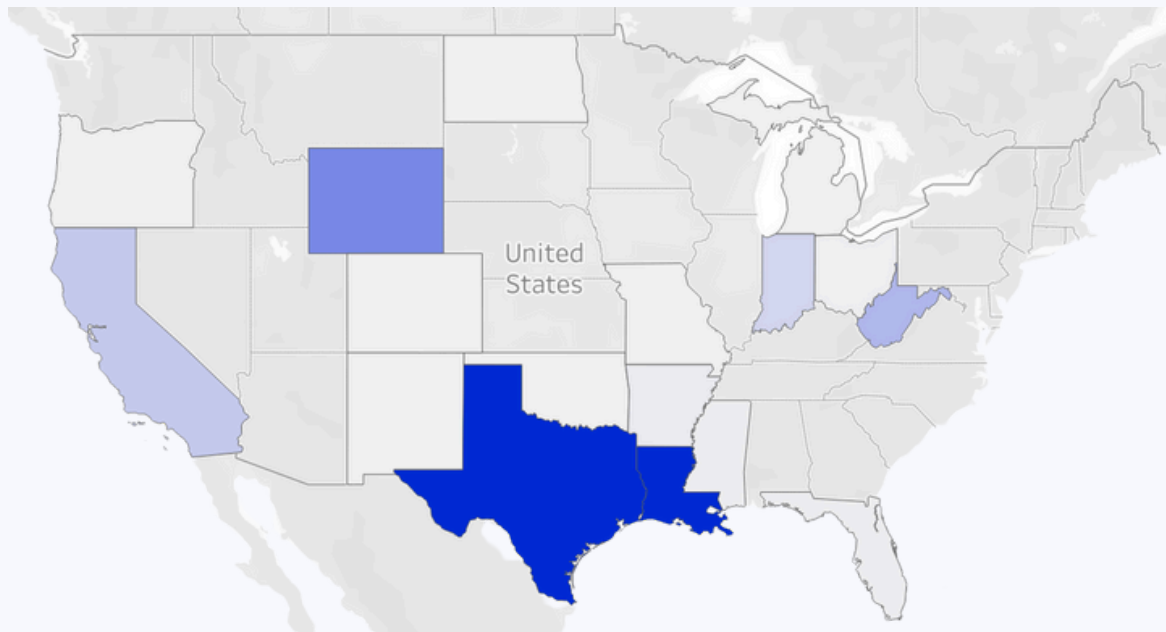
[174] Matthew Dobbins, Justine Jia, Conrad Bolston, Corinne Snow, Kelly Rondinelli, and Alyssa Sieja, “Outlook on the New Administration: What’s Next for CCS Permitting?” Vinson & Elkins LLP, February 26, 2025, [velaw.com](https://www.velaw.com).

[175] Rachel Cramer, “A South Dakota Law Creates New Hurdles for a Massive Midwest Carbon Dioxide Pipeline,” Nebraska Public Media, March 21, 2025, [nebraskapublicmedia.org](https://www.nebraskapublicmedia.org).

TECH PILLAR: CCUS

CCUS development is heavily concentrated in Texas, Wyoming and Louisiana, Republican-led states.¹⁷⁶ According to Forbes, these two states are among the largest CCUS hubs in the U.S., with a high volume of project proposals and substantial storage capacity.¹⁷⁷ The U.S. Gulf Coast -especially Texas and Louisiana- offers the largest concentration of low-cost, high-volume CO₂ emitters and some of the most favorable geology for storage, making it the epicenter of CCUS investment.¹⁷⁸ This heavy concentration strengthens bipartisan incentives to maintain supportive federal policies, as both Republican and Democratic constituencies benefit economically from the continued growth of the CCUS sectors.¹⁷⁹

Total CCUS Investment, Q1 2018 - Q4 2024 by State



Investment Data from Rhodium Group Climate Deck (2018Q1-2024Q4)

[176] David Blackmon, "Why Texas, Louisiana Are Poised to Win the Carbon Capture Sweepstakes," Forbes, April 24, 2023, forbes.com.

[177-178] Ibid. (same Blackmon article cited again).

[179] Sebastian Manhart, "Carbon Removal Policy in Trump's Second Term: What to Expect," Carbonfuture, January 13, 2025, carbonfuture.earth.

TECH PILLAR: CCUS

Policy Analysis

The Section 45Q tax credit for carbon capture remains one of the most politically durable components of the Inflation Reduction Act (IRA), embedded in the tax code and challenging to fully repeal. Interviews with public, private, and academic experts reveal strong industry support—over 160 companies advocate preserving the credit.¹⁸⁰

However, 45Q is not immune to risks. The introduction of the “45Q Repeal Act” in March 2025¹⁸¹, led by Representative Scott Perry (R-PA) and Representative Ro Khanna (D-CA), signals isolated bipartisan opposition to the credit. Reflect ideological concerns from both ends of the political spectrum—ranging from fiscal skepticism about federal subsidies¹⁸² to environmental criticisms of CCS as a fossil fuel enabler.¹⁸³

While 45Q’s political resilience is supported by bipartisan economic incentives, regulatory and operational challenges pose significant threats to CCUS deployment. Permitting delays are a major bottleneck: Class VI well approvals for CO₂ injection average 24 months,¹⁸⁴ with the EPA approving only 11 permits by April 2025 despite over 164 applications pending.¹⁸⁵

Additionally, inflation has increased CCUS project costs driven by higher equipment and construction expenses.¹⁸⁶ Local opposition to CO₂ pipelines further complicates commercialization.¹⁸⁷ For example, the Summit Carbon Solutions pipeline in Iowa, intended to transport CO₂ faces delays due to landowner protests over safety and eminent domain concerns, stalling more than 2,500 miles of planned infrastructure in Iowa, South Dakota, Nebraska, North Dakota and Minnesota.¹⁸⁸ This highlights a significant transportation risk, as opposition and permitting hurdles can delay the development of critical CO₂ pipeline infrastructure when needed for project viability.

[180] Carbon Capture Coalition, “Coalition Leads National, Multi-Stakeholder Call on Congress to Maintain Critical Support for 45Q Tax Credit,” January 28, 2025, carboncapturecoalition.org.

[181] U.S. Congress. House. 45Q Repeal Act of 2025, H.R. 1946, 119th Cong., 1st sess., introduced March 6, 2025, congress.gov.

[182] Scott Perry, “Congressman Scott Perry Introduces the 45Q Repeal Act,” Office of U.S. Representative Scott Perry, March 10, 2025, perry.house.gov.

[183] Jessica Corbett, “Exclusive: Khanna Proposes End to ‘Unconscionable’ Taxpayer Subsidies for Big Oil,” Common Dreams, September 14, 2023, commondreams.org.

[184] U.S. Environmental Protection Agency, “Class VI – Wells Used for Geologic Sequestration of Carbon Dioxide,” accessed April 24, 2025, epa.gov.

[185] U.S. Environmental Protection Agency, “Class VI Well Permitting Dashboard,” accessed April 24, 2025, epa.gov.

[186] Hugh Barlow, Shahrzad S. M. Shahi, and David T. Kearns, Advancements in CCS Technologies and Costs, Global CCS Institute, January 2025, globalccsinstitute.com.

[187] Luke Schields, CO₂lossal Connections: Examining Policy Incentives for Advancing Carbon Dioxide Pipeline Infrastructure in the United States, M-RCBG Working Paper No. 234, Harvard Kennedy School, May 2024, hks.harvard.edu.

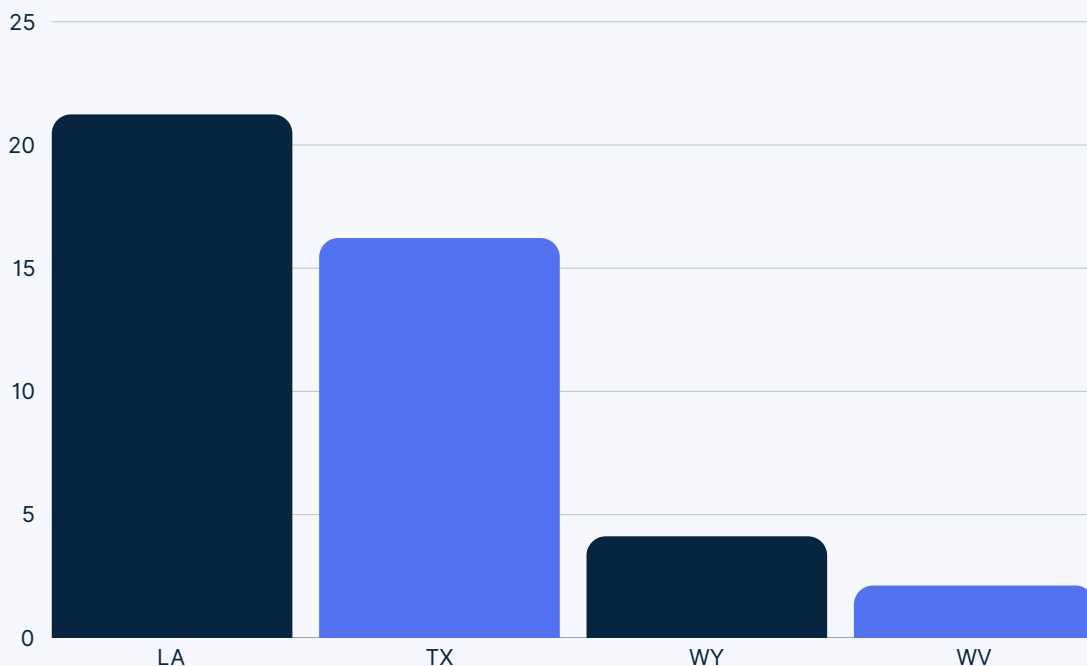
[188] Cami Koons, “Pipeline Opponents Push for a Ban on Eminent Domain for Carbon Pipelines,” Iowa Capital Dispatch, March 18, 2025, iowacapitaldispatch.com.

TECH PILLAR: CCUS

Partial rollbacks, regulatory slowdowns, or an administrative freeze under a new administration could disrupt deployment. Looking ahead, a Republican-led Congress in 2026 might push for broader IRA rollbacks, particularly if budget deficits grow, potentially capping 45Q credit durations or reducing rates.

Finally, while political risks remain, CCUS has structural advantages from its alignment with industrial decarbonization. Bipartisan interest in grid reliability and innovation continues to create momentum for CCUS investment, although execution risks persist. Industry coalitions have also issued forward-looking recommendations to strengthen carbon management policies, including adjusting the 45Q credit for inflation, expanding deployment pathways, and streamlining regulatory barriers for carbon reuse. Despite these efforts, NGCC CCUS projects continue to face significant financial barriers that undermine their viability and outweigh their potential benefits.

Top 4 States for CCUS Investment, Billions USD, Q1 2018 - Q4 2024



TECH PILLAR: CCUS

Financial Analysis

Using an internal financial model, our team evaluated the financial viability of a hypothetical 850 MW Natural Gas Combined Cycle (NGCC) carbon capture and storage (CCS) project located in California. The model's assumptions are drawn primarily from the U.S. Department of Energy's FEED study database.

Sources and Uses		
PP&E	\$M	2,010.00
PP&E	\$/ton/year	810
Cost of FEED	\$M	10
Total Cap.Ex	\$M	2,830.00
Total Cap.Ex (w/ Tariff)	\$M	2,830.00

Operational Cost		
Fixed O&M	% of Cap.Ex	3.00%
Variable O&M	\$/Mt	100
Power	\$/Mt	10
Transportation and Storage	\$/Mt	10
Escalation Index	%	2%

Generation		
Total Emissions	MtCO ₂ /year	2,215,185.00

Revenues		
Cap-and-Trade	\$/MT	30
LCFS	\$/MT	60
45Q	\$/MT	85
LCFS Time Frame	yr	12
45Q Time Frame	yr	12

TECH PILLAR: CCUS

Revenue Streams

In California, CCS projects can monetize captured CO₂ through three primary mechanisms:

- 1) 45Q Federal Tax Credit - \$85/ton for power-sector CCS, as amended by the Inflation Reduction Act (2022), contingent upon compliance with prevailing wage and apprenticeship requirements.
- 2) California Cap-and-Trade - \$30/ton, based on 2024 market prices reported by the California Air Resources Board (CARB).
- 3) Low Carbon Fuel Standard (LCFS) - around \$60/ton. However, NGCC CCS projects are generally not eligible for LCFS credits unless paired with hydrogen production or bioenergy inputs, per CARB eligibility guidelines. 45Q and LCFS are modeled to last for 12 years.

Cost Structure

The model simplifies NGCC CCS costs to the following categories: 1) Fixed O&M: Estimated at 3% of total capex, which is around \$85 million/year based on FEED study benchmarks. 2) Variable O&M (capture cost): Estimated at \$100/ton of CO₂ captured. This aligns with industry survey findings. 3) Fuel (natural gas): Assumed stable; not a primary driver of the variation in cost. 4) Transportation & Storage: Modeled at \$10/ton based on short-distance pipeline scenarios.

Emissions and Capture Potential

The project assumes an 85% capacity factor, producing around 6.33 million MWh annually. Using an emission factor of 0.35 tCO₂/MWh (per NREL), annual gross emissions are estimated at 2.21 million metric tons.

Financial Insight

Despite full access to all incentives, including 45Q, cap-and-trade, and (hypothetically) LCFS, the project remains economically unviable under current policy and market conditions:

- EBITDA remains negative in every modeled year
- Annual EBITDA losses: \$38M - \$42M
- Cumulative EBITDA (no tax credit): - \$6.72 billion

Even with generous federal tax credits, carbon pricing, and favorable engineering assumptions, NGCC CCS projects struggle to achieve financial viability without additional revenue sources or deeper policy support. From a financial perspective, this project is currently unbankable. The persistent negative cash flow makes debt financing infeasible, as lenders require predictable, positive operating margins to support loan repayment.

NUCLEAR ASSESSMENT

TECH PILLAR: NUCLEAR

The nuclear energy landscape is experiencing renewed interest as the country faces growing electricity demand driven by artificial intelligence, electrification, and economic growth. This revival is occurring after decades of decline, with nuclear power valued for providing firm, around-the-clock, zero-carbon electricity that complements intermittent renewable energy sources like wind and solar. Traditional nuclear plants currently generate nearly 20% of U.S.¹⁸⁹ electricity, while small modular reactors (SMRs) are emerging as a potentially more economical nuclear technology.¹⁹⁰

The IRA has introduced significant support mechanisms through the Section 45Y Production Tax Credit (PTC) and Section 48E Investment Tax Credit (ITC), which could substantially improve the economics of both existing and new nuclear facilities by offsetting operating or capital costs, respectively.¹⁹¹ Despite growing popularity, nuclear energy's growth trajectory faces several challenges: economic viability, technological uncertainty, lead time, scalability, federal incentives, fuel, and public acceptance.¹⁹²

Economic viability remains uncertain, particularly for SMRs, which must demonstrate sufficiently low capital and operating costs to be competitive in markets like ERCOT that have historically low electricity prices. Research indicates that even with IRA tax credits, only SMRs with both low capital costs (under \$3,000/kWe) and low variable O&M costs (below \$22.50/MWh) would be economically feasible in low-price electricity markets.

Higher-priced markets like New England (ISO-NE) offer more favorable conditions for nuclear economics.¹⁹³ Additionally, historical patterns of significant cost overruns in nuclear construction projects raise concerns about financial risk, with most U.S. nuclear projects experiencing cost escalations of 200-300% above initial estimates.



[189] U.S. Energy Information Administration, "Nuclear Explained: U.S. Nuclear Industry," eia.gov.

[190] Larsen et al., "Effects of the U.S. Inflation Reduction Act on SMR Economics," *Frontiers in Nuclear Engineering*, May 2024.

[191] *Ibid.*

[192] Vivanco, "5 Factors That Will Shape Nuclear Energy's Future," ICF, March 2025.

[193] *Ibid.*, Larsen.

TECH PILLAR: NUCLEAR

Financial Analysis

1. Technology Specific Assumptions

For the modeling, we particularly focus on the technology of the Light Water Small Module Reactor (SMR). We are using the 77 MWe NuScale Power Module (NPM)¹⁹⁴ as our reactor, which is the first SMR to receive design approval from the U.S. Nuclear Regulatory Commission (NRC) in September 2020.¹⁹⁵ Since there is no existing Nuclear SMR project in the US, we are referring to latest academic research from Frontiers¹⁹⁶ and NREL 2024 Annual Technology Baseline (ATB) to find our assumptions.

The project expects to start commercial operation in 2030 and have an asset life of 60 years. Due to the large capital cost and longer asset life, we extend the debt tenor to 20 years. The project has four 77MWe NPM, adding up to a total nameplate capacity of 308MWe. The frontier report¹⁹⁷ used the Argonne Low-carbon Energy Analysis Framework (A-LEAF) model to assess SMR performance under various hypothetical capital and operating cost scenarios within the ERCOT market. In the report, it shows that a 300 MWe SMR project with variable cost of \$15/MWh, Capacity Factor of 94.1% is expected to get \$81.7 million revenue p.a. NREL's 2024 ATB report also shows a forecasted capacity factor at 93%. Therefore, we are using the number shown in the frontier report for our assumptions, assuming the project has a 94.1% capacity and gets \$81.7 million p.a through selling energy into the merchant market. Apart from the variable O&M costs of \$15/MWh, the project will also have \$122/kw-year as for the fixed O&M cost.

Generation		
Nameplate Capacity	Mwe	308.0
Capacity Factor	%	94.1%
Generation	million MWh p.a.	2.54

Revenues		
Merchant		
Revenue	\$M p.a.	81.7
Volume	%	100%

Operational Cost		
Fixed O&M costs	\$/kW-year	122.00
Variable O&M costs (Including fuel)	\$/MWh	15.00

[194] U.S. Nuclear Regulatory Commission, NuScale US460 Standard Design Approval Application Review, nrc.gov.

[195] Ibid.

[196] Larsen et al., "Effects of the U.S. Inflation Reduction Act on SMR Economics," Frontiers in Nuclear Engineering, May 2024. (

[197] Ibid.

TECH PILLAR: NUCLEAR

The Capex of the SMR project can be split into two parts: Overnight capital costs and grid connection costs. We are using the number of \$100/KWe from NREL's 2024 ATB report for grid connection costs. As for the overnight capital costs, we are using the median number of \$6,949/KWe from frontier report, which summarized the wide range estimation of overnight capital cost, ranging from \$1,995/KWe to as high as \$29,624/KWe.¹⁹⁸

Capex		
Overnight Capital Costs	\$/kWe	6,949.00
Grid Connection Costs	\$/kWe	100.00
Total Cap.Ex	\$M	2,171.09

2. Base Case

For the current environment, the Nuclear SMR seems to be financially unviable even with the 70% of ITC, showing a negative project IRR of -2.43% and equity IRR of -2.52%. If the tax credit gets fully repealed, the project IRR will further drop to -4.69% and equity IRR will be -4.74%.

Nuclear SMR	live	1	2	3	4	5	6
Case	Case	No change	Adders Repeal - High	Adders Repeal - Base	Adders Repeal - Low	Transferability Repeal	Full Repeal
Debt Size	21.32	21.32	21.32	21.32	21.32	21.32	21.32
Average DSCR	3.00x	3.00x	3.00x	3.00x	3.00x	3.00x	3.00x
Min DSCR	3.00x	3.00x	3.00x	3.00x	3.00x	3.00x	3.00x
Leverage	0.98%	0.98%	0.98%	0.98%	0.98%	0.98%	0.98%
Project IRR	-3.69%	-2.43%	-3.34%	-3.69%	-3.99%	-4.19%	-4.69%
Equity IRR	-3.76%	-2.52%	-3.42%	-3.76%	-4.05%	-4.25%	-4.74%
Payback Period of Equity	-	-	-	-	-	-	-

TECH PILLAR: NUCLEAR

One important factor to consider for nuclear power is the significant risk of cost overruns during construction. A real-world example is the NuScale SMR project with Utah Associated Municipal Power Systems (UAMPS), which was canceled in 2023 due to major cost escalations and schedule delays. It was set to come online in 2029.¹⁹⁹ The Department of Energy (DOE) had provided \$232 million since 2020 and backed the project with a \$1.4 billion cost-share deal.²⁰⁰ In the model we have here, the assumptions for capital cost and operating costs are relatively low. However, the project still seems unable to generate positive returns.

3. Break Even analysis and Takeaway

3.1 Breakeven analysis

Looking ahead, we aim to identify what changes are necessary for a Nuclear SMR project to achieve a 10% project IRR, making it financially sustainable. To do this, we conducted a breakeven analysis across revenue, operating costs, and capital expenditures. In our sensitivity model, we tested reductions in CapEx and variable O&M, along with potential revenue increases through revenue stacking—each reflected as percentage changes. Here we use scenario 3 as the base case, assuming the project gets 40% ITC.

- **Reduction in Costs (O&M and CapEx)**

Assuming there is no change in revenue, with just the decrease in variable O&M and CapEx alone, it is still not enough to make the project financially viable. At the extreme case here, CapEx can reduce by 50% and Variable O&M can drop to as low as \$9.00/MWh, the project IRR is only 2.10%.

Sensitivities - Project IRR	0%	Variable O&M			
		-3.69%	15.00	13.00	11.00
CapEX	0%	-3.69%	-2.19%	-1.17%	-0.36%
	-10%	-3.44%	-1.92%	-0.86%	-0.02%
	-15%	-3.31%	-1.76%	-0.69%	0.16%
	-25%	-3.01%	-1.42%	-0.31%	0.58%
	-35%	-2.65%	-1.01%	0.15%	1.09%
	-40%	-2.45%	-0.78%	0.41%	1.38%
	-45%	-2.23%	-0.51%	0.71%	1.72%
	-50%	-1.98%	-0.22%	1.05%	2.10%

[199] World Nuclear News, "Idaho SMR Project Terminated," accessed April 2025, world-nuclear-news.org.

[200] Zach Bright, "NuScale Cancels First-of-a-Kind Nuclear Project as Costs Surge," E&E News, November 2023, eenews.net.

TECH PILLAR: NUCLEAR

- **Raise in Revenue (O&M and CapEx)**

Given the inherent difficulty in achieving higher revenues from merchant market energy sales, the model assumes incremental revenue through revenue stacking or different revenue streams. To support the development of nuclear SMRs, the project is expected to secure additional/different income streams, such as capacity payments or long term PPA contract from utilities or technology companies. This assumption is incorporated into the model as a percentage increase in revenue, with scenarios reflecting 50%, 80%, and 100% uplifts.

The sensitivity analysis across all scenarios illustrates the pivotal role of revenue enhancement in achieving the project's target IRR of 10%. At a 50% increase in revenue, the project's base case IRR remains low at 2.51%, requiring substantial CapEx reductions and operational cost improvements to approach viability. Even with a 50% reduction in CapEx and Variable O&M costs lowered to \$9/MWh, the IRR is still below 10%.

Sensitivities - Project IRR	50%	Variable O&M			
	2.51%	15.00	13.00	11.00	9.00
CapEX	0%	2.51%	2.96%	3.39%	3.81%
	-10%	2.97%	3.45%	3.92%	4.36%
	-15%	3.24%	3.73%	4.21%	4.68%
	-25%	3.85%	4.38%	4.90%	5.40%
	-35%	4.60%	5.19%	5.76%	6.32%
	-40%	5.06%	5.68%	6.29%	6.88%
	-45%	5.58%	6.24%	6.89%	7.53%
	-50%	6.19%	6.91%	7.60%	8.29%

TECH PILLAR: NUCLEAR

At an 80% increase in revenue, the base case IRR is only 4.55%, indicating that significant cost reductions are still essential. Even with a 50% CapEx reduction and a drop in Variable O&M to \$9/MWh, the IRR only reaches approximately 11.49%.

Sensitivities - Project IRR	80%	Variable O&M			
		4.55%	15.00	13.00	11.00
CapEX	0%	4.55%	4.93%	5.31%	5.68%
	-10%	5.15%	5.56%	5.97%	6.37%
	-15%	5.49%	5.92%	6.35%	6.77%
	-25%	6.30%	6.77%	7.24%	7.70%
	-35%	7.31%	7.85%	8.37%	8.89%
	-40%	7.94%	8.50%	9.06%	9.62%
	-45%	8.66%	9.27%	9.88%	10.47%
	-50%	9.52%	10.18%	10.84%	11.49%

At a 100% revenue increase, the project achieves a base case IRR of 5.76%, but meaningful improvements in CapEx and O&M are still required to cross the 10% threshold. Specifically, achieving at least a 35–40% CapEx reduction combined with Variable O&M reductions to \$11/MWh or below is necessary.

Sensitivities - Project IRR	100%	Variable O&M			
		5.76%	15.00	13.00	11.00
CapEX	0%	5.76%	6.13%	6.49%	6.84%
	-10%	6.46%	6.85%	7.24%	7.63%
	-15%	6.86%	7.27%	7.68%	8.08%
	-25%	7.80%	8.26%	8.71%	9.16%
	-35%	9.00%	9.52%	10.03%	10.53%
	-40%	9.74%	10.29%	10.84%	11.38%
	-45%	10.60%	11.20%	11.79%	12.38%
	-50%	11.63%	12.28%	12.92%	13.56%

TECH PILLAR: NUCLEAR

3.2 Takeaway

Despite renewed policy support and growing interest in firm, zero-carbon generation, the current economics of Nuclear SMR projects remain not financially feasible under merchant market conditions. Even with optimistic assumptions for capital costs, operating expenses, and receipt of a 40% ITC, the project struggles to achieve positive returns, posting a base case project IRR of -3.69%.

Break Even analysis further demonstrate that, without dramatic reductions in CapEx (by at least 35–50%), significant decreases in Variable O&M costs (toward \$11-\$9/MWh), and substantial new revenue streams such as capacity payments or PPA contracts (increases the revenue by more than 80%), Nuclear SMRs cannot meet a 10% project IRR threshold. Even at a 100% increase in revenue, the project only achieves a 5.76% IRR under base assumptions, requiring additional aggressive cost optimizations to become viable.

Given the persistent risks of construction cost overruns, market uncertainties in capacity revenue, and the sensitivity of returns to small cost or revenue changes, a "wait-and-see" investment posture is prudent. Captana should closely monitor further cost maturation, commercial deployments, and emerging incentive structures before committing capital to first-of-a-kind Nuclear SMR projects.

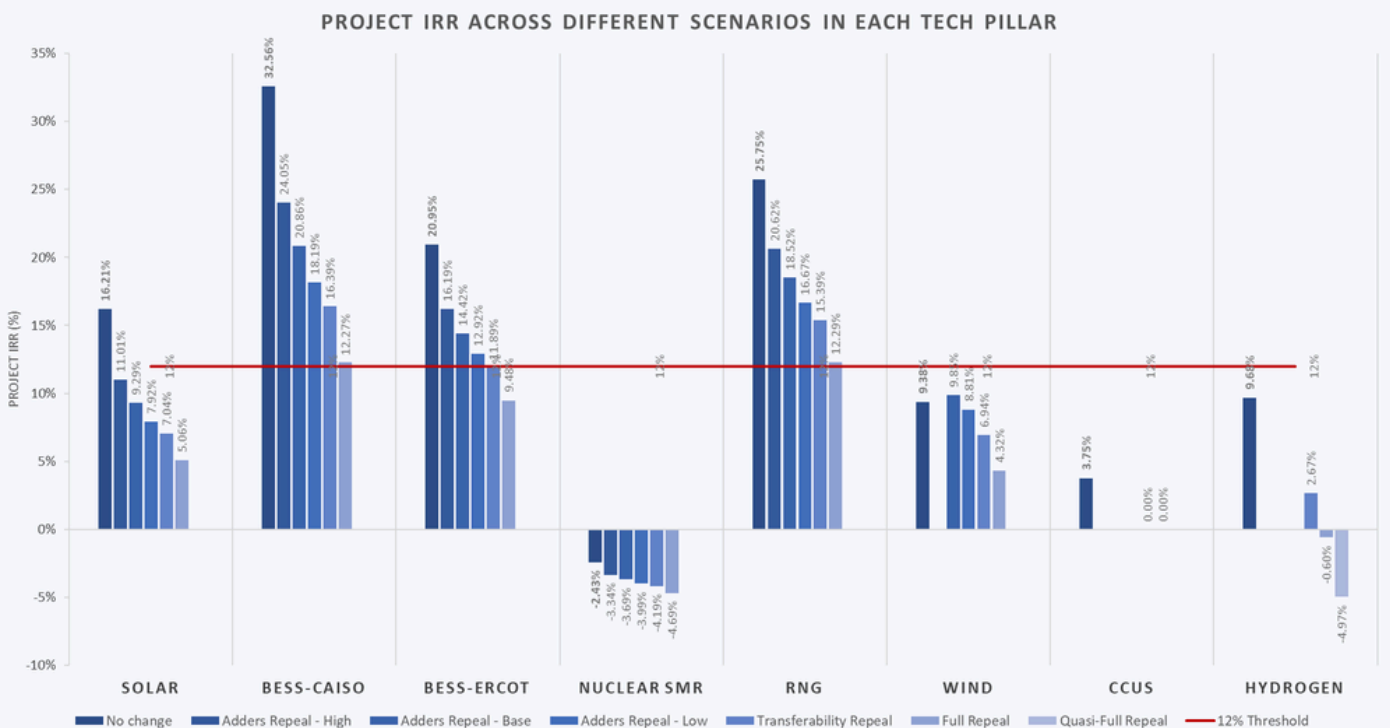


RECOMMENDATIONS

RECOMMENDATION FINANCIAL IMPLICATION

Based on the project IRR across different scenarios for our seven technology pillars, we recommend prioritizing BESS in CAISO, which demonstrate the highest project IRR at 32.56% under the "No Change" scenario and remain resilient under a full repeal scenario at 12.27%. Similarly, RNG is recommended, offering a strong IRR range between 12.29% and 25.75% across scenarios. In addition, BESS-ERCOT maintains a positive IRR of around 20.95% in all assessed scenarios and is also advised for prioritization. In contrast, solar is highly exposed to changes in tax credits, with project IRRs falling below 12% under adverse scenarios. Other technologies exhibit weaker returns under current assumptions, primarily due to their early stages of deployment.

Beyond financial returns considerations, placing near-term emphasis on less politically sensitive technologies offers a practical hedge. Investments in carbon capture, geothermal, or nuclear are widely seen as less likely targets for rollback, given their acceptance across partisan lines, especially coalition with the oil and gas sector. Meanwhile, solar and BESS, though not as politically favored as the aforementioned technologies, remain central to Captona’s portfolio and continue to offer attractive returns due to their proven track records. As part of any near-term due diligence, Captona should conduct localized analyses of permitting risks, thereby mitigating delays in more politically uncertain states.



RECOMMENDATION

FINANCIAL IMPLICATION

State-level programs & incentives

As a mitigation strategy, we can also look into state-level programs and incentives, which can provide additional revenue streams and policy stability that complement or enhance federal initiatives.

- **New York State’s “Energy Storage Roadmap 2.0” & 2025 Bulk Energy Storage Program:** introduce the Index Storage Credit (ISC), calculated as Strike Price – Reference Price, to provide revenue certainty. NYSERDA has also secured new funding to support an additional 4,700 MW of storage, including 3,000 MW targeted specifically for wholesale market participation.
- **California’s Low Carbon Fuel Standard (LCFS):** continues to serve as a major incentive for clean fuel technologies such as hydrogen and RNG, and indirectly supports clean electricity use for EV charging infrastructure.

States with unmet storage procurement targets

State	% Met	State	% Met
Connecticut	<1%	New Jersey	15%
Maine	21%	New York	24%
Maryland	2.60%	Oregon	-
Massachusetts	26%	Rhode Island	-
Michigan	<1%	Virginia	<1%

Furthermore, significant opportunities exist in states with unmet storage procurement targets, particularly Connecticut, Michigan, and Virginia, where current fulfillment rates remain below 1%, highlighting substantial room for market penetration and growth.²⁰¹

RECOMMENDATION

POLITICAL SIGNALS

As clean energy tax policy continues to evolve, several near-term political developments may influence market confidence and project timing. While not all events carry direct regulatory consequences, they signal broader Congressional sentiment toward the IRA and its implementation. Below are key dates and public positions worth tracking.

Key Dates to Watch

Over the coming weeks, the following dates may shape the legislative landscape around clean energy tax incentives:

1. **May 12th:** Marks the end of the 60-day Congressional review period for the IRS's January 15th guidance on the ITC and PTC. Lawmakers may submit formal objections, though significant changes are not currently expected.
2. **May 13th:** The target day for the House Ways and Means Committee to markup the Reconciliation Bill.
3. **May 26th:** The GOP's internal target date to release their version of the Reconciliation Bill, which may include proposed amendments to clean energy-related spending.

Key Political Voices

Here are the key political figures worth tracking, as their recent public statements and letters indicate potential areas of pushback or legislative focus:

1. **March 9th letter signatories**
2. **House of Representatives:** Mike Johnson, Steve Scalise, Tom Emmer, Lisa McClain, Kevin Hern
3. **Senate:** John Thune, John Barrasco, Tom Cotton, Shelley Moore, James Lankford, Tim Scott

RECOMMENDATION

LEGAL SAFEGUARDS

To reduce regulatory and procedural risks, several legal provisions should be carefully incorporated into project documentation during development and acquisition. These agreements can play a crucial role in preserving project economics and eligibility for tax incentives in an evolving policy environment.

- **Power Purchase Agreement (PPA):** Include an open clause that allows price modifications in the event of regulatory changes that materially affect the project's economics.
- **Engineering, Procurement, and Construction Contract (EPC):** Ensure compliance with IRS safe harbor provisions by meeting either the Physical Work Test or the Five Percent of Total Cost Spent threshold. These criteria are essential for securing tax credit qualification.
- **Pre-Acquisition Measures:** Prior to acquisition, consider pre-filing project codes to reduce procedural risks and mitigate delays from potential regulatory interference.

Also, in the immediate term, Captona should focus on securing tax benefits under current regulations before any statutory or regulatory changes can take effect. Multiple interviewees in project finance and renewable energy loan underwriting mentioned a “safe harbor” strategy, in which eligible equipment is procured or construction milestones are reached under existing guidance that can lock in higher credit values. Projects targeting commercial operation within the next 12-18 months should be prioritized accordingly.

RECOMMENDATION

LONG-TERM STRATEGY

Medium to Long-Term Positioning

Over a longer horizon, maintaining optionality is critical. By staggering development schedules and tying capital deployment to milestone-based triggers, Captona can pivot if political risks increase. Securing flexible debt or partnership structures that permit phased capital commitments further strengthens this real-options approach. In addition, diversifying revenue streams can buffer potential reductions in federal tax credits.

Emphasizing development in states with robust Renewable Portfolio Standards (RPS), carbon markets, or well-funded clean energy programs reduces reliance on federal policy. Likewise, forging corporate off-take agreements for new renewable and clean fuels projects can stabilize project economics even if federal incentives shift.

Another key facet of long-term positioning involves proactively adapting to potential changes to the elective pay and transferability of tax credits (Section 6418) and watching upcoming litigations. Administrative slowdowns or reinterpretations can impact market pricing for transferable credits.

Considerations for Investment Decisions

From 2025 onwards, staged commitments to a broader project pipeline can keep downside risk in check. This approach allows Captona to pause, exit, or accelerate investments based on real-time policy signals, depending on individual contract terms. For projects already under development, locking in critical construction milestones or safe-harboring equipment can help preserve favorable credit treatments and minimize exposure to an uncertain future.

RECOMMENDATION

RISK MITIGATION

Risk Mitigation Approaches through Contingent Financing

We provide the following market proven strategies used in scenarios in the past with approximately 10% loss of funding amount as contingent consideration.

1. Two-tranche financing facility

The first recommendation is a two-tranche financing facility. The sponsor first secures a “base” tranche sufficient to complete the bulk of project construction. Depending on Captona’s entry point, Captona can form a similar structure among investors. Alongside the base tranche, a contingent tranche is pre-negotiated but only accessed if the federal tax credit fails to materialize by the time it is needed. The base tranche represents conventional project debt or equity at a known cost of capital, while the contingent tranche is priced at a higher yield, often at mezzanine or preferred equity, to reflect the additional risk.

From a real-options perspective, the sponsor holds a “call option” on the second tranche. One person from a leading energy credit trading company said that a typical capital stack makes up 40% tax credit and adders. As of April 2025, if the 40% total credit is gradually repealed, the sponsor can “call” on the mezzanine or preferred investors to fund the shortfall gradually, therefore ensuring uninterrupted construction. Conversely, if the tax credit is ultimately preserved or reinstated, the sponsor simply does not exercise the option for the contingent tranche, saving the additional interest cost.

RECOMMENDATION

RISK MITIGATION

2. Equity Ratchet

Another approach is to introduce an equity “ratchet”²⁰² mechanism that adjusts the sponsor/investor ownership shares based on the actual availability of the total tax credits. At the time of financial close, all parties assume that the credits will remain in place, establishing a baseline equity split. If those credits are repealed or significantly delayed, a predefined ratchet triggers: investor ownership increases while the sponsor’s stake decreases, compensating investors for lost incentive-based upside and protecting them from diminished returns.

This arrangement embodies a “split option” in which both sponsor and investors hold a stake in the underlying asset, yet that stake is not defined at the project’s inception. The sponsor, while conceding a portion of ownership if the credit vanishes, benefits from having guaranteed capital commitment to finish the project. If federal policy changes harm expected project economics, investors are automatically shielded via an increased equity share. This approach fits Captona’s profile that invests in late stage construction, mitigates the risk of project abandonment or early liquidation. However, depending on the scale of the volume and terms of acquisition, the equity ratchet can impact Captona’s total debt profile.

RECOMMENDATION

3. Reserve and Release Option

A “reserve and release”²⁰³ structure is an escrow-oriented solution, in which a dedicated contingency reserve is established during late-stage construction. Based on our understanding, late-stage construction is where Captona enters and operates either as operator-owner or investor. Here, the sponsor deposits either cash or a Letter of Undertaking into an escrow account.

If tax credits fail to materialize, the funds are automatically released to fill the capital gap and ensure project completion. If, however, the tax credits are confirmed and stable at the commercial operation date, the reserve is canceled and reverts to the sponsor. This arrangement parallels an insurance-like call option, allowing the sponsor to effectively self-insure against the loss of the tax credit. The sponsor pays an opportunity cost by raising funds more than needed, tying up capital in escrow, yet in exchange, the sponsor can protect against a worst-case policy scenario. This serves more as a credit-enhancement signal to lenders and counterparties, who may be wary of funding shortfalls prior to the project completion.

RECOMMENDATION

4. Put Option Buy-Back

This structure mirrors a put option.²⁰⁴ In this scenario, the sponsor negotiates a contractual right to sell a specific percentage of its equity to co-investors at an agreed price if federal incentives are not received. This means the sponsor would pay a premium and, in return, retains the right to exit part of its position under adverse policy conditions.

This mirrors a financial put option used in equity markets. The co-investors, presumably with better diversification, can absorb that additional risk for a suitable premium. The risk is that it may dilute the sponsor's stake if the put is exercised.

5. Price Collar Swap

Under such a swap,²⁰⁵ the project sponsor and the utility offtaker agree on a floor price for generated energy. If the federal tax credit is lost, making project economics less favorable, the offtaker pays a higher rate to compensate based on contract language. If the credit remains intact, the project might offer the offtaker a reduced price or share in additional revenue gains. The sponsor, in turn, hedges revenue risk without exposing itself to market price volatility after losing federal incentives.

[204] Jim Lantis and Kayla Schultz, "Tax Equity Buyout: Practical Considerations for Sponsoring Investors," CohnReznick, August 12, 2024, [cohnreznick.com](https://www.cohnreznick.com).

[205] Synertics, "Understanding Financial PPAs with Collars," Synertics Blog, March 11, 2024, [synertics.io](https://www.synertics.io).

CONCLUSION

The Inflation Reduction Act has fundamentally reshaped renewable energy investment in the United States, but its future under the current political landscape remains uncertain. Based on our comprehensive analysis across technology pillars, policy environments, and financial structures, we conclude the following:

Political Vulnerability Assessment

The IRA faces a spectrum of political risks, with varying degrees of vulnerability across different provisions:

- Core Tax Credits (45Q, 48E, 45Y) remain the most politically durable components, requiring legislative action for full repeal. Their economic benefits in Republican districts create bipartisan incentives for preservation.
- Regulatory Provisions including bonus adders (domestic content, energy communities) face higher vulnerability through administrative action, as they can be delayed, reinterpreted, or scaled back without congressional approval.
- Transferability Mechanisms (Section 6418) are at moderate risk during budget negotiations, as they could be modified or capped as political bargaining chips.

Technology-Specific Impacts

Our financial modeling reveals differential impacts across clean energy technologies:

- Solar and Storage: Remain financially viable even with partial rollbacks due to falling costs and established market position, though project returns would decline.
- Wind: Highly dependent on IRA tax credits, with potential rollbacks significantly impacting project economics. Only the most favorable sites would remain viable under reduced incentives.
- Green Hydrogen: Most vulnerable to policy changes, with financial viability contingent on 45V credits and transferability provisions. Project IRRs fall below investment thresholds in most repeal scenarios.
- CCUS: Enjoys stronger bipartisan support but faces permitting bottlenecks that could undermine deployment regardless of tax credit preservation.

CONCLUSION

For Captona to navigate this uncertain policy environment, we recommend a multi-faceted approach:

1. Short-Term Focus: Prioritize projects that can reach significant construction milestones in 2025 to secure safe harbor protection under current guidance.
2. Geographic Diversification: Emphasize development in states with complementary clean energy policies and streamlined permitting processes.
3. Technology Balancing: Maintain core investments in proven technologies (solar, storage) while selectively pursuing emerging sectors with bipartisan appeal (CCUS, RNG).
4. Financial Structuring: Implement contingency mechanisms such as two-tranche financing facilities, equity ratchets, or reserve funds to mitigate potential incentive losses.
5. Operational Excellence: Focus on cost optimization and revenue diversification to reduce dependence on federal incentives.

While the IRA faces challenges under the current administration, its complete dismantling remains unlikely. Strategic investors who can navigate partial rollbacks through careful project selection, financial innovation, and policy monitoring will continue to find compelling opportunities in the U.S. clean energy transition.

ACKNOWLEDGEMENT

We would like to express our profound gratitude to Professor Jeanne Fox and Mr. Louie Reckford for their exceptional guidance and support throughout the course of this Capstone project.

Professor Fox, our faculty advisor at Columbia SIPA, played a pivotal role in shaping our research and analytical framework. Her deep knowledge of energy policy, combined with her unwavering commitment to mentorship, elevated the rigor and relevance of our work. From the start, Professor Fox provided strategic direction, fostered critical discussions, and consistently challenged us to engage more deeply with the complex intersections of policy, politics, and clean energy investment. Her support extended well beyond the classroom through meaningful introductions to industry leaders and ongoing feedback that significantly enhanced the quality of our final deliverables.

We are also deeply thankful to Mr. Louie Reckford, our advisor from Captona, for his thoughtful guidance and constructive feedback throughout the project. Mr. Reckford clearly articulated the Captona's objectives, helped us refine our methodology, and provided valuable insights during our regular check-ins. His contributions were instrumental in ensuring our analysis aligned with Captona's strategic priorities.

We are especially grateful to the public and private sector professionals, policymakers, and academic experts who generously shared their time and insights with us. Their perspectives were critical to understanding the evolving clean energy landscape and informed the core of our recommendations.

Finally, we thank Columbia SIPA for supporting this unique opportunity, and Captona for entrusting us with a project that addresses such a timely and consequential topic in the energy transition space.

MEET OUR TEAM



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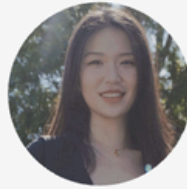
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Linden Site Visit. April 23rd, 2025

APPENDIX I

EXPERT INTERVIEWS

Expert Interviews Conducted by the SIPA Capstone Team

January – April 2025

The following interviews were conducted as part of original research for this report. Interviewees included professionals from the public sector, private investment and clean energy firms, and academic institutions. These conversations informed our assessment of the Inflation Reduction Act's implementation, tax credit vulnerabilities, and sector-specific outlooks.

To respect confidentiality agreements and protect the candid nature of these discussions, specific quotes or viewpoints are not attributed by name in the body of the report.

PUBLIC SECTOR & POLICY EXPERTS

- Sindhu Nathan, Senior Energy Official, U.S. Senate
- Pete Wyckoff, Assistant Commissioner for Federal and State Energy Initiatives, Minnesota Department of Commerce
- Miranda Peterson, Policy Advisor, U.S. Senate
- Chris Jackson, Senior Energy Official, U.S. Senate

ACADEMIC EXPERTS

- Phil LaRocco, Adjunct Professor of Practice, Columbia University SIPA
- Jon Elkind, Senior Research Scholar, Columbia Center on Global Energy Policy
- Gernot Wagner, Climate Economist and Professor, Columbia Business School
- David Burton, Partner, Norton Rose Fulbright; Lecturer, Columbia University SIPA

PRIVATE SECTOR PRACTITIONERS

- Samuel Schreiber, Senior Managing Consultant, E3
- Stephanie Eldridge, Senior Vice President, Bank of America Sustainable Finance
- Marshall Mclean, Managing Director, Climate Investment Firm
- Michael Fairbanks, Clean Energy Analyst, J.P. Morgan
- Daniel Giuffrida, Founder, Independent Solar Developer; Lecturer, Columbia University
- Harry Warren, Managing Partner, Clean Infrastructure Consulting
- Joel Moser, Principal, Private Energy Development Firm; Lecturer, Columbia University
- Representatives from Sol Systems (solar project developer and financier)
- Retired Chief Information Officer at a hedge fund
- Former geopolitical risk managing director at a hedge fund
- Energy derivative trader

APPENDIX II

TAX STRUCTURE

Timeline:

These timelines dictate the window for leveraging credits to offset the high costs of adopting sustainable technologies, ensuring projects are prioritized and funded before subsidies diminish or expire.

For Clean Electricity credits (48E and 45Y), the timeline shows full availability until January 1, 2032, followed by a gradual phase-out, or the year when GHG emissions from electricity production are equal to or less than 25% (from 2022 levels).

The CCUS (45Q) and Clean Hydrogen (45V) credits have the longest timelines, extending through 2035, with 45Q offering a 12-year and 45V offering 10-year claim period for projects starting construction before 2033.

While Clean Fuel Production (45Z) is limited from 2025 through 2027. Which applies to eligible transportation fuel produced domestically after December 31, 2024, that is sold by December 31, 2027.

Zero-Emission Nuclear Power (45U) applies to existing nuclear facilities. Credits can be claimed through 2032, provided the facility continues to operate and meets labor and emissions criteria.

APPENDIX II

TAX STRUCTURE

Tax Credits Timeline

Name	Technology	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	...	2043	2043	2044	2045
		1	2	3	4	5	6	7	8	9	10	11	12	...	17	18	19	20
48E	Clean Electricity	100%	100%	100%	100%	100%	100%	100%	100%	75%	50%	0%						
45Y	Clean Electricity	100%	100%	100%	100%	100%	100%	100%	100%	75%	50%	0%						
45Q	CCUS																	
45Z	Clean Fuel																	
45V	Clean Hydrogen																	
45U	Zero-Emission Nuclear Power																	

Eligible Tax Credit

Eligible Tax Credit			
Technology	PTC	ITC	Comment
Solar	45Y	48E	Eligible for both 45Y (PTC) and 48E (ITC). Most utility-scale solar projects currently favor 48E due to high upfront capital costs and eligibility for bonus credits like domestic content and energy communities.
Wind	45Y	48E	Also eligible for both 45Y and 48E. Onshore wind often uses the PTC (45Y) for consistent revenue over time.
Battery Storage	45Y	48E	
CCUS	45Q or 45V 45Y	48E	Facilities cannot simultaneously claim both 45Q and 45V. However, under final IRS guidance, technologies such as natural gas generators with carbon capture plant will likely benefit more from the new tech-neutral credits (45Y/48E), offering greater flexibility in project structuring.
Clean Fuel	45Z	48E	
Clean Hydrogen	45V or 45Z	48E	Eligible for either 45V or 45Z (PTC), depending on project design. 45V is CI-based and can reach \$3/kg; 45Z is broader but lower per-unit value. Projects may also opt for 48E.
Nuclear	45U	48E	Eligible under 45U (PTC) and 48E (ITC). 45U supports existing zero-emission plants at risk of closure. New projects likely to opt for 48E given high upfront costs.

APPENDIX II

TAX STRUCTURE

This table shows whether developers can utilize an Investment Tax Credit (ITC) or Production Tax Credit (PTC) for different clean energy technologies.

Name	Technology	Type	Latest Rule/Guideline	Timeline	Base Credit	Full Credit*	Adders	Max Credits
48E	Tech-Neutral Clean Electricity	ITC	Jan 15, 2025	Jan 1, 2025 - Jan 1, 2032, or until GHG emissions from electricity \leq 25%	6% of project cost	30% of project cost	+10% for domestic content+10% for energy communities +(10-20)% for low-income areas	Up to 70% of project cost
45Y	Tech-Neutral Clean Electricity	PTC	Jan 15, 2025	Jan 1, 2025 - Jan 1, 2032, or until GHG emissions from electricity \leq 25%	0.30¢/kWh generated	1.5¢/kWh generated	+10% for domestic content+10% for energy communities	Up to 1.8¢/kWh generated
45Q	CCUS	PTC	Jul 24, 2024	Up to 12 years after equipment placed in service	Varies: \$12-\$180/metric ton(depends on storage method, start date)	Full value requires prevailing wage & apprenticeship	N/A	N/A
45Z	Clean Fuel	PTC	Jan 10, 2025	Jan 1, 2025 - Dec 31, 2027	Clean fuels: \$0.20/gallon SAF: \$0.35/gallon	Clean fuels: \$1.00/gallon SAF: \$1.75/gallon	N/A	N/A
45V	Clean Hydrogen	PTC	Jan 10, 2025	Starts Dec 31, 2022, operates for 10 years	\$0.60/kg H ₂ , produced	Up to \$3.00/kg H ₂ produced	N/A	N/A
45U	Zero-Emission Nuclear Power	PTC	Aug 16, 2022	Until Dec 31, 2032	0.3 cents/kWh	1.5 cents/kWh	N/A	N/A

For full credit under the Inflation Reduction Act (IRA), clean energy projects must meet Prevailing Wage and Apprenticeship standards. This means that all laborers and mechanics involved in construction, alteration, or repair must be paid wages at or above the rates set by the U.S. Department of Labor for similar work in that area. Additionally, a certain percentage of total labor hours must be completed by registered apprentices from certified apprenticeship programs. Meeting both standards allows the project to qualify for the full value of the tax credit, instead of receiving the base rate.

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