Solar Roof Monetization in US Industrial Real Estate

by

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ABSTRACT

The transition towards clean energy in the US has placed the industrial real estate sector at the forefront of solar energy adoption, to leverage the underused extensive roof for solar power generation. This thesis scrutinizes the process of solar roof monetization, assessing the interplay between market dynamics, policy frameworks, and the financial implications of various solar roof business models within industrial real estate sector.

Through a mixed-methods approach, including structured interviews with industry stakeholders and an extensive review of public databases and industry research reports, the research delineates the nuanced dynamics of the industrial solar market, marked by state-dependent variability and diverse regulatory environments, and business model for deployment. The study critically assesses two predominant business models – self-ownership and roof leasing, exploring their operating structure and implications to real estate owners.

Utilizing a model grounded in real-world industrial underwriting, the thesis extends to a detailed financial analysis of the two solar roof business models integrating federal- and state-level policy incentives, signatured with tax credits, accelerated depreciation and renewable energy certificates. A critical examination of operating metrics – production efficiency, capital expenditures, financing costs, and revenue projections – also reveals their pivotal impact on investment returns.

The thesis concludes with practical implications for industry stakeholders, providing a comprehensive guide to executing solar roof projects that not only align with corporate sustainability targets but also enhance financial and property values. This paper serves as a roadmap for industrial real estate owners seeking to capitalize on the transition to a cleaner energy grid while reinforcing their market position in an evolving landscape shaped by environmental imperatives and economic opportunities.

Thesis supervisor: Albert Saiz

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Mr. Peter Merrigan
Mr. Vibhu Kaushik
Mr. Zachary Vaughn

Your willingness to share time and industry insights has been a cornerstone of this work, providing a genuine reflection of industry practices and contributing to the broader narrative of sustainable advancement within the real estate sector. The inspiring and meaningful work you are doing is what advances the real estate sector and promotes the transition to cleaner energy for our world.

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Chapter 1. Introduction

1.1 Rise of solar solutions in industrial real estate

The real estate industry is witnessing a discernible shift towards a heightened consciousness about environmental and energy costs. This trend is not just a result of mounting global concerns over climate change, but also the realization that sustainable practices can lead to significant financial benefits in the long run.

In the pursuit of climate change mitigation and fluctuating energy prices, decarbonizing the built environment with clean energy has emerged as a pivotal strategy. Central to this effort are solar photovoltaic (PV) systems, which are now more affordable than ever, particularly in the US with a nation-level commitment to achieve 100% net-zero electricity grid by 2035, a target demanding profound transformations in energy production.

Industrial real estate, often featuring expansive, unused rooftops, is ideally positioned to capitalize on solar energy. Converting these spaces into solar generation areas not only aids in grid transition but also unlocks new revenue streams for property owners.

The decline in solar system costs, alongside the fluctuations of electricity prices dependent on traditional resources, extends industrial property owners' prime opportunities to monetize their rooftops. Plus, the Inflation Reduction Act of 2022 acts as a catalyst, further enhancing the financial feasibility of rooftop solar projects through a range of federal and state incentives.

Industrial solar roofs, therefore, provide a dual benefit for the industrial real estate sector: they contribute to a greener grid and yield tangible financial returns, embodying the potential for substantial environmental and economic impact.

1.2 Thesis purpose and structure

This paper explores the monetization strategies for solar roofs by examining market dynamics, policy incentives, and the prevalent business models applied by the industrial real estate sector, paired with a thorough financial analysis of solar investments. The extended analysis provided in this paper tend to act as a roadmap for stakeholders in the industrial real estate industry who are looking to leverage solar roofing opportunities.

Chapter 2 examines the current market dynamics of fragmented solar roof landscape, which is shaped by solar radiation, industrial property inventory, number of supportive policies and electricity tariff. It also offers an insight into installed on-site solar capacities of major corporate players.

Chapter 3 outlines the array of federal and state policy incentives that are essential for the monetization of solar roofing, which act as significant drivers for industry growth and investment.

Chapter 4 presents an investigation into the business models of developing solar roof within industrial real estate. This investigation is informed by interviews with a diverse range of stakeholders, encompassing real estate owners, investors, and solar energy advisory. It provides a comprehensive examination of prevailing business models that have emerged within the solar roof sector, detailing the unique strategies and financial incentives that are available to industrial real estate owners.

With the exploration of business models, **Chapter 5** articulates a financial analysis applied to a hypothetical based in New Jersey, meticulously constructed to simulate the real-world application of different business models, scenarios and financing methods. The case study serves as a vehicle for quantifying and comparing the potential returns on investment and incremental value on the property across different solar implementation strategies.

Finally, **Chapter 6** recaps the study on the market growth, policy context, business implementation models and financial analysis, to provide implications to industry stakeholders for conducting solar roof solutions with the vision of potential challenges.

1.3 Research methodology and limitations

The research methodology for this paper is multi-faceted, aiming to draw from a wide array of perspectives within the industry, involving both primary and secondary information collection.

Primary information on the industry practice is collected through structured interviews with stakeholders. The interviewee profiles are outlined below:

- Total number of companies: 6
- Total number of interviewees: 9
- Company ownership structure: 2 public real estate/REITs companies, 2 private real estate companies, 2 solar energy advisory firms
- Company size: mid-to-large cap with nationwide operations
- Geography: 5 US headquartered and 1 globally headquartered with major operations in the US
- Asset class: 2 real estate companies specializing in industrial sector, 2 real estate companies covering all asset types
- Function and seniority: 6 senior leaders/analysts in renewable energy or ESG, 3 company CEO/co-founders

These interviews are designed to glean insights into the practical experiences, strategic approaches, and financial impacts of solar roof implementations in real estate.

Secondary data regarding the solar market landscape and policy incentives is sourced from an extensive review of public databases, including federal and state government websites, policy databases, solar industry research reports, and real estate broker research publications. Specially, the financial analysis is adapted from a real industrial underwriting model for solar roof, with underwriting assumptions based on the specific market.

While the paper is intended to provide insights into the market, policy incentives and business practice of US industrial real estate companies to do solar roof, there are several limitations of this research given the feasibility of data and information collection.

Limited study scope: The primary data is based on interviews with only a limited number of companies, which may not fully represent the diversity and breadth of the industry especially with a lack of smaller-cap companies.

Data availability and bias: The reliance on public databases for secondary data means the research is constrained by the availability and transparency. Additionally, the industry research reports, and brokerage data used could potentially reflect subjective interpretations, thereby not offering a completely unbiased viewpoint.

Segmented industry landscape: Given the variability of solar roof adoption and the impact of state-level policies, some findings may not be applicable across different states or regions due to the segmented nature of the market and regulatory environments.

Time sensitivity: Market trends, policy incentives, and capital costs in the solar industry are subject to rapid change. Some findings might become outdated quickly, requiring constant updates to maintain relevance.

Complexity of financial analysis: Financial impacts are often complex and can be affected by a multitude of variables not fully explored in this paper. The financial analysis might not capture all the nuanced factors that affect the profitability and cost-efficiency of solar roof investments.

Chapter 2. Industrial solar roof market dynamics

2.1 Mapping fragmented solar energy landscape in the US

The US is a leading producer of solar energy with diverse sunlight resources across states. According to Solar Energy Industries Association (SEIA)[1], as of Q3 2023, the US boasted around 161 GW of solar PV capacity installed. Over the past decade, the US commercial solar sector has seen a CAGR of 7.0% and expecting 8% annual growth in next five years (see Figure 1). This expansion is fueled by dropping PV panel costs, favorable financial incentives from government such as the Investment Tax Credit and Renewable Energy Certificate, and a growing appetite for clean energy from both the public and private sectors. Notably, industrial infrastructures like warehouses and distribution centers with extensive flat roofs, are significant contributors to this commercial growth.

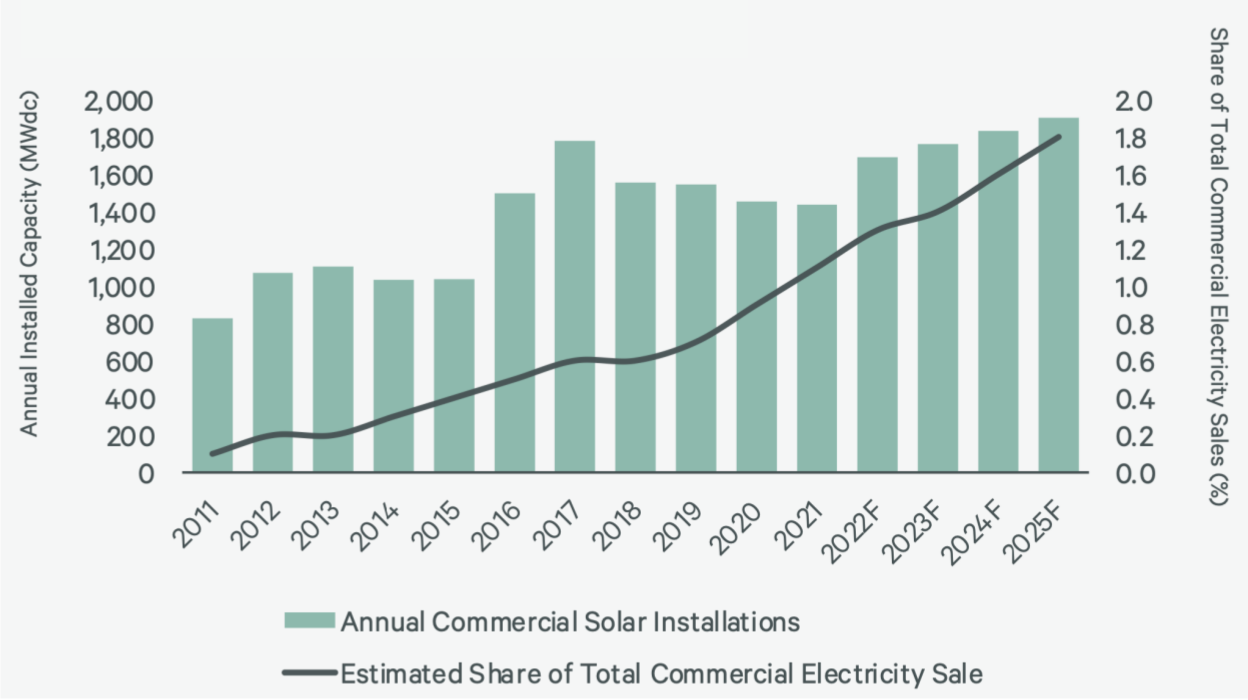

Figure 1 – Commercial Solar Installations Since 2011 and Forecast (CBRE, 2022)
Note: MWdc is Megawatt of power with direct current

[1] Wood Mackenzie and Solar Energy Industries Association, *US Solar Market Insight Executive Summary Q4 2023* (Wood Mackenzie and Solar Energy Industries Association, 2023), 4.

While nation-level commercial solar sector is in robust growth, the industry is a “50-state” market which vary by regions significantly with factors including solar radiation, industrial property inventory, number of supportive policies and retail electricity rate.

Solar radiation

The irradiance map referenced suggests that West Coast and Southeastern states possess the greatest solar potential due to higher levels of sunlight, whereas the Northeast and Midwest see less solar radiation (see Figure 2).

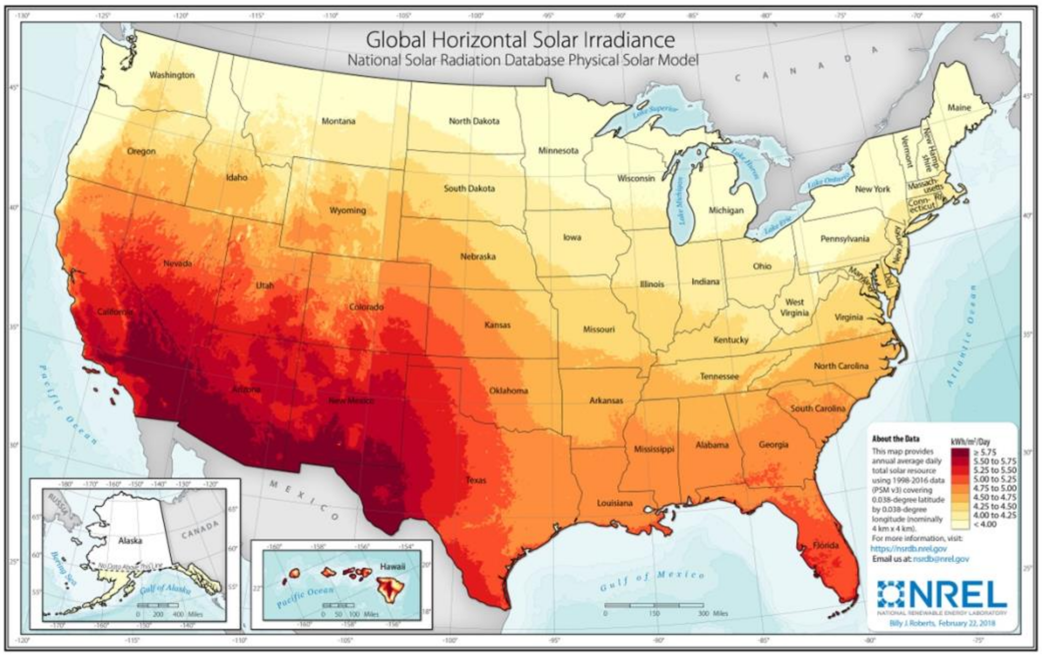

Figure 2 – Global Horizontal Solar Irradiance Map in US (National Renewable Energy Laboratory, 2018)

Industrial property inventory

The assessment of solar roof market specifically in the industrial real estate sector also requires considerations on the available industrial property space. States such as California, Texas, Florida, New York, Pennsylvania, Ohio, and Illinois, with their extensive logistics real estate inventory exceeding 1 billion square feet (SF), offer substantial opportunities for solar roof development (see Figure 3).

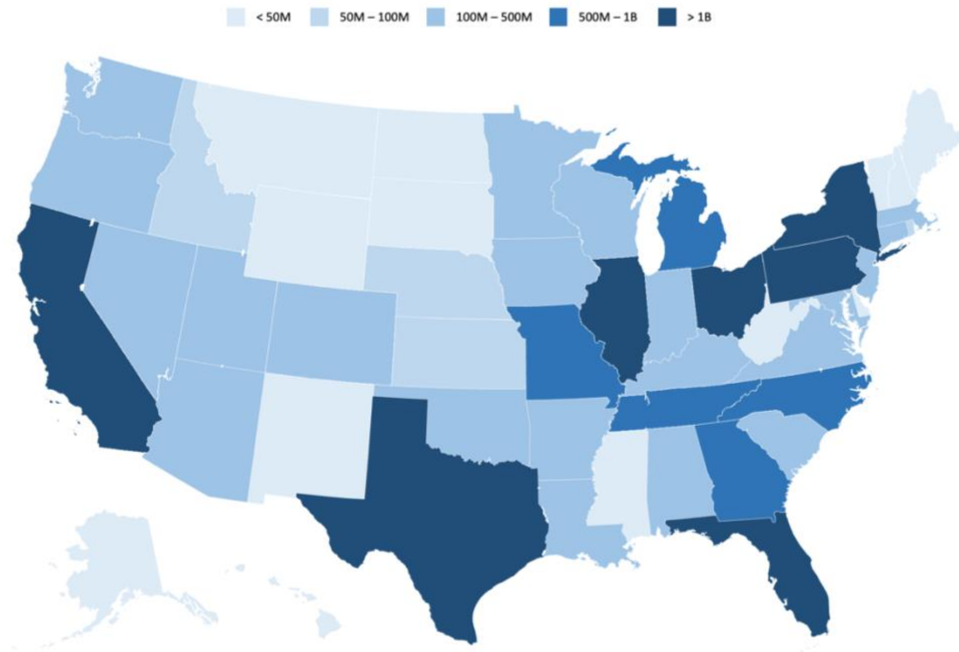

Figure 3 – Industrial Real Estate Inventory (SF) by States as of Q3 2023 (Cushman & Wakefield, 2023)

Number of supportive policies

Policy actions and incentives are key to identifying and nurturing solar energy markets with significant growth potential. The NC Clean Energy Technology Center offers a map that charts various state-level incentives and policies fostering solar PV development across the US (see Figure 4). Per this map, states like California, Texas and Colorado are distinguished by their active

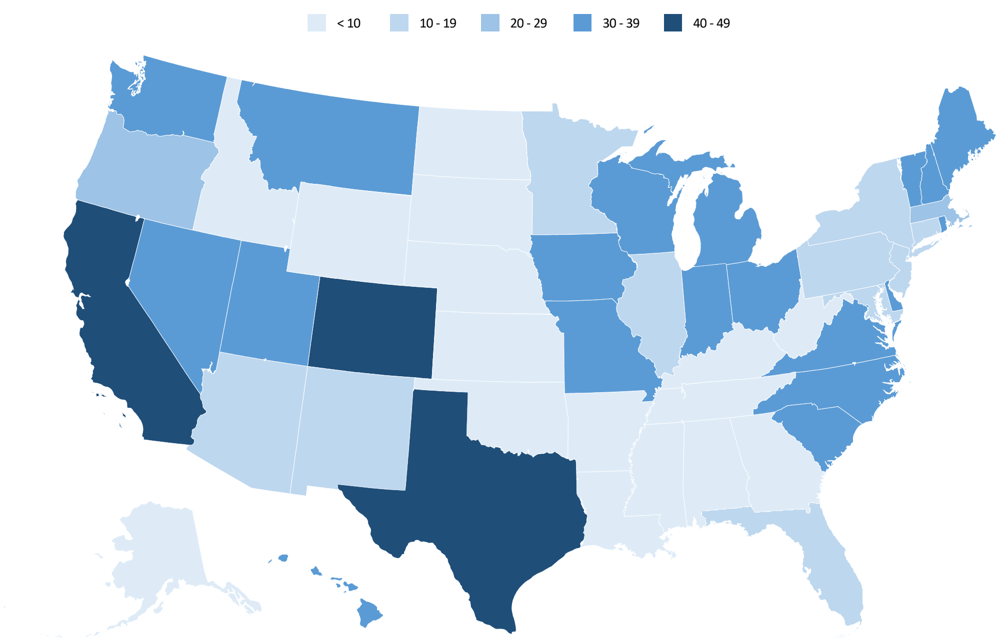

Figure 4 – Number of State-level Solar PV Policies and Incentives (NC Clean Energy Technology Center, 2023)

policy landscapes that bolster solar energy development. This proactive stance suggests that these states may experience considerable growth in their solar markets, propelled by supportive policies.

Retail electricity tariff

Between 2012 and 2020, electricity prices remained relatively stable until the onset of the COVID-19 pandemic. With the sharp uptick in inflation that began in early 2021, energy costs, including electricity, climbed correspondingly. Concurrently, prices for natural gas soared, which passed to utility-scale electricity as natural gas fuels approximately 38% of US electricity generation in 2022 according to US Energy Information Administration (EIA)[2], causing a 24.7% increase in electricity tariff for industrial sector. Simultaneously, the installation costs for solar PV systems in the US have decreased substantially by 62% over 2012 - 2022, presenting a significant investment opportunity in solar energy amidst the backdrop of rising electricity prices (see Figure 5). Variation of electricity across the US, influenced by factors such as energy sources, state policies, and global events, further strengthened the difference of each regional solar market. California, New England, Alaska, Hawaii, and New York face the highest electricity costs, largely due to high reliance on natural gas and energy policies not prioritizing cost or reliability, alongside regulatory hurdles.

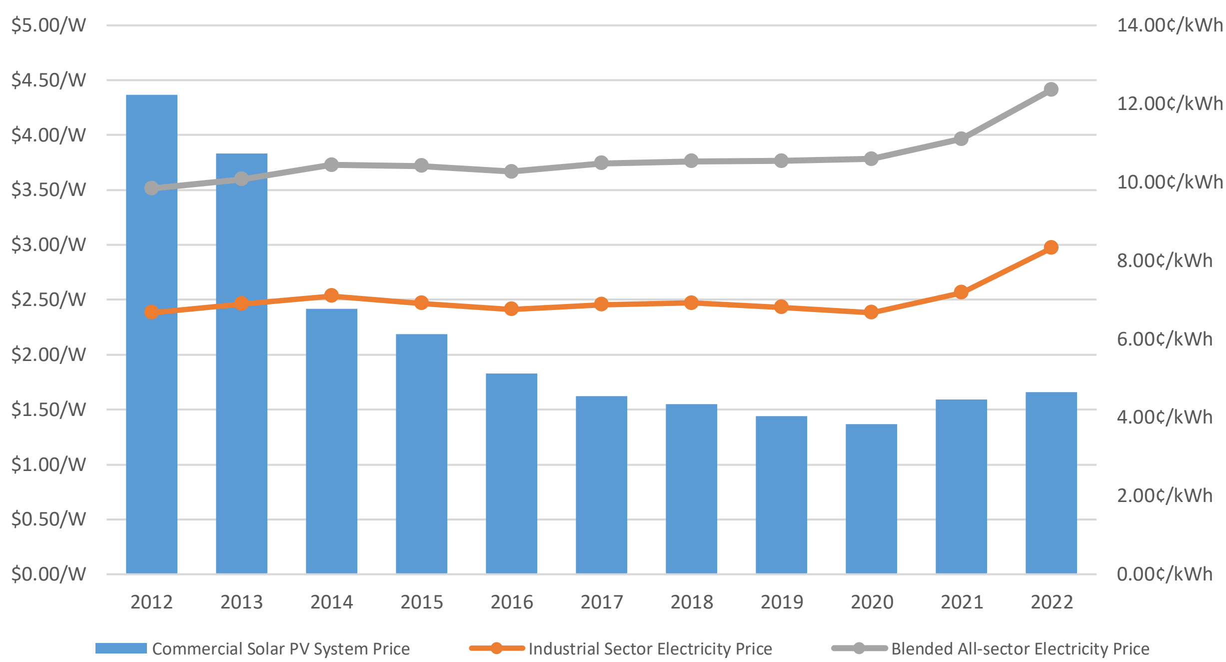

Figure 5 – Number of State-level Solar PV Policies and Incentives (EIA & SEIA, 2023)

[2] U.S. Energy Information Administration, *Average Price of Electricity to Ultimate Customers by End-Use Sectors 2012 through 2022*, October 19, 2023, https://www.eia.gov/electricity/annual/html/epa_02_04.html.

Conversely, eleven states, notably Wyoming and North Dakota, have rates below 10 ¢/kWh, benefiting from coal and renewable energy sources (see Figure 6).

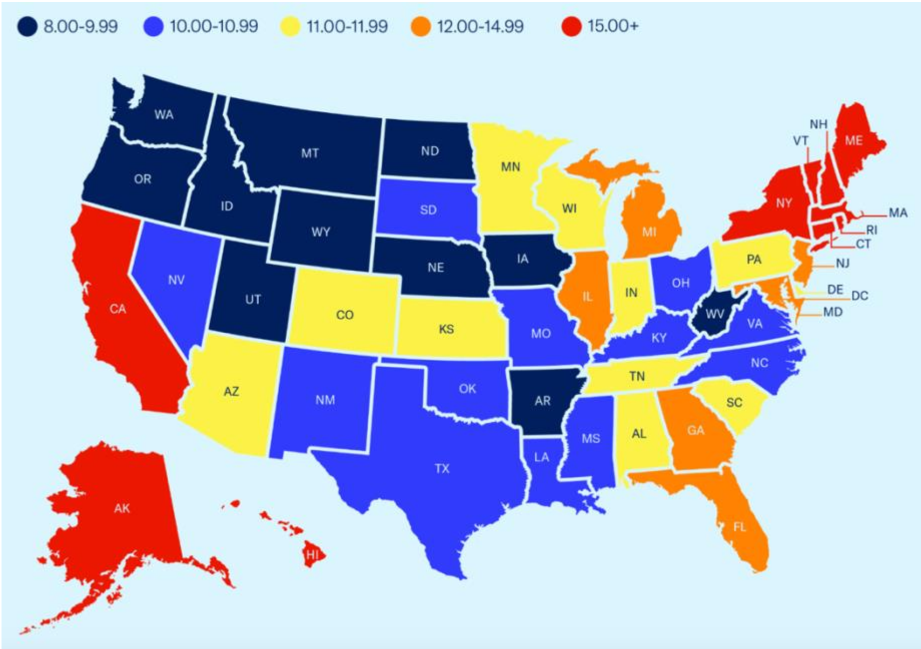

Figure 6 – Average Electricity Retail Price in US as of 2022 (U.S. Chamber of Commerce's Global Energy Institute, 2023)

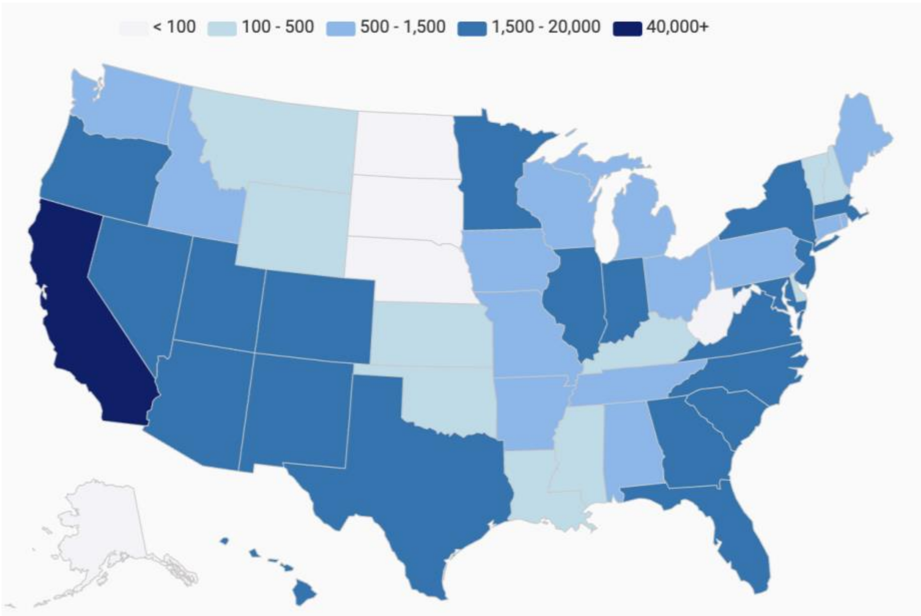

Figure 7 – Cumulative Solar Installations (MW) by State as of Q3 2023 (SEIA, 2023)

Compounded factors from solar capacity, property inventory, policy incentives and electricity rates, generate a highly fragmented landscape of solar markets across states. Historically, California has been at the forefront of the US solar energy sector with abundant solar radiation, supportive policies, and high retail electricity price, and further strengthened by large industrial property stock for solar roof growth. However, the landscape is shifting as other states experience swift growth. In recent years, Texas, Illinois, Florida, New Jersey, and New York notably increased their solar installations (see Figure 7).

Taking the above factors into consideration, CBRE's research identifies 15 submarkets with high potential for solar roof installations, selecting properties with over 100,000 SF of roof space close to populated areas[3]. These properties, 1.2B SF in total, represent 58% of the industrial building inventory since 2010. With an estimation of each 100,000 SF of roof potentially generating 1.2 GWh annually, these markets could collectively produce 350 to 1,700 GW of energy, contributing up to 11.7 TW, or 0.3% of the US total energy consumption in 2021.

Market	**Number of Qualified Properties**
Inland Empire	416
Dallas	314
Indianapolis	169
Kansas City	122
Memphis	71
Chicago	446
Houston	392
Phoenix	189
Central NJ	125
Savannah	78
Atlanta	315
Fort Worth	231
Columbus	112
Allentown	86
Stockton	73

Table 1 – Top 15 Markets for Potential Solar Growth Opportunities (CBRE, 2022)

[3] CBRE Econometric Advisors, *Solar Energy Opportunities in U.S. Industrial Real Estate* (CBRE, 2022), 7.

Market	Industrial Property Under Construction (SF)
Dallas	52.5M
Phoenix	49.6M
Inland Empire	42.2M
Atlanta	35.4M
Chicago	30.9M

Table 2 – Top 5 Markets of Property under Construction as of Q3 2023 (CoStar, 2023)

Within the examined markets, five stand out for having the most extensive development pipeline for industrial properties (see Table 2). The growing awareness of decarbonization, coupled with the shift towards renewable energy adoption, has fueled a preference for incorporating solar roofs into new industrial developments. Consequently, properties currently under construction are poised to make a significant contribution to the expansion of the industrial solar roof market.

2.2 Major corporate players

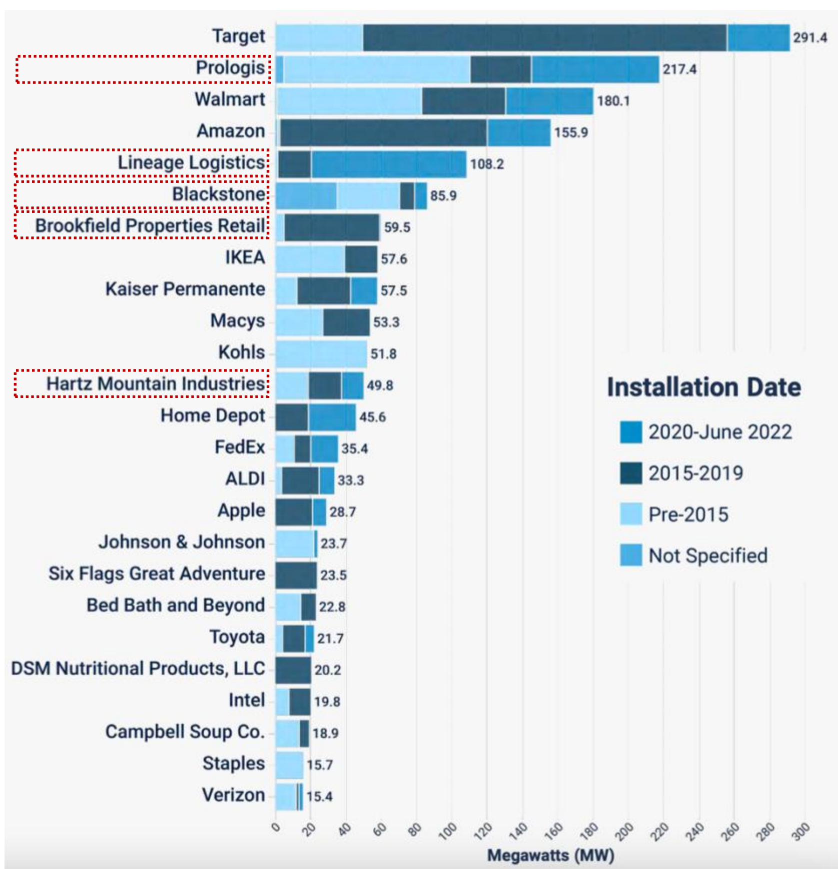

Figure 8 – Top 25 Corporate Users by Total Installed On-Site Solar Capacity (SEIA, 2022)

The commercial solar market is significantly influenced by major corporations from diverse sectors (see Figure 8). Retail and technology giants such as Target, Walmart, and Amazon consistently rank high in terms of on-site solar capacity installation. Real estate firms, particularly those with large industrial portfolio, gain advantages from their expansive building footprints and roof areas, allowing substantial solar installations. Companies like Prologis, Lineage Logistics, Blackstone, Brookfield, Hartz Mountain are among the top 15 companies by on-site solar capacity, leveraging their considerable real estate assets to invest in sustainable energy solutions.

While significant solar energy development progress has been made among these first movers, industrial REITs present underexploited opportunities for roof solar. Analysis of six prominent industrial REITs reveals a discrepancy between the current on-site solar capacity reported by these companies and the feasible capacity (see Table 3). It is assumed that up to 70% of roof space is suitable for solar PV panel installation, with an expected power output density of 15W per square foot. This untapped potential presents a considerable opportunity for industrial REITs to further embrace solar energy and leverage their extensive roof areas for the generation of sustainable power.

Company Name	US Footprint (MSF)	Approx. Roof Area[4] (MSF)	Potential On-site Solar Capacity[5] (MW)	Installed On-site Solar Capacity (MW)	Market Cap ($M)
Prologis	797.0	531.3	5,579.0	217.4	103,059.7
Rexford Industrial Realty	42.4	28.3	296.8	9.0	10,023.2
STAG Industrial	112.0	74.7	784.0	25.6	6,503.9
Terreno Realty Corporation	15.8	10.5	110.6	8.4	4,764.5
Granite REIT	38.8	25.9	271.6	10.9	3,205.1
Dream Industrial REIT	9.7	6.5	67.9	19.5	2,454.1

Table 3 – Solar Capacity of Selected Large/mid Cap Industrial REITs as of Q2 2023 (Capital IQ, Company reports, 2022)

[4] Assuming 67% of total footprint to be roof space
[5] Assuming 70% roof space efficiency for solar PV installation and 15W capacity per SF

Chapter 3. Policy and incentives

3.1 Regulatory policy

Net metering and interconnection (state-level)

Solar roof may generate more electricity than the building needs as industrial properties are usually less energy intensive. This excess power can be sent back to the utility electricity grid through a billing mechanism known as "net metering". It allows the owners of the solar panels to receive a credit on their utility bills for the power they contribute to the grid. The amount credited is often at the full retail price of electricity, which is quite beneficial to solar system owners since their operational costs for electricity generation are usually lower than those of traditional utility companies.

However, the rules for net metering of solar systems to the grid can differ by state and are subject to change. For example, California is considering a change in current net metering policy that would lower the credit rates, altering the financial benefits for roof solar owners, which has met with some resistance and is still under evaluation[6]. Similarly, in Florida, there was a proposal to reduce the credit given for net metering in 2022, but it was vetoed by the state governor[7]. Plus, Alabama, South Dakota and Tennessee are not offering net metering programs yet. These examples highlight the dynamic nature of policies across states affecting the economic incentives for adopting solar energy.

Interconnection delay and high cost is another headwind. Driven by covid-related slowdowns and overall, a large queue of projects, developers are seeing material delays in the approval of new projects. Lawrence Berkeley National Laboratory (LBNL) reports that the timeline from the initial connection request to having a fully built and operational plant has increased from less than 2 years for projects built in 2000-2007 to nearly 4 years for those built in 2018-2022, with the vast majority

[6] California Public Utilities Commission, *NEM Revisit Proceeding (R.20-08 020),* November 15, 2023, https://www.cpuc.ca.gov/nemrevisit

[7] Abbie Bennett, "Fla. Governor Vetoes Controversial Net Metering Bill," S&P Market Intelligence, April 27, 2022, https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/fla-governor-vetoes-controversial-net-metering-bill-70024382.

of request coming from solar capacity[8]. LBNL also points out that interconnection costs have grown substantially over time and upgrade requirements of the broader transmission system are the primary cost driver. Without reforms, interconnection is likely to remain a major obstacle to meeting solar energy deployment.

Community solar program (state-level)

Solar roof owners can engage in community solar programs, where they sell electricity to individuals who can't install their own solar systems. Within community solar program, all the power generated is firstly feed into the grid, and then allocated to subscribers, who compensate the solar owner at a predetermined rate. This arrangement often results in lower electricity expenses for the subscribers when compared to standard utility costs, benefiting community members, especially those in lower-income brackets. With its growing appeal, particularly among households, solar owners can potentially earn more from these sales than they would through net metering due to the higher rates of residential sector end-users.

Community solar provides real estate owners with an additional revenue stream by leasing their roofs to solar developers who install panels on the property. The generated electricity is then connected to the local grid. Real estate owner can also offer property tenants the option, not an obligation, to subscribe community solar for cheaper and cleaner energy.

Such initiatives are typically regulated by public utility commissions and implemented in collaboration with utility companies. This approach not only strengthens community ties and supports local energy needs but also allows property owners to align with Environmental, Social, and Governance (ESG) criteria, demonstrating a commitment to sustainable practices while earning additional lease income.

The community solar sector has expanded from under 1 GW at the end of 2017 to about 5 GW by the end of 2022[9]. Policy developments in states like New Jersey, Maryland, and Minnesota have been positive, with expansions and reforms aiming to bolster the community solar market and

[8] "Grid Connection Requests Grow by 40% in 2022 as Clean Energy Surges, despite Backlogs and Uncertainty," *Berkeley Lab - Electricity Markets & Policy*, April 6, 2023, Lawrence Berkeley National Laboratory, https://emp.lbl.gov/news/grid-connection-requests-grow-40-2022-clean.
[9] Solar Energy Industries Association, *The 2022 Solar Means Business* (Solar Energy Industries Association, 2023), 26.

incentivize property owners to conduct solar roof solutions. Despite this growth, the sector is facing challenges like market saturation in established areas, ongoing interconnection delays, and slow program reform, all contributing to ongoing hurdles for deployment at scale.

Solar related mandates (state-level)

Beyond encouraging policies, some states have established mandatory requirements for the integration of solar solutions into buildings. California will lead the nation in 2023 by requiring the installation of solar PV and energy storage systems on all new and select retrofitted commercial buildings, an update that stems from the California Energy Commission's 2022 Building Energy Efficiency Standards[10].

Similarly, New Jersey has taken legislative action with the passage of Assembly Bill A3352 in 2021, which obligates certain new warehouses to be constructed with solar readiness in mind. Specifically, this legislation dictates that any new warehouse structures that are 100,000 SF or more must allocate a minimum of 40% of their roof area to accommodate the future installation of solar PV or thermal systems.

In many states, mandates requiring the adoption of solar energy have primarily targeted the residential sector. However, with trailblazing states such as California and New Jersey setting precedents, and the increasing drive toward achieving state-level clean energy goals, it is expected that more states will broaden these mandates to encompass the commercial and industrial sectors.

3.2 Financial incentives

Tax credit (federal-level)

Industrial real estate owners can benefit financially from two main solar tax credits: the Investment Tax Credit (ITC) and the Production Tax Credit (PTC)[11]. The ITC offers a 30% base deduction on the installation costs of solar systems from federal taxes which meets prevailing wage and apprenticeship requirements. The ITC is in place for the next 10 years through the gamechanger Inflation Reduction Act (IRA) passed in 2022. The PTC gives a credit for the electricity

[10] California Energy Commission, *2022 Building Energy Efficiency Standards.* CEC-400-2022-010-CMF. August, 2022, 148. https://www.energy.ca.gov/sites/default/files/2022-12/CEC-400-2022-010_CMF.pdf
[11] "Federal Solar Tax Credits for Businesses," Solar Energy Technologies Office, August 2023, https://www.energy.gov/eere/solar/federal-solar-tax-credits-businesses#_edn1.

(2.75 ¢/kWh) that solar systems produce over the first 10 years of a system's operation, which reduces the federal income tax liability and is adjusted annually for inflation.

Often, solar project developers don't have enough tax liability to immediately benefit from the ITC. To capitalize on the tax advantages that come with their projects, developers commonly enter "tax equity" transactions, typically via a partnership between the developer and tax equity investors, which will be discussed in detail in next chapter. The 2022 IRA, however, introduces a new dynamic by allowing the direct sale of these tax credits. This enables developers to turn their tax credits into cash benefits upfront, without needing the tax appetite usually required to benefit from the tax credits.

Property owners can't use both credits for the same property, though they can claim different credits for co-located systems, like solar and storage, subject to further guidance issued by the IRS. They need to choose the tax credit program that fits best based on their project's size and location. In general, the ITC is great for upfront savings, especially for smaller projects or those in areas with less sunlight. The PTC can be beneficial over time, especially for larger projects in sunnier spots. As installed PV costs decrease over time or power generation becomes more efficient, the PTC may achieve better economics to solar developers.

IRA further defined other tax credit bonuses when fulfilling certain conditions. First one is Energy Community Bonus, applying a 10% increase to ITC/PTC to projects located in brownfields, fossil fuel communities with high unemployment, and coal closure communities as defined by IRA. Second one is Domestic Content Bonus, which is applicable to renewable energy facilities that are constructed with a minimum percentage of produced and manufactured components from the US, and provides a 10% bonus for facilities financed by ITC/PTC. However, the current qualification requirements pose a challenge for many solar developers to qualify for Domestic Content Bonus. Third one is the Low-income Bonus which offers an additional 10% or 20% tax credit, available for solar projects under 5 MW that are in a designated low-income community or are qualified low-income residential projects with benefits allocated to residents. However, qualifying for the Low-income Bonus is highly limited by specific location and property type criteria, making it less viable to industrial solar roof projects.

While these tax credits and bonuses are designed to encourage solar adoption by reducing 30% to 80% of upfront cost or tax liabilities during operation, their effectiveness is yet to be materialized due to currently high interest rates, rising costs, local opposition, and notably, constraints in tax credit qualifications, especially concerning domestic content and low-income requirements.

Federal Tax Credit (Construction between 2023-2033)	**ITC (% of Total Project Cost)**	**PTC ($/MWh)**
Base Rate	30%	27.5 (as of 2023)
Energy Community Bonus	10%	2.75
Domestic Content Bonus	10%	2.75
Low-income Bonus	10% or 20%	N/A
Maximum Tax Credit	**80%**	**33**

Table 4 – Summary of Federal Tax Credits and Bonus (US Department of Treasure, 2022)
Note: Rates are applicable for projects meeting prevailing wage and apprenticeship requirements

Property & sales tax exemption (state-level)

Other than tax credit at federal level, state level tax incentives include property tax exemption and sales tax exemption. Property tax exemptions allow qualified businesses and homeowners to exclude the entire or a portion of added value of a solar system from the valuation of the property for taxation purposes. Sales tax incentives typically provide an exemption from the state sales tax (or sales and use tax) for the purchase of a solar energy system, which helps to reduce the upfront costs of a solar installation.

The complexity of securing tax exemptions for solar installations on industrial properties is heightened by two primary factors. Firstly, in a typical triple net lease scenario, property owners do not directly benefit from tax exemptions as property taxes are transferred to tenants. This arrangement prevents owners from reaping the benefits of tax exemption incentives. Secondly, in states like Massachusetts, only solar systems that solely meet on-site energy demands are eligible for tax exemptions. This criterion excludes grid-connected systems that supply surplus energy back to the grid. Furthermore, since property taxes are governed at the state level, local tax assessors wield significant authority in interpreting these regulations. Their varying interpretations can lead to a fragmented enforcement landscape, further complicating the process of obtaining tax exemptions for solar energy systems across different regions.

Modified Accelerated Cost-Recovery System (federal-level)

Based on *The Tax Cuts and Jobs Act of 2017*, qualified solar energy equipment is eligible for a cost recovery period of five years. When an ITC grant is claimed, the owner needs to reduce the project's depreciable basis by 50% from the value of the 30% ITC, allowing the net depreciation at 85% of the ITC eligible basis.

The Modified Accelerated Cost-Recovery System (MACRS) enables businesses to depreciate the investment over five years, improving cash flow and speeding up the return on investment in solar projects, which has been a significant key factor in the growth of the solar sector.

Renewable Portfolio Standards & Renewable Energy Certificates (state-level)

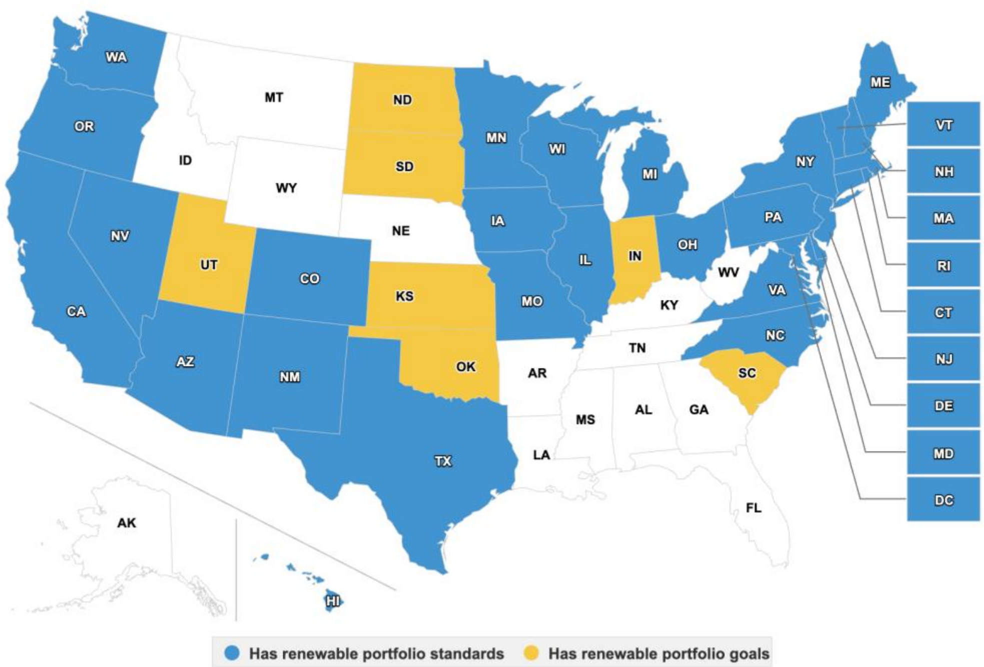

Figure 9 – Renewable Portfolio Standards by State (EIA, 2022)

Renewable Portfolio Standards (RPS) are state-level policies that drive solar energy development, which mandate electric utilities or load-serving entities to source a certain percentage of their electricity from renewable resources (see Figure 9).

Renewable Energy Certificates (RECs) are key tools of RPS policies to encourage and monetize renewable energy deployment. RECs are tradable certificates representing that 1 MWh of electricity was generated from a renewable source such as solar. Owners of solar generation can trade these rights - allowing the buyer to claim credit for "green" electricity without directly purchasing power from a renewable energy source (seller forfeits this right). In states with RPS that require renewables to comprise a certain percentage of power generation within the state, fossil fuel weighted utilities with deficits may purchase RECs for regulatory compliance. Beyond the compliance with RPS, RECs have developed a voluntary market, offering a flexible and accessible way for organizations to support renewable energy and achieve clean energy goals.

RECs can be bought separately from electricity (as "unbundled RECs"), from brokers or directly from renewable energy generators, enabling organizations in regions without green power options from local suppliers, or where direct engagement in renewable projects is not feasible, to still contribute to renewable energy goals. This approach doesn't require altering existing power contracts and overcomes geographic or transmission constraints.

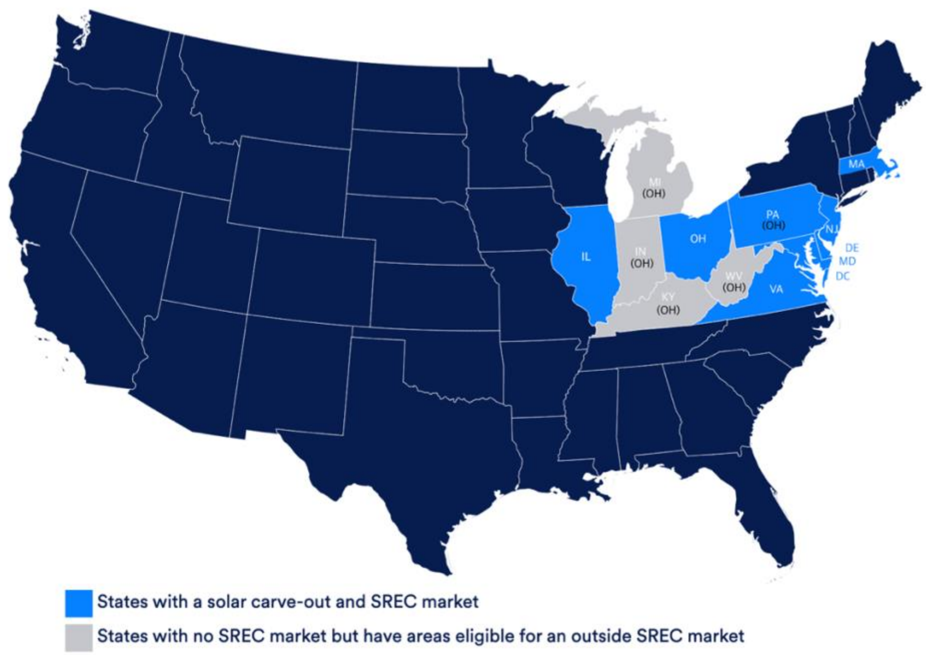

Figure 10 – Eligibility for SREC by State (SRECTrade, 2023)

More specifically in solar sector, 13 states have either developed Solar REC (SREC) market or have areas eligible for outside SREC markets (see Figure 10). Dictated by the supply and demand and policy dynamics of complying with respective RPS, SREC prices vary across states from \$4.0/MWh in Ohio to \$422.5/MWh in Washington, D.C. for energy year 2023 (see Figure 11).

While SRECs offer a potential revenue stream for solar systems, the market's fluctuations and the tendency towards bilateral agreements pose challenges, particularly for small-scale sellers. The preference among some buyers to deal in bulk transactions can make it more difficult for those with fewer credits to find favorable deals.

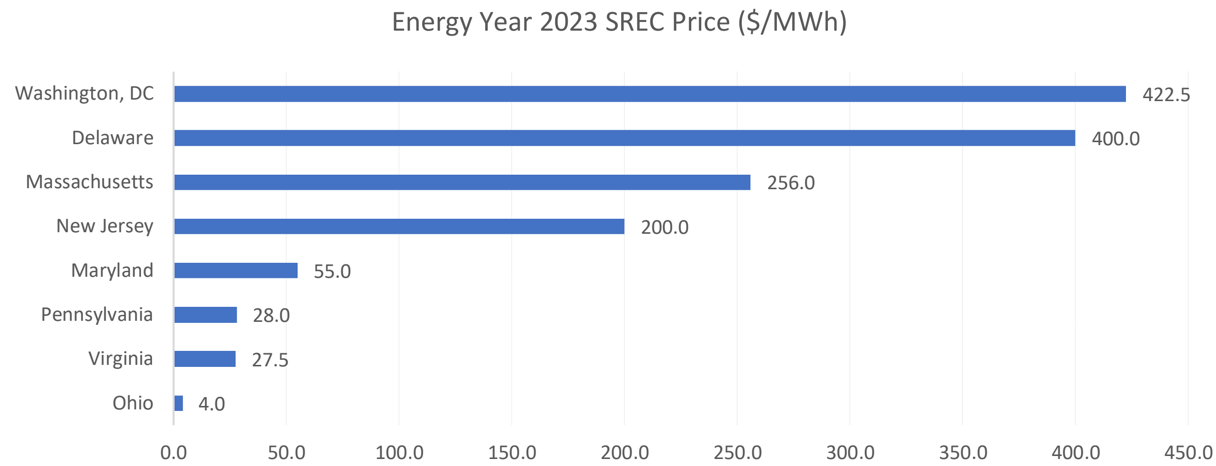

Figure 11 – SREC Prices in Major Markets (SRECTrade & Flettexchange, 2023)

Furthermore, in states such as New Jersey where the current SREC market is to be replaced by new programs generating SREC-II for new solar projects, the transition may result in repricing on SREC, introducing uncertainties regarding the financial gains from SREC transactions.

Market Segment	**Size (MW)**	**SREC-II Price ($/MWh)**
Small Net Metered Non-Residential on Rooftop	< 1	110
Large Net Metered Non-Residential on Rooftop	1 – 5	100
Community Solar	< 5	90

Table 5 – SREC-II Pricing of New Jersey Successor Solar Incentive (SuSI) Program (New Jersey Board of Public Utilities, 2021)

However, as the national market for SREC matures, regional disparities in trading may decrease, leading to a more integrated market. This is anticipated as an increasing number of states move forward with legislation to facilitate the sale of SRECs.

Chapter 4. Business models

4.1 Corporate rationale of pursing solar solutions

Industrial real estate companies are increasingly turning to solar panel installations on their buildings for a variety of strategic reasons.

Primarily, adopting solar solutions aligns with a corporation's overarching decarbonization goals. As real estate companies set ambitious targets to reduce their carbon footprint, solar roofs become a tangible step towards achieving these objectives, which is highly viable for industrial sector with unutilized large roof space and less energy consumption. This not only demonstrates a commitment to environmental stewardship but also positions the company as a responsible leader in the transition to a low-carbon economy.

Another pivotal driver is that the installation of solar panels serves as a source of additional revenue. By harnessing solar energy, developers can sell the generated electricity or benefit from tax credits and RECs, which provide financial incentives. This not only diversifies their income streams but also enhances the overall value of their assets.

Furthermore, there is a growing expectation from investors that the companies they invest in will commit to sustainable practices, as investors have their own mandates of decarbonizing invested portfolio. This investor pressure is a significant motivator for developers to adopt solar solutions, aligning their operations with the broader shift towards ESG criteria that are becoming a staple in investment decision-making.

Lastly, tenant demand plays a crucial role. As businesses themselves become increasingly environmentally conscious, they seek spaces that reflect their values and help them meet their sustainability targets. According to the industrial and logistics occupier survey by CBRE, 37% of respondents plan to use alternative on-site energies like solar panels to meet net-zero target[12]. This statistic underscores the necessity for developers to provide facilities that support their tenants' corporate decarbonization responsibility goals.

[12] CBRE Research, *2022 U.S. Industrial & Logistics Occupier Survey* (CBRE, 2022), 20.

4.2 Business model categorization

In existing literature work, solar business models are usually differentiated based on roles, activities, and applications. Role categorization is characterized based on who owns the solar PV system in relation to who owns the property where it is located and who consumes/sells the electricity that is produced. Activity categorization is defined by business position in the solar PV value chain that can be divided into an upstream and downstream part. Application categorization refers to where the solar PV system is installed which, in turn, can be determined based on sector (residential or commercial), size and location (roof- or ground-mounted).

In the context of solar roof in industrial real estate, the main distinctions of prevailing corporate business models lie on the operating control of roof and ownership of solar PV systems. Based on these criteria, there are two major solar roof business models for industrial real estate.

Self-ownership model

In the self-ownership model, the real estate owner maintains control of the roof and is responsible for the installation, operation, and ownership of the solar PV systems.

As industrial property is usually not energy-intensive, the property and solar system owner have the option to use generated electricity for on-site energy demand through individual Power Purchase Agreement (PPA) with property tenants and then sell the surplus electricity to the utility grid.

Alternatively, the property owner might sell all electricity to community solar programs and give tenant the option of subscribing the community solar. As mentioned in **Section 3.1**, community solar is gaining more popularity as it extends the social value of affordable energy to low-income households and achieves higher sales rates from residential sector end-users.

The self-ownership model can further monetize the solar roof by capturing benefits from federal and state incentives. ITC and PTC respectively reduces the upfront capital cost and tax burden during operation. SREC sales that are permitted in certain states presents additional income stream to self-owned solar system.

Benefit from MACRS depreciation is another important tool for self-ownership model to recover certain capital costs over the property's lifetime. Allowing businesses to deduct the depreciable basis over five years reduces tax liability and accelerates the rate of return on a solar investment.

The self-ownership model for solar PV systems typically necessitates the formation of an internal team responsible for overseeing the installation, operation, and maintenance of the panels. The team size varies with the company's scale, with mid-sized firms typically employing 2-3 individuals and larger corporations potentially staffing up to 70 personnel. Due to this requirement for dedicated oversight and the associated resources, this model is generally more suitable for mid-to-large scale industrial real estate companies that have the capacity to manage these functions in-house.

Roof leasing model

In the roof leasing model, the real estate owner leases roof space to a third-party solar developer, in exchange for rental payments like traditional property leasing. The solar developer then takes on the ownership, installation, and operation of the solar PV systems and has the autonomy to use or sell the generated electricity to the grid or community solar program. In the roof leasing process, tenants can be totally excluded given they don't own roof rights, and they have the option of purchasing the electricity from grid or community solar programs.

Under this model, the real estate owner monetizes the solar roof by receiving additional rental income without any initial investment. The solar developer capitalizes on the discrepancy between lower cost of electricity generation (i.e. levelized cost of electricity or LCOE) and higher sales price to the grid or community solar program. As the asset owner, solar developer also captures values from tax and energy credits associated with the solar PV system. Typically, solar developers target an unlevered internal rate of return (IRR) of 9-10% from these roof solar projects. Industry stakeholders generally consider the model less viable in markets where the commercial and industrial sectors pay less than 8 ¢/kWh for electricity, as the financial returns may not meet the necessary threshold.

In the roof leasing model, the property owner is not accountable for the maintenance or operation of the solar installation. This approach allows for the concurrent management of solar roof leasing alongside other property leasing activities, without the necessity of establishing a dedicated internal team to manage the solar infrastructure. Consequently, this model holds appeal for smaller real estate firms seeking to expand into sustainable energy without incurring significant overhead or operational complexity.

4.3 Roof rights control

To implement either of the two solar business models effectively, real estate owners must ensure they have operational control over the roofs as stipulated in their leasing agreements. Typically, landlords of multi-tenant buildings maintain exclusive rights over the roof. However, in the case of single-tenant buildings or properties with ground leases, the roof rights, including maintenance and repair, might reside with the tenant. Corporate tenants, particularly those with broad sustainability objectives like Amazon and Walmart, often prefer to install and manage solar systems themselves by maintaining the roof operating control as part of their lease agreements, capitalizing on their large-scale solar deployment capabilities to advance their sustainability goals.

If the property tenant is responsible for the roof's maintenance under the terms of the building lease, the building owner may need to amend the building lease to obtain control over the roof and take over the maintenance and repair responsibilities so that the building owner may legally install solar roof systems or lease the roof to the solar provider, given the economics work. On the other hand, if the tenant wishes to install and manage solar systems independently and the lease does not grant them explicit rights to the roof, the landlord has the option to lease the roof space back to the tenant, typically for an additional rent, although this scenario is uncommon.

4.4 Debt financing tools

In the self-ownership model for solar roof, various debt instruments are available, in contrast to the roof leasing model, which does not require upfront financing.

Self-finance: This approach is predominantly used by large industry players. It involves leveraging the company's own balance sheet to finance the installation of PV systems. Companies with robust balance sheet benefit from vehicles with lower capital costs. By using this method, real estate owners can finance and directly own energy assets, integrating the derived value into their broader business portfolio.

Commercial Property Assessed Clean Energy (C-PACE): C-PACE, a state-level non-recourse financing tool which exists in 38 states as of 2023, covers up to 100% of project costs with flexible terms from 5 to 20 years and typical fixed interest rates from 5 to 10%[13]. C-PACE loans take to encourage owners to invest in ESG-focused projects[14]. The loan is attached to the property, not the owner, and is repaid through a special assessment on property taxes, which will be transferred to new owners upon property sale. C-PACE is often viewed as an effective solution to the split-incentive issue that arises between property owners and tenants under triple net leases during energy efficiency upgrades. It becomes particularly advantageous when the reduction in tenants' utility costs due to lower electricity purchase prices, surpasses the incremental property tax payments passed to tenants. However, when developing solar roofs, the savings in utility costs for tenants can vary significantly based on factors like their electricity usage, the grid rate, and the project cost for energy production. These variations introduce uncertainties in determining whether tenants will benefit more from the savings than they would from the incremental increase in property tax payments. In situations where these savings are not substantial, or the costs of the solar system are high, the industrial property owner might end up bearing a larger portion of the loan repayment.

Green Bonds: Green bonds are specialized financial instruments designed to fund projects with environmental benefits, such as renewable energy installations like solar PV systems. While the borrowing cost of green bond is not necessarily lower, its primary benefit over traditional corporate bonds is the sharpen focus on environmental sustainability that attracts ESG-focused fixed-income investors looking for alternative green investments. A notable example is Prologis' green bond framework, where the proceeds fund the construction or retrofitting of buildings and renewable energy or storage projects meeting specific environmental standards[15]. This process requires rigorous selection criteria, comprehensive disclosure, and external review of proceeds allocations. However, the sophisticated nature and scale of green bonds make them more suitable for larger

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[13] American Council for an Energy-Efficient Economy, "Property Assessed Clean Energy (PACE)," ACEEE.org, January 27, 2017, https://www.aceee.org/toolkit/2017/01/property-assessed-clean-energy-pace.
[14] Will Johnson, "Five Things to Know about C-PACE Lending," Real Estate Capital USA, April 20, 2022, https://www.recapitalusa.com/five-things-to-know-about-c-pace-lending/.
[15] Prologis, *2022 Green Bond Report* (Prologis, December 2022), https://prologis.getbynder.com/m/505e5baff1e29890/original/2022-PELF-Green-Bond-Report.pdf, 6.

companies with significant market capitalization and financial needs, rendering them less feasible for smaller real estate firms.

4.5 Tax benefit monetization

Beyond debt financing, monetization of tax incentives is the core financing strategy for solar roof projects in the self-ownership model for real estate owners. Major incentives of investing in solar systems include ITC/PTC and accelerated depreciation. The reduction in the taxes the business would otherwise owe is effectively the federal government’s subsidy of solar. Initially, to directly benefit from these incentives, a business needed sufficient tax liability, often leading to partnerships with tax equity investors. However, with the IRA of 2022, new rules allow for the transfer of ITC/PTC beyond traditional tax equity partnerships. This section will cover three tax benefit monetization strategies: tax equity partnership flips, ITC transfers, and PTC transfers.

Tax equity partnership flip

It’s been the most common tax equity structure used by renewable energy sector. A partnership flip involves a solar developer (sponsor) partnering with a tax equity investor to jointly own a renewable energy project. In this arrangement, income, losses, and tax credits of the partnership are passed on to the partners for reporting.

Initially, the tax equity investor receives 99% of these benefits, income, or loss, and provides 30-40% of the capital stack until the target yield (often 6-8%) is achieved, while cash distribution may follow a different ratio (often 20%) before the flip occurs. Once this target is met, the sponsor receives 90-95% of the profits and tax benefits, with the option to purchase the investor’s stake.

The partnership flip allows the sponsor to retain a long-term interest in the solar systems and eventually regain full ownership at a reasonable cost after the tax benefits have been fully utilized by the tax equity investor. However, the complexity of allocation mechanisms and substantial legal and accounting expenses can deter real estate owners who lack experience in tax equity partnerships from considering this financing option.

ITC transfer

IRA of 2022 introduced a new provision in the Internal Revenue Code (IRC), Section 6418, which permits the transfer (literally sale) of certain energy-related tax credits to unrelated third parties. This development has generated considerable enthusiasm in the renewable energy sector to streamline transactions, broaden the pool of potential investors, and simplify intricate financial accounting procedures. The tax credit market proved favorable rate to ITC sales, which is around 90 – 92¢ on per dollar credit, and is expected to eventually settle at 95¢ or 96¢ in the future - nearly full face value[16].

For industrial real estate owners, the ability to sell ITCs gained from solar installations is particularly impactful. It offers a way to capitalize on tax credits without needing to offset their own tax liabilities, which is beneficial for those with limited tax burdens and avoids the need for complex tax equity partnership arrangements.

REITs find this especially advantageous as they typically have lower tax liabilities due to exemptions from corporate tax. Importantly, income from the sale of tax credits does not count towards REITs' income tests that at least 75% of gross income should be derived from rental income, allowing them to invest in solar energy and gain the full benefit of the tax credits, either by utilizing them or by selling them to third parties.

Notably, for ITC transfers, the received cash are neither taxable for the seller nor deductible for the buyer. Plus, the tax credit transaction is limited to a single sale, preventing brokers from acting as intermediaries for resale.

PTC utilization

As PTC is linked with electricity production at an inflation-adjusted rate for the first 10-year production period, the impact is reflected in reducing operating cost. The comparison of the value of ITC and PTC will largely depend upon two economic inputs - the total project cost and expected power production. Projected production is subject to various influences including the operational efficiency of the equipment, the available solar radiation, and potential production interruptions.

[16] Keith Martin, "Transferability: Selling Tax Credits," Norton Rose Fulbright - Project Finance News, March 6, 2023, https://www.projectfinance.law/publications/2023/march/transferability-selling-tax-credits/.

The lower the cost and the higher the production, the likelier it is that the PTC, even when the cash-flows are discounted to reflect the 10-year period, will be higher than the ITC. Projects that can minimize costs while maximizing output are more likely to benefit from the PTC, even after adjusting for the ten-year time span.

As a result, the PTC tends to be more beneficial for larger projects that have lower costs per kilowatt and are expected to operate at higher capacity factors, making the PTC a more lucrative option in such scenarios.

4.6 Integration with battery storage

Integrating Battery Energy Storage System (BESS) with solar roofs is an emerging monetization strategy that becomes increasingly valuable as more renewable energy enters the grid. Battery storage enhances energy production by allowing excess solar power to be stored and used during non-peak sunlight hours, which is especially crucial as climate change potentially leads to more frequent and severe power disruptions. This combination helps maintain a steady supply of solar energy to the grid and bolsters energy independence. Moreover, current shifts in net metering policies (such as lower sales price to grid in California) and tax incentives for storage systems suggest that battery storage could bolster the financial benefits of solar roof. The new IRA permits

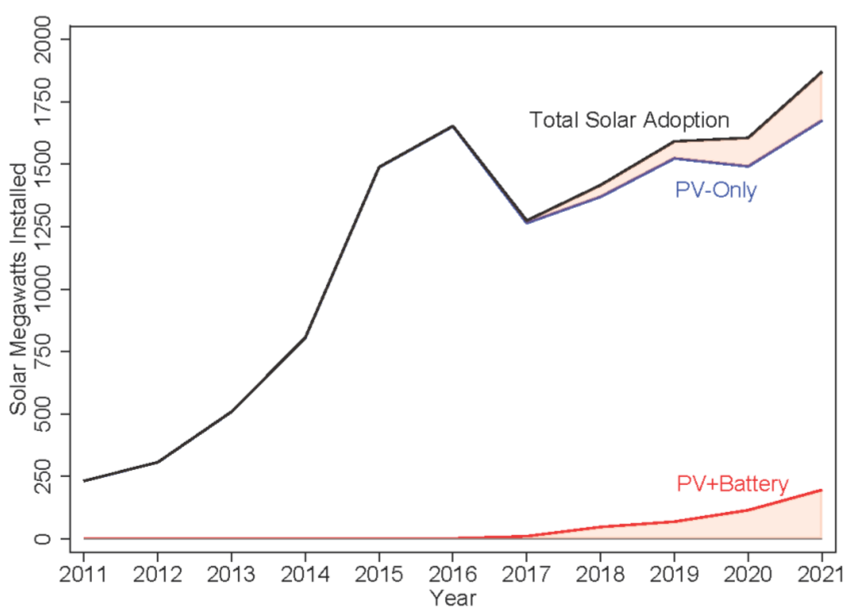


Figure 12 – Installed Solar PV and Battery Storage Capacity 2011 - 2021 (LBNL, 2023)

solar and storage systems to qualify for both ITC and PTC, providing a concurrent financial advantage for integrated solar and storage solutions.

BESS enhances solar roof projects by providing additional income streams. It offers capacity contract revenue by guaranteeing necessary power during peak demand periods for solar systems, ensuring a stable long-term revenue source. Energy rate arbitrage is another income stream, allowing storage of low-cost electricity and selling it when demand peaks and energy prices are high. Ancillary services offer a third stream, maintaining grid stability by providing immediate response to frequency changes. For industrial real estate owners, the predictability and stability of capacity contract revenue make it an attractive financial option. Overall, the economics for integrating BESS with solar projects requires analysis of BESS capital expenditures and potential revenue streams.

Chapter 5. Financial Analysis

5.1 Analytical methodology and framework

This chapter delves into the financial viability of implementing solar roofs within the US industrial real estate sector, employing a hypothetical project to assess profitability and value generation across different scenarios and sensitivity analysis.

Scenario categorization

The scenario studies cover two business models: self-ownership and roof leasing. As framed in Chapter 4, the determination of two business models is the operating control of the roof and ownership of solar systems. In the self-ownership model, further scenario tests are undertaken to evaluate the financial impact of different tax credit monetization approaches and the integration of BESS into solar PV systems. The roof leasing model introduces the perspectives of industrial real estate owners and third-party solar developers. From the solar developer's standpoint, the financial analysis takes identical operating and financing assumptions compared to the self-ownership model, and the only difference is the additional line items for roof leasing payments. From the industrial real estate owner's standpoint, the extra profits and property value creation solely come from additional roof rent revenue.

In summary, the scenarios are categorized into:

Scenario	Solar System	Tax Credit Monetization
Scenario 1: Self-ownership model		
1-A (Baseline)	Solar PV only	ITC transfer
1-B	Solar PV only	ITC tax equity partnership
1-C	Solar PV only	PTC
1-D	Solar PV + BESS	ITC transfer
1-E	Solar PV + BESS	ITC transfer + PTC
Scenario 2: Roof leasing model		
2-A	Solar PV only	ITC transfer

Table 6 – Scenario Categorization

Profitability metrics

The profitability analysis of solar roof projects will deploy Internal Rate of Return (IRR) and Net Present Value (NPV) metrics.

In the self-ownership model, the profitability stands at the industrial real estate owner's (also solar developer's) perspective. The self-ownership model views profitability from the standpoint of the industrial real estate owner, who also acts as the solar developer. In the roof leasing model, profitability is assessed from the perspectives of the property owner and the third-party solar developer.

The IRR metric pairs unleveled pre-tax IRR and levered pre-tax IRR to integrate the influence from the capital structure while being isolated from the impact of tax liabilities and loss carryforward. In the self-ownership model, IRR measures the project's financial performance solely to the property owner (also the solar developer). In roof leasing models, the IRR metric is considered from the perspectives of property owners and third-party solar developers. Notably, in this model, the IRR for the property owner can appear nearly infinite due to minimal upfront costs for leasing out the roof space.

The NPV metric takes a Discounted Cash Flow (DCF) approach to determine the current value of development profit. In the self-ownership model, NPV represents the sum of discounted levered after-tax cash flow to measure the net development profit after considering capital structure and tax implications. In the roof leasing model, the third-party solar developer's NPV includes roof lease payments in its cash flow. For the property owner, NPV represents the discounted stream of roof rental income over the roof leasing period, typically shorter than the solar system's operational lifespan due to the distinct investment horizons associated with industrial real estate and renewable energy projects.

Value creation

To distinguish the value creation rationale of the two business models, the valuation of solar roofs is assessed in different methods.

In the self-ownership model, the incremental value comes from solar system installation on the roof of the industrial property. The appraisal value of the solar systems uses an income approach based on unleveled operating cash flow plus net eligible tax benefits.

In the roof leasing model, the value appreciation is from the additional income stream of roof rent. This rent contributes to the property's Net Operating Income (NOI), and the industrial real estate owner may prefer the direct capitalization method to estimate the incremental property value, which is calculated by dividing the roof rent by the property's cap rate. However, this method assumes perpetually constant NOI, which does not align with the reality that cumulative roof lease periods, considering lease transfer upon property sales, are finite and typically aligned with the solar system's operational life of 25 to 35 years. Therefore, a DCF analysis that accounts for the rental income over the solar system's lifespan will be used alongside the direct capitalization method to provide a more conservative and realistic valuation.

New Jersey market as the basis for analysis

To comprehensively integrate the impact of local market conditions and policy context into financial projections, this financial analysis will assume a hypothetical New Jersey project whose unique characteristics will serve as a representative case study to explore crucial factors that shape the project's economics.

Despite not being known as a sunny state with abundant sunshine, New Jersey has emerged as a frontrunner in the US solar market, holding the 10th spot for total solar capacity among all states and generating 7.55% of its electricity from solar power[17]. The state's market is expected to maintain strength bolstered by supportive policies, financial incentives, and electricity retail rates that exceed the national average.

Beyond federal initiatives such as Interconnection Standards, ITC/PTC tax credits, and MACRS depreciation benefits, New Jersey enhances solar energy deployment through tailored state incentives. These include Net Metering, Property and Sales Tax Exemptions, access to C-PACE financing, and establishing a permanent Community Solar Program following a successful pilot phase. The Community Solar Energy Program (CSEP) mandates that participating facilities do not

[17] Solar Energy Industries Association, "New Jersey Solar," SEIA.org, December 2023, https://www.seia.org/state-solar-policy/new-jersey-solar.

surpass 5 MW and that at least 51% of their capacity is subscribed by low and moderate-income (LMI) households.

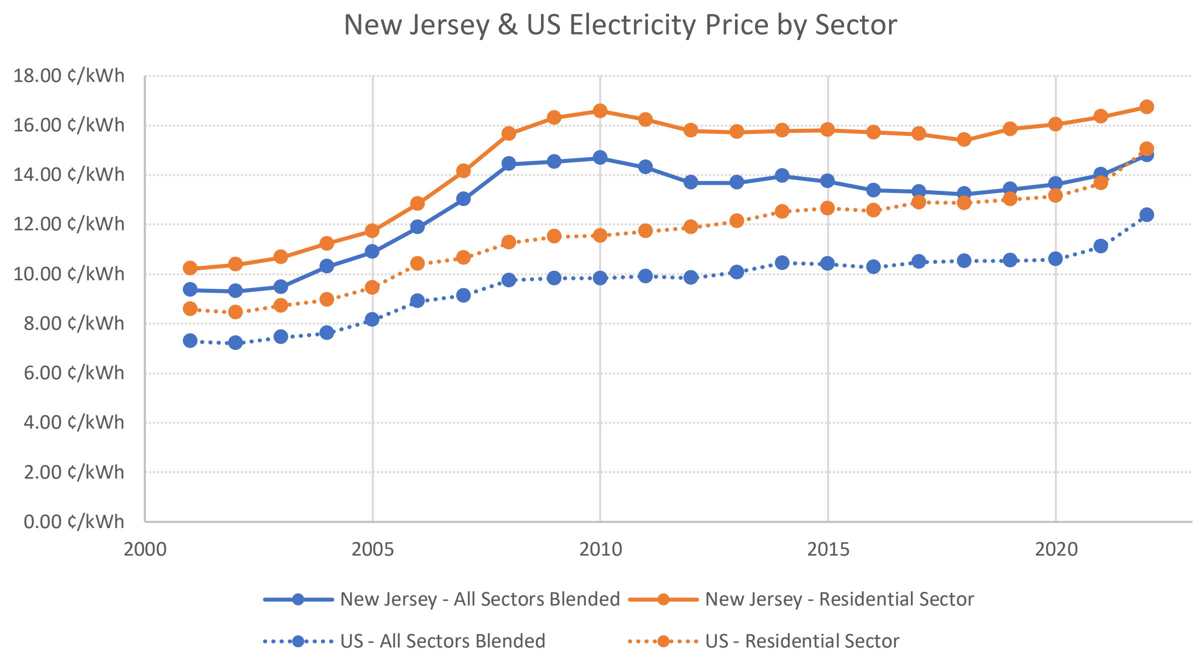


Figure 13 – Annual Electricity Retail Rates of New Jersey and US Average by Sector 2001 - 2022 (EIA, 2023)

A solar RPS and an accompanying SREC market also drive the New Jersey market's growth. Detailed in **Section 3.2**, the New Jersey Board of Public Utilities (NJBPU) initiated a new Successor Solar Incentive (SuSI) Program in 2021, using SREC-II to replace the existing SREC market, which is coupled with a price drop in SREC from around $200/MWh to $70-100/MWh. This shift has reduced SREC prices from approximately $200/MWh to a range of $70-100/MWh. Despite this decrease, SREC-II sales continue contributing to a considerable revenue stream for solar roof projects.

Furthermore, New Jersey's solar market benefits from the state's higher-than-average electricity retail rates (see Figure 13). Additionally, the disparity between the blended electricity price for all sectors and the specific rates for residential customers in New Jersey provides a favorable environment for community solar programs aimed at residential users.

Finally, New Jersey stands out with aggressive energy storage goals and is committed to installing 2,000 MW by 2030. The NJBPU is advancing the New Jersey Energy Storage Incentive Program (NJ SIP) proposal, which plans to offer both Fixed and Performance-based Incentives for energy storage projects such as BESS. With the eligibility for claiming ITC and PTC for co-located solar PV and BESS, incorporating these systems into solar roof projects presents notable opportunities.

New Jersey's distinctive blend of supportive state policies, high electricity rates, and commitment to solar and energy storage targets presents a compelling financial analysis framework for solar roof projects in the industrial real estate sector. This combination of numerous favorable factors provides a comprehensive model for assessing the economic potential of solar roof investments.

5.2 Key underwriting assumptions and financial summary for baseline case

Below are the key assumptions and summary economics for Scenario 1-A, the baseline case, to develop a solar roof under the self-ownership model, considering specific market conditions and policy influences in New Jersey. In this baseline scenario, the 350,000 SF solar roof will generate 20.3% levered IRR, and $36.18 incremental value on per square foot of roof area.

Project Snapshot		
Scenario		1-A (Baseline)
Roof Area		350,000 SF
Roof Efficiency		75%
Generation Capacity		18 W/SF
Nameplate Capacity		4.7 MW
Annual Production Efficiency		1,200 MWh/MW
Annual Panel Degradation		0.5%
Year 1 Energy Production		5,670 MWh
Return Summary		
Profitability		
Unlevered Pre-tax IRR		12.5%
Levered Pre-tax IRR		20.3%
Holding period NPV	*$7.58/SF*	$2,652,303
Solar System Valuation	*$36.18/SF*	$12,661,399
Key Dates		
Start of Development		Sep-23
Start of Construction		Jun-24
Start of Operation		Mar-25
Operational Life		30 Years
End of Operational Life		Mar-55

Project Costs

Development Expenses		*$0.47/W*	$2,236,891
Capital Expenses		*$1.69/W*	$7,961,625
Transaction Expenses	*$0.06/W*		$260,489
Total Project Costs	***$2.21/W***		**$10,459,004**

Financing

Construction Loan	
Debt Amount	90% of project costs
All-in Interest Rate	7.50%
Permanent Loan	
Terms	15 Years
All-in Interest Rate	6.25%
Maximum Leverage (LTC)	65%
Target Debt Service Coverage Ratio (DSCR)	1.35x

Taxes

Tax Credit		
ITC Rate		30%
ITC Value	*$0.65/W*	$3,074,947
ITC Transfer Recovery Rate		90%
ITC Transfer Proceeds	*$0.59/W*	$2,767,453
ITC Transfer Date		Mar-25
Depreciation		5-Year MACRS
Federal Tax Rate		21.00%
State Tax Rate		10.75%

Operations

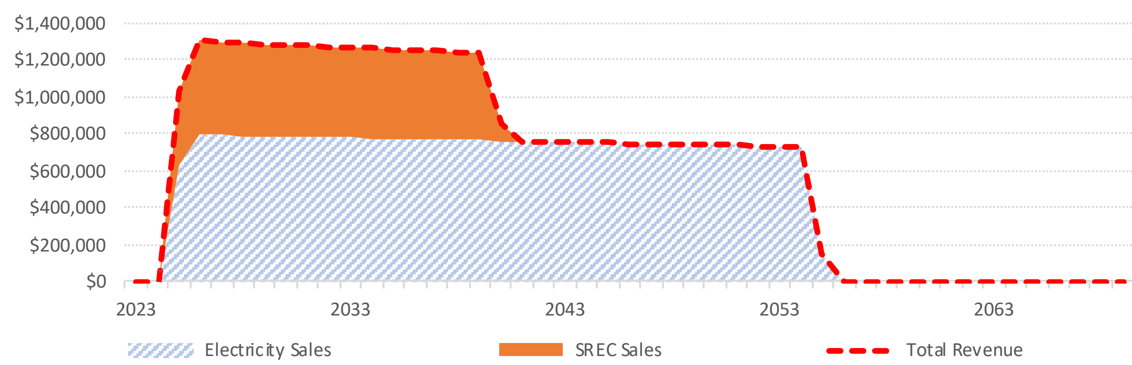
Solar Energy Program	Community solar
Subscriber Mix	
LMI Residential Allocation	51%
Non-LMI Residential Allocation	49%
Electricity Sales	
Sales Terms	30 Years
Residential Sector Rate	$0.165/kWh
All-Sector Blended Rate	$0.145/kWh
Annual Escalation Rate	0.20%
LMI Residential Discount Rate	20%
Other Sectors Discount Rate	10%
SREC Sales	
Sales Terms	15 Years
SREC Price	$90/MWh
Operating Expenses	$0.04/W
Inflation Rate	2%

Table 7 – Scenario 1-A (Baseline) Key Underwriting Assumptions and Return Summary

Sources and Uses of Funds as of Project Operation Start (as of Mar-25)

Uses			
	Capital Expenses	*75%*	$8,356,570
	Development Expenses	*20%*	$2,236,891
	Financing Costs	*2%*	$224,241
	Debt Service Reserve	*3%*	$282,592
	Total Uses		**$11,100,294**
Sources			
	Equity	*17%*	$1,889,162
	ITC Transfer Proceeds	*25%*	$2,767,453
	Debt	*58%*	$6,443,679
	Total Sources		**$11,100,294**

Revenue Breakdown



Solar Developer Cash Flow

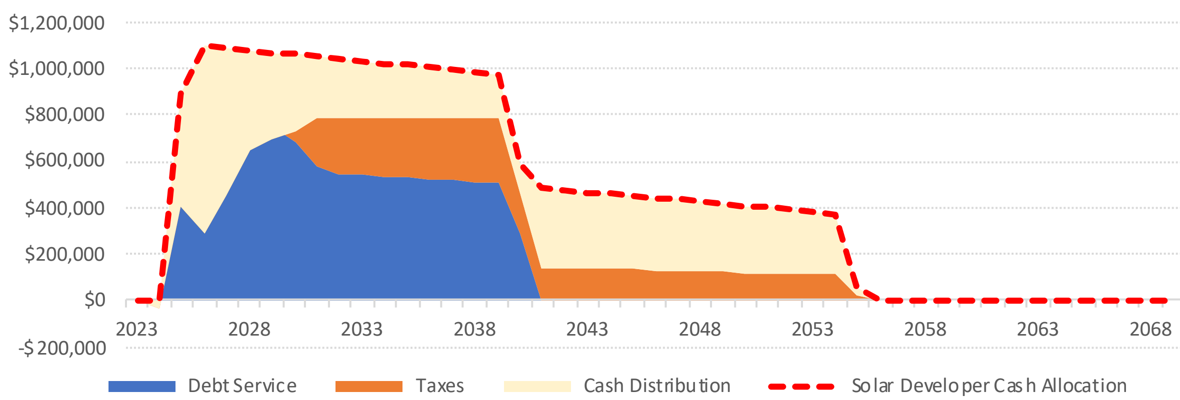


Table 8 – Scenario 1-A (Baseline) Sources & Uses of Funds, Revenue Breakdown and Cash Flow

5.3 Sensitivity analysis for baseline case

This section presents a thorough sensitivity analysis to evaluate the impact of underwriting inputs on the project's profitability and value creation. This study tests critical inputs, including power production, project capital expenditures, financing and tax credit monetization, and operational revenue streams, providing a comprehensive understanding of how each variable influences the overall economic feasibility of the project.

Power production

Power production of solar roofs hinges on the combination of usable roof area, generation capacity per square foot, and production efficiency. Solar PV panel types and operating conditions determine generation capacity. On the other hand, production efficiency refers to the rate at which installed capacity is converted into actual power output. This figure largely depends on the level of solar irradiance received. Assuming 75% of roof space contributes to power generation, the following sensitivity table reveals that the production efficiency will significantly impact the return and value creation via income approach, where higher efficiency means that unit roof area will have higher actual power output and revenue. Significant constraints for this factor will be the regional solar radiation level, which ranges from 1,100 to 1,300 kWh/kW in New Jersey.

Profitability - Unlevered Pre-tax IRR / Levered Pre-tax IRR / Holding Period NPV

	Production Efficiency (kWh/kW)				
Generation Capacity (W/SF)	1,100	1,150	1,200	1,250	1,300
8	10.7% / 13.9% $2.27/SF	11.6% / 16.7% $2.81/SF	12.5% / 20.1% $3.35/SF	13.4% / 23.6% $3.86/SF	14.2% / 25.0% $4.30/SF
13	10.7% / 14.0% $3.71/SF	11.6% / 16.8% $4.59/SF	12.5% / 20.2% $5.46/SF	13.4% / 23.5% $6.28/SF	14.2% / 24.9% $7.00/SF
18	10.7% / 14.0% $5.16/SF	11.6% / 16.8% $6.37/SF	**12.5% / 20.3% $7.58/SF**	13.4% / 23.5% $8.71/SF	14.2% / 24.9% $9.70/SF
23	10.7% / 14.0% $6.60/SF	11.6% / 16.8% $8.15/SF	12.5% / 20.3% $9.69/SF	13.4% / 23.5% $11.13/SF	14.2% / 24.9% $12.40/SF
28	10.7% / 14.0% $8.05/SF	11.6% / 16.8% $9.93/SF	12.5% / 20.3% $11.81/SF	13.4% / 23.5% $13.56/SF	14.2% / 24.8% $15.10/SF

Solar System Valuation

Generation Capacity (W/SF)	Production Efficiency (kWh/kW) 1,100	1,150	1,200	1,250	1,300
8	$15.00/SF	$15.54/SF	$16.07/SF	$16.61/SF	$17.15/SF
13	$24.39/SF	$25.26/SF	$26.13/SF	$26.99/SF	$27.86/SF
18	$33.77/SF	$34.97/SF	**$36.18/SF**	$37.38/SF	$38.58/SF
23	$43.15/SF	$44.69/SF	$46.23/SF	$47.76/SF	$49.30/SF
28	$52.53/SF	$54.40/SF	$56.28/SF	$58.15/SF	$60.02/SF

Table 9 – Scenario 1-A (Baseline) Sensitivity Analysis – Power Production

An increase in generation capacity per square does not correspondingly boost unlevered IRR because capital and operating expenses are tied to capacity only, not actual energy production. Therefore, benefits from higher power generation due to higher capacity are offset by increased expenses linked to capacity. As for levered IRR, as the permanent loan in project finance is sculptured with factors including project costs, LTC cap, and DSCR target, change in capacity will have a compounded effect, which is negligible in this study. On the other hand, improvement in production efficiency will significantly enhance IRR with higher operating cash flow.

From the perspective of solar system value, both higher generation capacity and efficiency contribute to higher revenue, enhancing system valuation using the income approach. Every 1W increase per SF will result in around $2 incremental value, while every 100 kWh/kW increase in efficiency generates around $2.4 incremental value.

Project capital expenditures

Capital expenses for solar systems encompass the costs for components, installation, design, engineering, and contingencies. Reducing capital expenses can significantly enhance profitability, and the national trend of falling costs for solar systems is set to improve project returns notably.

The system valuation, which factors in operating cash flow less depreciation and the net effect of tax credits, is also positively correlated with capital cost growth, highlighting the critical influence of accelerated depreciation and ITC in boosting the valuation of solar systems. A 5% increase in capex will generate around $0.5/SF more in system value.

Profitability - Unlevered Pre-tax IRR / Levered Pre-tax IRR / Holding Period NPV

		Capital Expenses ($/W)		
10%	**5%**	**0%**	**(5%)**	**(10%)**
1.95	**1.77**	**1.69**	**1.61**	**1.44**
11.3% / 15.9% $6.54/SF	11.9% / 17.9% $7.06/SF	**12.5% / 20.3%** **$7.58/SF**	13.1% / 23.1% $8.08/SF	13.8% / 24.1% $8.44/SF

Solar System Valuation

		Capital Expenses ($/W)		
10%	**5%**	**0%**	**(5%)**	**(10%)**
1.95	**1.77**	**1.69**	**1.61**	**1.44**
$37.16/SF	$36.67/SF	**$36.18/SF**	$35.68/SF	$35.19/SF

Table 10 – Scenario 1-A (Baseline) Sensitivity Analysis – Project Capital Expenditures

Financing and tax credit monetization

Financing structure and tax credit utilization are important drivers for the project returns. The eligible ITC rate normally ranges from 30% to 60% of the project costs based on the project type and location, composing an essential and low-cost component in the capital stack. Assuming same debt inputs, a case without ITC will reduce levered IRR from 20.3% to 8.0%.

Profitability - Unlevered Pre-tax IRR / Levered Pre-tax IRR / Holding Period NPV

Maximum LTC		Eligible ITC Rate				
		No ITC -	30% $0.65/W	40% $0.87/W	50% $1.08/W	60% $1.30/W
	45%	7.9% / 7.7% $0.41/SF	12.5% / 14.0% $6.58/SF	14.7% / 17.9% $8.64/SF	17.4% / 24.6% $10.69/SF	20.9% / 40.1% $12.75/SF
	50%	7.9% / 7.7% $0.61/SF	12.5% / 14.8% $6.79/SF	14.7% / 19.8% $8.85/SF	17.4% / 29.5% $10.90/SF	20.9% / 61.8% $12.97/SF
	55%	7.9% / 7.8% $0.86/SF	12.5% / 16.1% $7.04/SF	14.7% / 22.9% $9.10/SF	17.4% / 40.1% $11.17/SF	20.9% / 116.7% $13.23/SF
	60%	7.9% / 7.9% $1.17/SF	12.5% / 18.2% $7.36/SF	14.7% / 29.0% $9.42/SF	17.4% / 67.4% $11.48/SF	20.9% / 200.6% $13.55/SF
	65%	7.9% / 8.0% $1.42/SF	**12.5% / 20.3%** **$7.58/SF**	14.7% / 35.3% $9.63/SF	17.4% / 95.8% $11.68/SF	20.9% / 244.4% $13.73/SF

Solar System Valuation

Eligible ITC Rate				
No ITC -	30% $0.65/W	40% $0.87/W	50% $1.08/W	60% $1.30/W
$29.52/SF	**$36.18/SF**	$38.39/SF	$40.61/SF	$42.83/SF

Table 11 – Scenario 1-A (Baseline) Sensitivity Analysis – Tax Credit & Loan Size

With ITC transfer proceeds constituting a dominant segment (with an eligible ITC rate over 50%) in the capital stack, the debt amount is adjusted accordingly to be financially meaningful. The optimal case in this sensitivity analysis suggests a combination of a 60% eligible ITC rate and 45% LTC, yielding a 40.1% levered IRR, with the system valuation reaching $42.83/SF.

The ITC rate remarkably contributes to system value, where a $0.2/W increase in tax credit will result in a system value of around $2.1/SF higher.

The analysis also tests the effects of the recovery rate of ITC transfer and interest rate. The underwriting uses conservative assumptions reflecting the current ITC market conditions and the prevailing high interest rates. Under the modeling of an improved recovery rate from ITC transfers from 90% to 95%, coupled with a 50-bps reduction in the interest rate from 6.25% to 5.75%, the project's levered IRR will increase to 23.9%.

Profitability - Unlevered Pre-tax IRR / Levered Pre-tax IRR / Holding Period NPV

Perm Loan Interest Rate	ITC Transfer Recovery Rate: 85.0%	87.5%	90.0%	92.5%	95.0%
6.75%	12.2% / 17.6% $6.83/SF	12.3% / 18.2% $7.02/SF	12.5% / 18.8% $7.22/SF	12.7% / 19.4% $7.42/SF	12.8% / 20.2% $7.62/SF
6.50%	12.2% / 18.2% $7.00/SF	12.3% / 18.8% $7.20/SF	12.5% / 19.5% $7.40/SF	12.7% / 20.2% $7.60/SF	12.8% / 21.0% $7.80/SF
6.25%	12.2% / 18.9% $7.18/SF	12.3% / 19.6% $7.38/SF	**12.5% / 20.3% $7.58/SF**	12.7% / 21.0% $7.78/SF	12.8% / 21.9% $7.98/SF
6.00%	12.2% / 19.6% $7.36/SF	12.3% / 20.4% $7.56/SF	12.5% / 21.1% $7.76/SF	12.7% / 22.0% $7.96/SF	12.8% / 22.8% $8.16/SF
5.75%	12.2%/ 20.5% $7.55/SF	12.3% / 21.2% $7.75/SF	12.5% / 22.1% $7.94/SF	12.7% / 23.0% $8.14/SF	12.8% / 23.9% $8.34/SF

Table 12 – Scenario 1-A (Baseline) Sensitivity Analysis – ITC Transfer Recovery Rate & Interest Rate

As the capital costs remain constant and the income approach uses unlevered operating cash flow and nominal ITC amount, LTC limit, ITC recovery rate, and interest rate will not impact the system valuation.

Operational revenue streams

Operating revenue significantly shapes the project's economics. In the baseline scenario, the operating revenue comes from electricity sales via the community solar program and SREC transactions. Without SREC sales, under current electricity sales price and subscriber mix, the project could show a negative NPV, suggesting it may not be financially viable.

The analysis indicates that without SREC income, profitability hinges on residential electricity prices rising above $0.18/kWh, which underscores the importance of SREC sales in maintaining the viability of solar roof projects in New Jersey, especially if electricity prices were to fall.

Profitability - Unlevered Pre-tax IRR / Levered Pre-tax IRR / Holding Period NPV

SREC Price ($/MWh)		Residential Sector Electricity Price ($/kWh)				
		0.145	0.155	0.165	0.175	0.185
	No SREC Sales	3.4% / 2.2% ($4.19/SF)	4.4% / 3.3% ($3.00/SF)	5.3% / 4.4% ($1.81/SF)	6.2% / 5.5% ($0.61/SF)	7.1% / 6.6% $0.58/SF
	80	9.9% / 12.0% $4.15/SF	10.8% / 14.2% $5.34/SF	11.7% / 16.8% $6.54/SF	12.5% / 19.9% $7.73/SF	13.3% / 23.3% $8.90/SF
	85	10.4% / 13.1% $4.67/SF	11.2% / 15.6% $5.87/SF	12.1% / 18.4% $7.06/SF	12.9% / 21.9% $8.25/SF	13.7% / 24.0% $9.30/SF
	90	10.8% / 14.4% $5.20/SF	11.7% / 17.1% $6.39/SF	**12.5% / 20.3% $7.58/SF**	13.3% / 23.4% $8.71/SF	14.1% / 24.6% $9.71/SF
	95	11.2% / 15.8% $5.72/SF	12.1% / 18.8% $6.91/SF	12.9% / 22.4% $8.10/SF	13.7% / 24.1% $9.12/SF	14.5% / 25.3% $10.12/SF
	100	11.6% / 17.4% $6.24/SF	12.5% / 20.7% $7.43/SF	13.3% / 23.5% $8.53/SF	14.1% / 24.7% $9.53/SF	14.9% / 26.0% $10.54/SF

Solar System Valuation

SREC Price ($/MWh)		Residential Sector Electricity Price ($/kWh)				
		0.145	0.155	0.165	0.175	0.185
	No SREC Sales	$24.66/SF	$25.85/SF	$27.05/SF	$28.25/SF	$29.45/SF
	80	$32.76/SF	$33.96/SF	$35.16/SF	$36.36/SF	$37.56/SF
	85	$33.27/SF	$34.47/SF	$35.67/SF	$36.87/SF	$38.07/SF
	90	$33.78/SF	$34.98/SF	**$36.18/SF**	$37.37/SF	$38.57/SF
	95	$34.29/SF	$35.48/SF	$36.68/SF	$37.88/SF	$39.08/SF
	100	$34.79/SF	$35.99/SF	$37.19/SF	$38.39/SF	$39.59/SF

Table 13 – Scenario 1-A (Baseline) Sensitivity Analysis – Residential Sector Electricity & SREC Price

This analysis also compares the performance of community solar programs targeting the residential sector and traditional PPA with all-sector end-users. The difference between the two solar energy sales programs is minimal in current underwriting. PPAs might outperform community solar regarding returns when the overall electricity price is high. Conversely, if the electricity price gap expands and SREC prices for non-community-solar projects decrease, the community solar model could offer better financial returns.

Operation Assumption

	Community solar	PPA
Solar Energy Program	Community solar	PPA
Subscriber Mix	LMI Residential: 51% Non-LMI Residential: 49%	All-sector blended
Electricity Sales		
Sales Terms	30 Years	30 Years
Electricity Rate	$0.165/kWh	$0.145/kWh
Annual Escalation Rate	0.20%	0.20%
LMI Residential Discount Rate	20%	-
Other Sectors Discount Rate	10%	10%
SREC Sales		
Sales Terms	15 Years	15 Years
SREC Price	$90/MWh	$100/MWh
Profitability		
Unlevered Pre-tax IRR	12.5%	12.4%
Levered Pre-tax IRR	20.3%	20.2%
Holding period NPV	$7.58/SF	$7.27/SF
Value Appreciation	$36.18/SF	$35.84/SF

Table 14 – Comparison of Community Solar and PPA

Profitability - Levered Pre-tax IRR

SREC Price ($/MWh)	All-sector Blended Electricity Price ($/kWh): 0.115	0.125	0.135	0.145	0.155
90	9.27%	11.48%	13.92%	16.71%	20.03%
95	10.26%	12.63%	15.27%	18.36%	22.11%
100	11.35%	13.89%	16.79%	**20.24%**	23.39%

Table 15 – PPA Sensitivity Analysis - All-sector Blended Sector Electricity & SREC Price

5.4 Scenario comparison

Building upon the scenario categorization framework outlined in **Section 5.1**, which aligns with business models, type of solar system, and tax credit monetization strategies, the analysis proceeds with identical key underwriting assumptions and valuation methods. Notably, the comparison overlooked the management cost difference to simplify the scenario analysis. The resulting return summary presents a varied picture that underscores the influence of these critical factors on the economic outcomes of solar roofs. The baseline scenario generates the highest levered IRR, while Scenarios 1-E and 1-D generate the highest NPV and system value.

In the roof leasing model, under the scenario that the third-party solar developer earns a 9.4% unlevered IRR, the industrial property owner will enhance its roof space value by $5.86/SF via the DCF approach or $8.00/SF via the direct cap approach.

	Profitability			**Value Creation**
Self-ownership Model	Unlevered Pre-tax IRR	Levered Pre-tax IRR	Holding Period NPV[18]	Income Approach[18]
1-A (Baseline): Solar PV only / ITC transfer	12.5%	20.3%	$7.58/SF	$36.18/SF
1-B: Solar PV only / ITC tax equity partnership	12.4%	19.7%	$5.09/SF	$33.74/SF
1-C: Solar PV only / PTC	9.4%	10.6%	$4.39/SF	$32.41/SF
1-D: Solar PV + BESS / ITC transfer	10.1%	12.0%	$8.52/SF	$55.86/SF
1-E: Solar PV + BESS / ITC transfer + PTC	8.5%	8.9%	$9.24/SF	$52.75/SF
	Profitability			**Value Creation**
Roof Leasing Model	Unlevered Pre-tax IRR	Levered Pre-tax IRR	Holding Period NPV[18]	Income Approach[18]
2-A: Solar PV only / ITC Transfer				
Solar Developer Perspective	9.4%	11.0%	$3.20/SF	$31.71/SF
Real Estate Owner Perspective	N/A	N/A	$2.50/SF	$5.86/SF (DCF) $8.00/SF (Direct Cap[19])

Table 16 – Return Summary by Scenario

[18] Using 6.75% discount rate
[19] Using 5.00% cap rate

Tax credit utilization methods

Scenarios 1-A, 1-B, and 1-C in the analysis address the different methodologies for leveraging tax credits.

Based on profitability metrics, scenarios involving ITC transfers and tax equity partnerships yield comparable results due to the efficient tax credit utilization. An ITC transfer directly converts tax credits into cash. In contrast, a tax equity partnership brings in an investor early in the project's life to share upfront costs and the ITC, eventually taking over the project once the target yield is met. ITC transfer case has a higher NPV as the ITC proceeds to reduce the upfront costs while leveraging the total operating income without allocating a portion of the tax savings to an investor.

Tax Equity Partnership Structure

Tax Equity Yield Target	8.0%
Pre-flip Cash Allocation to Tax Equity Investor	20%
Post-flip Cash Allocation to Tax Equity Investor	5%
Pre-flip Taxable Operating Income Allocation to Tax Equity Investor	99%
Post-flip Taxable Operating Income Allocation to Tax Equity Investor	5%

Table 17 – Scenario 1-B Tax Equity Partnership Structure

The scenario involving the transfer of PTCs shows lower IRR and NPV because it requires a larger equity investment, as shown in the comparison of capital stacks.

Capital Stack

1-A: ITC transfer		
Solar Developer Equity	$1.89M	17%
ITC Transfer Proceeds	$2.77M	25%
Debt	$6.44M	58%
1-B: ITC tax equity partnership		
Solar Developer Equity	$1.65M	15%
Tax Equity	$3.72M	34%
Debt	$5.66M	51%
1-C: PTC		
Solar Developer Equity	$4.61M	42%
Debt	$6.49M	58%

Table 18 – Capital Stack Comparison of Scenario 1-A, 1-B and 1-C

From a valuation perspective, despite integrating production tax benefits into the operating cash flow, the system value in the PTC scenario remains lower than that of the ITC scenarios. Within the meaningful range of production efficiency factor in the following sensitivity analysis, the PTC case does not show better economics regarding IRR and valuation, indicating that the production level and PTC unit value have yet to materialize to exceed ITC. As for system valuation, all three scenarios show a similar sensitivity level to the production change, where a 50 kWh/kW increase in efficiency contributes to around $1.2/SF incremental value of the solar system.

Return Comparison - Levered Pre-tax IRR / Solar System Valuation

Production Efficiency	1,100 kWh/kW	1,150 kWh/kW	1,200 kWh/kW	1,250 kWh/kW	1,300 kWh/kW
Annual Production	**5,198 MWh**	**5,434 MWh**	**5,670 MWh**	**5,906 MWh**	**6,143MWh**
1-A	14.0% $33.77/SF	16.8% $34.97/SF	**20.3%** **$36.18/SF**	23.5% $37.38/SF	24.9% $38.58/SF
1-B	13.8% $31.58/SF	16.5% $32.66/SF	**19.7%** **$33.74/SF**	23.8% $34.81/SF	29.3% $35.89/SF
1-C	7.7% $29.76/SF	9.1% $31.09/SF	**10.6%** **$32.41/SF**	12.0% $33.73/SF	13.1% $35.06/SF

Table 19 – Return Comparison of Scenario 1-A, 1-B and 1-C

The study further tested the impact of PTC value on financial performance. The result shows that even with a substantial 50% boost in PTC value, the returns are still lower than using ITC. Hence, ITC is a preferred tax credit option for solar roofs under current capital costs and production level assumptions.

In comparing three methods of tax credit monetization, ITC transfers are poised to be the choice for real estate owners because of their straightforwardness and effectiveness. As production efficiency and the value of PTCs grow, they may also become more attractive. Conversely, the more complex and less efficient tax equity partnerships will likely decline in use for converting tax credits to cash.

Scenario 1-C Returns - Levered Pre-tax IRR / Solar System Valuation

PTC Value ($/kWh)		Production Efficiency (kWh/kW) 1,100	1,150	1,200	1,250	1,300
0.0275	0%	7.7% $29.76/SF	9.1% $31.09/SF	**10.6% $32.41/SF**	12.0% $33.73/SF	13.1% $35.06/SF
0.0303	+10%	7.9% $30.03/SF	9.3% $31.36/SF	10.9% $32.70/SF	12.3% $34.04/SF	13.4% $35.37/SF
0.0330	+20%	8.1% $30.29/SF	9.6% $31.64/SF	11.2% $32.99/SF	12.6% $34.34/SF	13.7% $35.68/SF
0.0358	+30%	8.3% $30.56/SF	9.8% $31.92/SF	11.4% $33.28/SF	12.9% $34.64/SF	14.0% $36.00/SF
0.0385	+40%	8.6% $30.82/SF	10.1% $32.19/SF	11.7% $33.57/SF	13.2% $34.94/SF	14.4% $36.31/SF
0.0413	+50%	8.8% $31.09/SF	10.3% $32.47/SF	12.0% $33.85/SF	13.5% $35.24/SF	14.7% $36.62/SF

Table 20 – Scenario 1-C Sensitivity Analysis – Production Efficiency & PTC Value

BESS Integration

Scenarios 1-D and 1-E incorporate BESS into the solar roof system. This integration results in cash flow patterns that, while reducing IRR compared to scenario 1-A without BESS, also contribute an added value of $16-19 per square foot to the solar roof.

BESS Assumptions

Power Capacity		3,500 kW
Battery Duration		4 Hours
Energy Storage		14,000 kWh
Total Project Cost	*$1.92/W*	$6,725,000
Contract Capacity Revenue		$10/kW/Month

Table 21 – BESS Underwriting Assumptions

Scenario 1-E distinguishes from 1-D by utilizing the ITC for BESS and PTC for the solar PV system, whereas 1-D applies ITC to both. When comparing the IRR and the valuation of the solar roof, scenario 1-D demonstrates better returns, indicating the ITC's higher financial efficiency, similar to the conclusion applied to the solar PV system from **Section 5.3.**

The accompanying sensitivity analysis examines the impact of increased BESS revenue and capacity when using ITC for both systems. The analysis reveals that an increase in revenue of $2.5 per kW per month translates to an additional value of approximately $3.2 per square foot. Like the solar PV capacity, the BESS capacity is associated with capital costs; thus, expanding BESS capacity tends to deviate development cash flow and reduce the IRR while improving the overall valuation of the system.

Scenario 1-D Returns - Levered Pre-tax IRR / Solar System Valuation

BESS Capacity (kW)	BESS Revenue ($/kW/Month) 5.0	7.5	10.0	12.5	15.0
3300	7.3% $48.43/SF	9.7% $51.58/SF	12.2% $54.74/SF	15.0% $57.89/SF	18.5% $61.05/SF
3400	7.2% $48.80/SF	9.5% $52.05/SF	12.1% $55.30/SF	14.9% $58.55/SF	18.2% $61.80/SF
3500	7.1% $49.17/SF	9.4% $52.52/SF	**12.0% $55.86/SF**	14.9% $59.21/SF	17.8% $62.55/SF
3600	6.9% $49.54/SF	9.3% $52.98/SF	11.9% $56.42/SF	14.8% $59.87/SF	17.5% $63.31/SF
3700	6.8% $49.91/SF	9.2% $53.45/SF	11.8% $56.99/SF	14.7% $60.52/SF	17.3% $64.06/SF

Table 22 – Scenario 1-D Sensitivity Analysis – BESS Revenue & Capacity

This scenario presumes that BESS revenue is entirely from fixed contracts. While additional earnings could arise from energy price arbitrage during peak and off-peak periods or via participation in the wholesale ancillary services market, the nascent stage of New Jersey's energy storage program suggests that contracted revenue will remain the most reliable stream for financial underwriting purposes.

Dual views of roof leasing

Under the roof leasing model, Scenario 2-A examines the financial returns of real estate owners and solar developers. With $0.4/SF annual roof leasing rent and a 10-year lease, the property owner can realize a total monetization of $2.50 per square foot. The extra rental income, assuming lease renewal every ten years, also contributes to an increase in property valuation at $5.86/SF (DCF approach) or $8.00/SF (direct cap approach with 5% cap rate) over the solar system's 35-year operational lifespan.

Following roof leasing payments, the solar developer is projected to attain a 9.4% unlevered pre-tax IRR or an 11.0% levered pre-tax IRR, aligning with the benchmark IRR for solar system development projects.

Roof Leasing Assumptions

Leasing Terms	3,500 kW
Leasing Area	350,000 SF
Annual Leasing Rent	$0.4/SF
Property Cap Rate	5%
Rent Growth	2.0%

Table 23 – Roof Leasing Underwriting Assumptions

The economic viability for solar developers targeting a 9-10% unlevered IRR has been assessed through sensitivity analysis of roof leasing rents to explore the maximum rent a solar developer would be willing to pay to meet the IRR threshold. The table indicates that an annual rental rate of approximately $0.45/SF is the upper limit that maintains an 8.9% unlevered IRR for a solar developer, correlating with an increase in property value by $6.59/SF.

Solar Developer Unlevered Pre-tax IRR / Property Value Appreciation from Roof Rent

Annual Leasing Rent ($/SF)				
0.30	**0.35**	**0.40**	**0.45**	**0.50**
10.2% $4.39/SF	9.8% $5.12/SF	**9.4%** **$5.86/SF**	8.9% $6.59/SF	8.5% $7.32/SF

Table 24 – Scenario 2-A Sensitivity Analysis – Annual Leasing Rent

This conclusion is definite to the underwriting of this hypothetical project as a reference for pricing the roof rent. Market trends and prevailing sentiments will significantly influence the actual rates. Moreover, ESG considerations from property owners and tenants may further contribute to the dynamics of solar roof rent.

Chapter 6. Conclusion

6.1 Summary of analysis results

In Chapters 2, 3, 4, and 5, this paper investigates the US industrial solar roof market dynamics, policy context and financial incentives, business models, and financial analysis. Below is a summary of key takeaways from the investigation results.

Industrial solar roof market dynamics: The industrial solar roof market is influenced by a blend of factors, including the push for energy transition within the real estate sector, solar irradiance levels, the inventory of industrial properties, the array of supportive policies and incentives, and the retail electricity rates that delineate the supply side. This results in considerable variation across states. States like California, Texas, Illinois, Florida, New Jersey, and New York showcase the most dynamic markets due to their extensive installed solar capacities. Within these broader markets, specific submarkets such as Dallas, Inland Empire, and Chicago are distinguished by extensive pipelines of industrial properties and state-level commitments to solar growth, indicating a substantial opportunity for integrating solar roofing in new developments.

Policy context and financial incentives: Solar energy policies are crafted from a combination of regulatory frameworks and financial incentives at both the federal and state levels. Regulatory mechanisms crucial for solar energy transactions encompass net metering, interconnection standards, and community solar initiatives, which vary by state. On the financial side, federal-level ITC, PTC, and accelerated depreciation MACRS play pivotal roles in the financial feasibility of industrial solar roofs. State-specific incentives like property and sales tax exemptions and the trading of RECs bolster these.

Business models: In the industrial real estate sector, the prevalent solar roof business models are self-ownership and roof leasing. Larger firms often choose The self-ownership model that can leverage a diverse property portfolio and manage solar roofs with an in-house team, with financial returns bolstered by strategies such as integrating battery storage and optimizing tax credit monetization. Conversely, the roof leasing model suits smaller companies benefiting from solar energy without heavy initial investments. Both models require securing roof rights through leasing agreements to implement solar projects legally.

Financial analysis: The financial analysis in this thesis employs an actual industrial underwriting model to forecast the returns of a hypothetical solar roof project, specifically tailored to the market conditions and policy landscape in New Jersey. The study conducts scenario and sensitivity analyses using key profitability indicators like IRR and NPV alongside potential value creation via solar installations or roof rent. These analyses evaluate the effects of disparate tax credit monetization approaches, business models, and crucial operational variables such as production efficiency, capital expenditures, financing costs, and the pricing of electricity and RECs. The findings suggest that ITC transfer most efficiently monetizes the tax credit. At the same time, incorporating BESS offers the most substantial potential increase in property value at more considerable investment costs.

6.2 Implications for industry stakeholders

Solar roof monetization presents unique opportunities to the industrial real estate sector to gain financial returns, increase property value, and contribute to a clean grid. Based on findings and analysis from the paper, there are several critical implications for industry stakeholders considering solar roof deployment.

The 50-state market for solar roofs: The industrial solar market is characterized by variability and inconsistency across states, shaped by divergent policy frameworks. For industrial real estate owners looking to invest in solar roofing - whether implementing installations at scale or individual projects - it is imperative to thoroughly comprehend and monitor the unique aspects of each regional market. This understanding will inform the selection of the most suitable investment and operational approach, ensuring alignment with local regulations and maximizing return on investment.

Business model selection: The self-ownership and roof leasing models for solar PV systems yield distinct outcomes under the current market; the former offers higher profit potential and boosts property values but necessitates a dedicated team for project oversight. The latter yields lower returns but eliminates the need for specialized in-house expertise. Industrial real estate firms considering solar roofs should assess how these models integrate with their core business, weighing the financial implications and human resource commitments.

Co-existence with property tenancy: When integrating solar roofs with existing property tenancies, industrial real estate owners must navigate potential conflicts, especially if tenants need additional rooftop installations. To prevent operational disruptions, a portion of the rooftop - typically 5 to 10% - should be reserved for future mechanical needs. The strategic planning ensures that the primary industrial operations are not compromised by the addition of solar energy systems, thereby avoiding potential conflicts between the interests of energy initiatives and property stakeholders.

Navigating lower-cost capital: Tax credits and renewable energy-related loans critically lower the financial burden of solar roof projects, yet complexities in financing structures and regulatory landscapes pose challenges to industrial property owners. C-PACE financing's availability varies by state and lender market, and green bonds are better suited for larger companies. Direct transfer simplifies the monetization of tax benefits, otherwise entailing intricate tax equity partnerships. Therefore, real estate owners should carefully assess the local regulatory environment and financing options, understand the specific requirements and benefits of different financing structures, and seek to streamline the monetization process of tax credits to ensure a balance between cost-effective capital access and long-term investment in solar roofs.

Technical issues: Although not explored in depth in this thesis, industry stakeholders should also carefully examine technical issues when deploying solar roofs. Attention to the roof's structural capacity, interconnection infrastructure with the grid, and supply chain of solar system components is essential. Effective management of these technical aspects will reduce the capex and opex to enlarge the financial returns of solar roofs.

In summary, solar roof monetization in the industrial real estate sector hinges on strategic decision-making aligning with financial goals, operational capabilities, market region-specific regulatory frameworks, subsidies, and fundamentals. Stakeholders must navigate state variability, choose the suitable business model, manage technical and financial complexities, and safeguard against operational conflicts. Efficiently leveraging these elements will enhance property value, energy sustainability, and long-term returns on solar investment.

List of figures and tables

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Bibliography

American Council for an Energy-Efficient Economy. “Property Assessed Clean Energy (PACE).” ACEEE.org, January 27, 2017. https://www.aceee.org/toolkit/2017/01/property-assessed-clean-energy-pace.

U.S. Energy Information Administration. *Average Price of Electricity to Ultimate Customers by End-Use Sectors 2012 through 2022*. October 19, 2023. https://www.eia.gov/electricity/annual/html/epa_02_04.html.

Bennett, Abbie. “Fla. Governor Vetoes Controversial Net Metering Bill.” S&P Market Intelligence, April 27, 2022. https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/fla-governor-vetoes-controversial-net-metering-bill-70024382.

California Energy Commission. *2022 Building Energy Efficiency Standards.* CEC-400-2022-010-CMF. August, 2022. https://www.energy.ca.gov/sites/default/files/2022-12/CEC-400-2022-010_CMF.pdf

California Public Utilities Commission. *NEM Revisit Proceeding (R.20-08 020).* November 15, 2023. https://www.cpuc.ca.gov/nemrevisit

CBRE Econometric Advisors. *Solar Energy Opportunities in U.S. Industrial Real Estate.* CBRE, 2022.

CBRE Research. *2022 U.S. Industrial & Logistics Occupier Survey*. CBRE, 2022.

“Federal Solar Tax Credits for Businesses.” Solar Energy Technologies Office, August 2023. https://www.energy.gov/eere/solar/federal-solar-tax-credits-businesses#_edn1.

“Grid Connection Requests Grow by 40% in 2022 as Clean Energy Surges, despite Backlogs and Uncertainty.” *Berkeley Lab - Electricity Markets & Policy,* April 6, 2023. Lawrence Berkeley National Laboratory. https://emp.lbl.gov/news/grid-connection-requests-grow-40-2022-clean.

Johnson, Will. “Five Things to Know about C-PACE Lending.” Real Estate Capital USA, April 20, 2022. https://www.recapitalusa.com/five-things-to-know-about-c-pace-lending/.

Martin, Keith. “Transferability: Selling Tax Credits.” Norton Rose Fulbright - Project Finance News, March 6, 2023. https://www.projectfinance.law/publications/2023/march/transferability-selling-tax-credits/.

Prologis. *2022 Green Bond Report*. Prologis, December 2022. https://prologis.getbynder.com/m/505e5baff1e29890/original/2022-PELF-Green-Bond-Report.pdf.

Solar Energy Industries Association. “New Jersey Solar.” SEIA.org, December 2023. https://www.seia.org/state-solar-policy/new-jersey-solar.

Solar Energy Industries Association. *The 2022 Solar Means Business.* Solar Energy Industries Association, 2023.

Wood Mackenzie, and Solar Energy Industries Association. *US Solar Market Insight Executive Summary Q4 2023.* Wood Mackenzie and Solar Energy Industries Association, 2023.