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Review

Benefits of Property Assessed Clean Energy Programs and Securitization of Property Assessed Clean Energy Loans

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Abstract: Property Assessed Clean Energy (PACE) programs finance energy efficiency and renewable energy improvements to residential and commercial properties with a special tax assessment added to property taxes. This paper surveys the literature and documents the quantitative estimates of the environmental and economic benefits. This paper extends to discuss the securitization of PACE loans. The issuance of PACE green bonds frees up capacity for more PACE improvements. In addition, we summarize the concerns raised after the programs have been implemented. Those concerns include consumer protection, audit after program implementation, and lien-related risks for lenders. We discuss those concerns and suggest measures to continue to grow PACE financing. The success of PACE programs will contribute to reducing carbon emissions, mitigating climate change and to achieving six of the seventeen United Nations Sustainable Development Goals (SDGs).

Keywords: property assessed clean energy; sustainable development goals; energy-efficient mortgages; environmental benefits; energy efficiency; securitization; green bonds

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1. Introduction

Property Assessed Clean Energy (PACE) programs provide financing for energy efficiency and renewable energy improvements. Property owners make repayments via an assessment on their property tax bill. The financing arrangement can be transferred to the new owner upon sale. PACE loans are an alternative to traditional financing such as a personal bank loan or an energy-efficient mortgage (a mortgage to finance or refinance an energy-efficient home or to pay for energy-efficient improvements). PACE programs are public–private partnerships. Public partners are the state and the municipality. The state enacts legislation enabling the program and the municipality performs and collects special assessments. Private partners are the funds providers that provide money to pay for the improvements and receive repayments from the assessed taxes. PACE loans are often securitized and sold to capital markets. This securitization frees up lending capacity for new loans.

PACE financing is available for commercial properties, referred to as Commercial PACE (CPACE), as well as residential properties, referred to as Residential PACE (RPACE). (For commercial PACE, both abbreviations C-PACE and CPACE have been used in the literature. For residential PACE, both R-PACE and RPACE have been used in the literature.) PACE financing is tied to the property rather than the owner and is repaid through a special assessment added to the property tax bill. The municipality collects the assessed tax payments and passes them on to the lender. Such a structure is different from an energy-efficient mortgage (EEM). Under an EEM, the loan depends on the borrower's credit and ability to repay. Furthermore, the PACE loan may transfer with property ownership. Thus, the property owner may transfer the remaining balance to the buyer upon sale. In contrast, a mortgage must be repaid when the title is transferred to the new owner.

The environmental benefits of PACE programs are a reduction in energy and water use, greenhouse gas emissions, and hazard vulnerability [1–5]. PACE financed improvements

reduce the carbon footprint and contribute to the mitigation of climate change, directly supporting the 2050 net-zero target and the Sustainable Development Goals (SDGs). (The net-zero target is to reduce greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed into the atmosphere. This was called for by the Paris Agreement to cut emissions by 45 percent by 2030 and to reach net-zero by 2050. The United Nations established seventeen Sustainable Development Goals in 2015 to provide a shared blueprint for peace and prosperity for people and the planet.) The financing also generates economic benefits [3–6]. PACE programs help stimulate job growth in the clean energy sector. The installation of energy-efficient and renewable energy systems creates employment opportunities in the local community. These upgrades reduce energy consumption and save on utility bills, leading to increased disposable income for property owners. Energy-efficient upgrades improve quality of dwelling (healthier homes) and, together with savings on energy bills, can enhance the value of the property as well [7].

In the United States, PACE programs are active in 32 states and in Washington, D.C. Most of the programs are for commercial customers. Residential programs are currently available in California, Florida, and Missouri. PACE programs in the remaining states are still under development. Data from PACENation (www.pacenation.org) shows that cumulative investments in CPACE are USD 7.2 billion (2009–2023) and in RPACE are USD 8.4 billion (2015–2022). The investments in CPACE included 3340 projects and, in RPACE, upgraded 344,000 homes.

PACE programs are public–private partnerships. This collaboration provides an alternative source for property owners to finance energy improvements. The market is still in its early stages of development. The literature on empirical studies of PACE is limited. This paper surveys the literature, documents empirical evidence of PACE benefits, addresses concerns, especially for low-income participants, and discusses measures to support the continued growth of PACE programs. Energy-efficient and healthy homes contribute to meeting six of the seventeen SDGs established by the United Nations (https://sdgs.un.org/goals, accessed on 18 April 2024). Table 1 lists the seventeen SDGs and the six goals that PACE financing is aligned with. The six PACE-aligned goals are directly related to energy and the environment. The seventeen SDGs are the United Nations 2030 Agenda for Sustainable Development.

Table 1. Sustainable Development Goals and Property Assessed Clean Energy financing.

Sustainable Development Goals	**Aligning PACE with SDGs**
1 No Poverty	
2 Zero Hunger	
3 Good Health and Well-Being	V
4 Quality Education	
5 Gender Equality	
6 Clean Water and Sanitation	
7 Affordable and Clean Energy	V
8 Decent Work and Economic Growth	
9 Industry, Innovation and Infrastructure	
10 Reduced Inequalities	V
11 Sustainable Cities and Communities	V
12 Responsible Consumption and Production	V
13 Climate Action	

Table 1. *Cont.*

Sustainable Development Goals	Aligning PACE with SDGs
14 Life Below Water	
15 Life on Land	V
16 Peace, Justice and Strong Institutions	
17 Partnerships for the Goals	

The "V" in the second column indicates PACE aligned with the SDG. Source: https://sdgs.un.org/goals (accessed on 23 September 2024).

This paper surveys the development and the economic and environmental benefits of PACE financing. We discuss the securitization of PACE loans to access the capital market to finance improvements. We compare energy-efficient mortgages with PACE financing and discuss the securitization of both types of loans. We also examine the concerns and measures that grow PACE programs. The purpose is to highlight PACE benefits and promote PACE financing to contribute to the mitigation of climate change.

The rest of this paper is organized as follows: Section 2 covers a review of the literature. Section 3 first discusses energy-efficient mortgages and then offers a more detailed description of PACE programs. The next section covers the securitization of PACE loans to replenish capital for PACE financing. Such green securitization is an additional mechanism to unlock financing for small-scale low-carbon projects for residential and commercial properties. Section 5 discusses the concerns of PACE financing and measures to promote PACE programs. Finally, the last section concludes the paper and discusses potential future research areas.

2. Literature Review

PACE loans finance energy efficiency and renewable energy improvements to residential properties (RPACE) and commercial properties (CPACE). PACE financing is tied to the property, not to the owner. The owner repays through a special tax assessment. The assessment is a lien on the property. In the case of a sale, the PACE loan may transfer with property ownership if the buyer agrees to assume the loan and the new mortgage lender allows the loan to remain with the property.

We group the literature into three categories. First, several articles discuss the development of PACE programs. Second, we summarize empirical estimates of the environmental benefits from the literature. The environmental benefits are a reduction in energy use, emissions, and hazard vulnerability. Finally, the third category includes estimates of economic benefits, including output, taxes, jobs, and resale value of homes related to PACE financing.

2.1. Market Development

Ref. [8] discusses the growth and challenges of CPACE. The report cites the Clinton Climate Initiative estimates that the market potential for CPACE is between USD 88 and USD 133 billion in large commercial buildings. (The Clinton Climate Initiative of the Clinton Foundation focuses on solutions related to climate change. It aims at a holistic approach to address the main sources of greenhouse gas emissions.) The initial success of CPACE has been led by local governments. However, municipalities encounter steep learning curves and high costs. The report explains how state energy offices and other state-level partners can establish more favorable conditions to increase local CPACE participation. The report offers insights and strategies for state-level entities to provide statewide coordination and support to PACE programs. Another report [9] focuses on RPACE. The report reviews the development of RPACE. The report discusses concerns raised by mortgage lenders and consumer advocates. Mortgage lenders are concerned about the senior lien of PACE over mortgages. Consumer advocates raised concerns about potential financial risks RPACE poses to borrowers, as RPACE tax assessments are a tax obligation and are different from the repayment requirements of a traditional consumer credit or mortgage. The report

supports the inclusion of the ability to pay, strengthened disclosure practices, contractor oversight, and other provisions in PACE laws in California.

For the impact of PACE financing, ref. [10] shows that from 2008 to 2010, PACE programs increased solar energy installations in three California programs (Palm Desert, Yucaipa, and Sonoma County). Ref. [11] estimates the effect of PACE bonds issued between 2009 and 2017 on energy purchases and self-generation. They find more residential energy self-generation in California counties with PACE programs, but the results for electricity and natural gas purchases are inconclusive. With a different focus, ref. [12] studies the effect of PACE loans on consumer financial outcomes from over 200,000 consumers who applied for PACE loans. They compare mortgage delinquency between those who have taken a PACE loan and those who were approved but did not take the loan. They find that PACE loans cause an increase in negative credit outcomes, particularly in mortgage delinquency. Ref. [13] criticizes PACE for inadequate consumer protections and for not requiring environmental performance checks. Central to those concerns is that PACE does not assess the borrower's financial status to determine whether the borrower can repay. The second flaw in PACE program design is that it does not require a pre-project energy audit or post-construction inspection. Thus, they recommend requirements to ensure environmental benefits. Note that the matter related to consumer protection will be resolved with the Consumer Financial Protection Bureau's proposal to prescribe ability-to-repay rules for PACE financing and to apply the civil liability provisions in the Truth in Lending Act for violations (see also [14]).

2.2. Environmental Benefits

Ref. [4] utilizes Economic Consequence Analysis to examine the economic impacts of PACE in Florida and California. Their study focuses on PACE financing by the Ygrene Energy Fund, Inc. The data sample period is between 2013 and July 2018. Their results show that, in California, the environmental benefits include a reduction in water consumption of 2.36 billion gallons, in electricity consumption of 3.63 million megawatt hours (MWh), in natural gas consumption of 2.86 billion cubic feet (bcf), in greenhouse gas emissions of 1.15 million metric tons of carbon dioxide equivalent (CO2e), and avoidance of property damage from earthquake of USD 2.36 million. In Florida, the environmental benefits are a reduction in electricity consumption of 0.46 million MWh, in natural gas consumption of 0.28 bcf, in greenhouse gas emissions of 0.26 million metric tCO2e, and avoidance of property damage of USD 507.76 million from hurricanes. Ref. [5] focuses the economic impact analysis of Ygrene-funded PACE projects in California during the same period. The results are included in [4], listed above.

Ref. [3] extends the research by ref. [4] for PACE in Florida from July 2018 to November 2019. They obtained data from the Ygrene Energy Fund, Inc. Their estimated results are as follows: the environmental benefits include a reduction in electricity consumption of 960 kilowatt-hours (kWh), in gas consumption of 580 Mcf (one thousand cubic feet), in greenhouse gas emissions of 0.54 million metric tCO2e, and in property damage avoidance from hurricanes of USD 970 million.

Ref. [1] investigates the energy use impacts of solar photovoltaic (PV) projects financed by RPACE in California. Their data sample covers RPACE projects submitted to the California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA) through June 2017. CAEATFA administers a loss reserve supporting RPACE assessments in the state. They obtained additional data on electricity and energy usage from four large utility companies. The results show that installed energy efficiency technologies reduce electricity consumption by about 3 percent and gas consumption by about 3.5 percent. Solar PV projects produce electricity for about 69 percent of average household electricity consumption. They estimate that California RPACE projects installed through 2019 reduce the annual consumption of grid-tied electricity by 506 Gigawatt hours (equivalent to the electricity consumption of 74,000 households) and gas consumption by 2 million therms (equivalent to the gas consumption of 4700 households).

2.3. Economic Benefits

In an early attempt to analyze the economic impact of PACE financing, ref. [6] assumes a PACE budget of USD 4 million and allocate USD 1 million to each of the following four cities: Columbus, OH; Long Island, NY; Santa Barbara, CA; and San Antonio, TX. They calculate the direct, indirect, and induced impacts associated with this hypothetical PACE financing. They show that the USD 4 million PACE financing has the potential to generate USD 10 million in gross economic output, USD 1 million in tax revenues, and 60 jobs.

After PACE programs have been implemented, ref. [4] estimates the economic benefits of PACE in Florida and California with data from 2013 to July 2018. Their results show that in California, PACE-funded projects generate a net present value of USD 661 million in economic output, a net present value of USD 120.9 million in tax impacts, and create 9774 person-year jobs. In Florida, the results show that PACE financing generates a net present value of USD 608.2 million in economic output, a net present value of USD 136.6 million in tax impacts, and creates 11,716 person-year jobs. Ref. [3] extends the research by ref. [4] for PACE in Florida from July 2018 to November 2019. Their estimated economic benefits include 21,820 person-year jobs and USD 1.14 billion in gross state product growth.

Additional publications in the literature examine the resale value and price appreciation of the home related to PACE financing. Ref. [7] use a dataset from Renovate America to estimate the changes in home value from PACE improvements. Their data cover 773 loans associated with PACE improvements. For each home, data include the purchase price, sale price, and PACE loan. All loans are in California. The average purchase price is USD 236,324 and the average sales price USD 342,577. The average PACE financing is USD 19,091. The study uses three different methodologies. Methodology 1 compares the PACE sales price with three home price indexes. The results show a positive PACE premium of USD 199–8882. The second methodology compares PACE homes with non-PACE homes. The PACE homes gain USD 5010 more than their non-PACE counterparts. The third approach is multivariate regression. The regression results show PACE improvements increase home resale value by USD 4042.

Conversely, ref. [15] employs a two-way fixed effects regression to estimate the effect of the RPACE program rollouts on local housing returns in Florida. They find RPACE rollouts lead to fewer home sales and weaker house-price appreciation in the year of PACE introduction and the year after.

3. Energy-Efficient Mortgages and PACE Programs

Energy-efficient mortgages (EEMs) and PACE programs are both designed to finance energy efficiency and renewable energy projects. However, the mechanics are different. An EEM is a mortgage tied to the borrower and is repaid via monthly mortgage payments. In the case of a sale of the property, the owner must pay off the mortgage. Conversely, a PACE loan is tied to the property and the property owner repays annually or semi-annually through a special tax assessment added to the property tax bill. If the property is sold, the PACE financing can be transferred to the buyer.

3.1. Energy-Efficient Mortgage

An EEM, also called a green mortgage, offers the mortgage borrower favorable terms to finance a new energy-efficient home or energy-efficient improvements. The loan can be used for two purposes. First, the borrower can use the loan to purchase or build an energy-efficient home. In this case, the lender takes into consideration energy savings when determining the amount of the loan. Second, there is an energy-improvement mortgage to pay for improvements to an existing home. The lender can increase the loan amount to an existing mortgage to pay for the upgrade. Those green mortgages have been securitized to issue green mortgage-backed securities. In the United States, Fannie Mae leads the market in green mortgage-backed securities, with issuances over USD 100 billion by 2021 [16]. Another federal agency, Freddie Mac, is also active in supporting EEMs.

An energy-efficient home lowers utility bills, and thus there is more income available for mortgage payments. The literature shows evidence of savings from energy improvements leading to lower mortgage defaults in the United States and other countries. For example, refs. [17,18] provide evidence for the United States, ref. [19] for the European Union, and ref. [20] for the United Kingdom. In addition, studies have also shown that energy-efficient homes have higher sale prices. For example, refs. [21,22] show positive estimates in the Unites States, ref. [23] in Tokyo, and ref. [24] in China.

In summary, EEMs contribute to a low-carbon economy, healthier and more comfortable homes, and lower mortgage defaults. These improvements also have a positive effect on property sale prices. Therefore, EEMs help finance greener homes that benefit the environment, the borrower, and the lender.

3.2. Property Assessed Clean Energy Financing

Under PACE, states must pass legislation to authorize PACE programs at the local level. PACE financing, unlike EEMs or other alternatives, is tied to the property. The repayment is structured as an assessment attached to the property and not the property owner. PACE funds the full cost of qualified structural improvements. The property owner repays semiannually or annually through a special assessment added to the property tax bill. The PACE financing may transfer with property ownership if the buyer agrees to assume the PACE loan and the new mortgage holder allows the PACE obligation to remain with the property.

One important characteristic of PACE financing is that the special assessment filed with the local municipality is a lien on the property. PACE loan assessments have lien priority like real-estate taxes and therefore have priority over existing mortgages and subsequent mortgage financing (note that measures have been adopted in California to protect the interests of mortgage lenders). PACE loans cannot be accelerated, even in the event of a missed assessment payment. In the event of a PACE loan foreclosure, only the amount of the past-due assessment is due at the time of foreclosure. Future assessments are payable as-scheduled initially.

There are two types of PACE programs. Commercial PACE is for commercial properties and Residential PACE for residential properties. CPACE is authorized by state legislation. It also requires further authorization from local governments. CPACE is an optional source for financing energy efficiency, renewable energy, and resilience upgrades in commercial buildings. CPACE programs are active in 32 states plus Washington, D.C. As of 2023, the total investment in CPACE is USD 7.2 billion in 3340 commercial projects. CPACE investments include projects in energy efficiency, renewable energy, and resilience.

For residential properties, homeowners can access RPACE to finance eligible improvements to their homes. RPACE is currently offered only in California, Florida, and Missouri. As of 2022, the cumulative investment in RPACE is USD 8.4 billion in 344,000 home upgrades. RPACE investments include improvements in energy efficiency, renewable energy, resilience, and water efficiency. Table 2 lists PACE by project type for residential and commercial properties. Improving energy efficiency accounts for most of the investments for both CPACE and RPACE. For residential properties, there is a five percent investment in water efficiency. Other smaller items are not listed in the table.

Table 2. PACE Investments in Project Type.

PACE Programs	Main Project Type	Percentage of Total
CPACE	Energy efficiency	55%
	Renewable energy	17%
	Mixed	15%
	Resilience	3%

Table 2. *Cont.*

PACE Programs	Main Project Type	Percentage of Total
RPACE	Energy efficiency	32%
	Renewable energy	29%
	Resilience	28%
	Water efficiency	5%

Source: https://www.pacenation.org/pace-market-data/ (accessed on 17 May 2024). The table lists the main project types. Other smaller items are not listed. Thus, the sum of the percentages is less than 100 percent.

4. Securitization of PACE Loans

PACE loans fund the initial cost of improvements in energy efficiency, renewable energy, water efficiency, and resiliency projects. Sponsoring states implement legislation to collect repayments through property tax bills and redistribute them to lending agencies. The payments and associated credit risks are passed on to investors through the securitization of PACE loans. Such securitization enables lenders to sell off PACE loans to free up capacity to fund more improvements. It is the process through which a lender creates PACE loan-backed securities. The PACE bonds are sold to investors, who receive a return from the special tax assessment of the underlying PACE loan.

4.1. Green Securitization of PACE Loans

PACE loans finance improvements to support a greener environment. Similar to energy-efficient mortgages, PACE loans can be aggregated together to issue PACE green bonds [25]. By pooling PACE loans into a common structure, this green securitization provides an avenue for institutional investors to fund improvements to residential and commercial properties. PACE green bonds follow the guidelines from the Green Bond Principles [26]. The principles are industry voluntary process guidelines for transparency and integrity in the green bond market. The principles include criteria for the use of proceeds, the issuer's process for project evaluation and selection, the management of proceeds, and reporting, both at the time of issuance and on a periodic basis thereafter. The principles also recommend a pre-issuance external review and post-issuance external audit.

PACE green bonds have one of the strongest forms of credit quality, as the tax assessments in most states have a lien priority on par with tax liens and above the liens on mortgages. PACE financing providers have issued these green bonds and have found that many investors are interested in purchasing high-quality green bonds that make a positive impact on the environment. As an example, Nuveen Green Capital has issued over USD 1 billion in securitizations of PACE assets [27]. Ygrene has several issuances of PACE green bonds totaling more than USD 2.5 billion [28]. According to data from PACENation (www.pacenation.org), PACE financing providers have provided more than USD 15.6 billion in qualified improvements to residential properties (USD 8.4 billion as of 2022) and commercial properties (USD 7.2 billion as of 2023).

4.2. Investing in PACE Green Bonds

PACE securitization allows investors to gain exposure to the risks and rewards of the green bond market. PACE green bonds are a recent addition to the growing green bond market. The green bond market started in 2007. Between 2007 and 2012, the annual issuance volume remained low, at less than USD 4 billion. The annual volume jumped to USD 11 billion in 2013. The market continued to grow and the total cumulative issuance volume reached a milestone at USD 1 trillion in 2020 (https://www.climatebonds.net/market/explaining-green-bonds, accessed on 8 June 2024). The green bond market is still small and has the potential to become a significant segment of the global fixed-income market.

One important contributing factor to the development and growth of the green bond market is the increased requirements to finance climate and environmental solutions. The Paris Climate Agreement provides additional motivation for investors to allocate some

of their investments toward climate solutions. The United Nations SDGs also call for investments supporting the environment. Green bonds are tailored to unlock private capital to fund climate or other environmental sustainability purposes. The need to finance climate and environmental solutions and growing investor demand will continue to lift green bond issuance.

In summary, many institutional investors allocate a portion of their investments to support a low-carbon climate. The demand is driven largely by investors with a green mandate, but also by regular investors interested in green bonds to gain exposure to the green theme. The strong demand for green investments leads to some observations that green bonds are priced at a lower yield than similar conventional bonds by the same issuer (also known as the green premium). For example, refs. [29–31] are among the many publications that show the existence of the green premium.

5. Challenges Faced by Developing Markets for PACE Loans and Securitized PACE Bonds

As of 2023, the cumulative investments in both CPACE and RPACE improvements are more than USD 15 billion. However, PACE market growth has faced challenges. Those challenges include program complexity, lack of standardization across jurisdictions, and administrative and legal lifts required for successful program implementation. Refs. [19,20] discuss the roles state energy offices can play in supporting and advancing PACE programs. Ref. [12] addresses concerns about consumer protection. Ref. [13] discusses concerns over consumer protection and the lack of pre-project audits or post-project inspections. These reports have identified the hurdles and offer recommendations to overcome the challenges. Below, we highlight several important areas that are helpful to the continued success of PACE financing.

First, PACE programs are established and operated at the state and local government levels. Some states have fully operational PACE programs. Other states have authorized PACE programs but have not been implemented or only have limited utilization. In addition, some states have introduced legislation but have not enacted them to authorize PACE programs. There is no uniformity in the application process, financing structures, or program procedures. It is helpful to promote the programs nationwide, establish a streamlined process for borrowers and bankers, and offer supportive federal and state policies to promote PACE programs.

Second, PACE loans are secured by the property and have senior lien over other debts on the property. In a foreclosure, this senior lien status means that the delinquent portion of the PACE loan obligation is paid by the foreclosure sale proceeds before the mortgage is paid. Such a senior lien has an impact on federally backed mortgage products; thus, RPACE has drawn attention from multiple federal agencies. In addition, some mortgage lenders have raised concerns about subordinating their mortgage to a PACE assessment. To mitigate the perceived risks of senior lien PACE loans, some have suggested implementing junior lien PACE programs that make PACE assessments subordinate to the mortgage. Furthermore, California has established a PACE Loss Reserve Program to make mortgage lenders whole for direct losses because of a PACE lien in a foreclosure or forced sale.

Another important issue in RPACE relates to consumer protection. As ref. [12] shows, consumer protection laws of 2018 in California for PACE lead to smaller increases in mortgage delinquency. Furthermore, PACE financing that includes income in the application process also leads to better outcomes in mortgage delinquency. Ref. [13] emphasizes the negative impacts on low-income Californians as one of the two serious flaws in PACE program design. Hence, the Consumer Financial Protection Bureau has proposed to prescribe ability-to-repay rules for PACE financing and to apply civil liability provisions in the Truth in Lending Act for violations.

The 2022 Inflation Reduction Act (IRA), the landmark federal climate law, includes USD 369 billion to mitigate climate change [32]. Those climate goals support the United Nations SDGs, as well. The IRA will increase the pace of emission reduction, but to reach the 2030 climate goal of cutting pollution by 45 percent from 2005 levels and to get on

a path to net-zero by 2050, additional efforts are required. PACE financing, a public–private partnership solution, has provided more than USD 15 billion for energy-related improvements in many states in the United States. With regulatory reforms and enhanced consumer protections, PACE will contribute to meeting the climate goals and to supporting the United Nations SDGs, as well.

6. Conclusions

PACE loans finance the cost of energy and other eligible improvements to the property. The owner pays back the costs overtime through a special tax assessment. The unique characteristic of PACE financing is that the assessment is attached to the property rather than the owner. PACE-financed improvements generate environmental and economic benefits. In addition, PACE can provide financing to those who might otherwise have difficulty obtaining other forms of credit. Another direct benefit to residential and commercial borrowers is that there is no down payment or initial cost. Together with other initiatives and incentives, PACE programs can be part of the government's efforts to mitigate climate change. PACE is also aligned with six United Nations SDGs.

In this paper, we discussed PACE programs in the United States and documented empirical estimates of economic and environmental benefits in the literature. In addition, securitization of PACE loans taps into the private capital market to expand the funding source for PACE programs. We also compared EEMs with PACE programs. Securitization of EEMs have been successful due to support from federal mortgage agencies. With measures to overcome the concerns surrounding PACE financing and investor allocations in green theme, PACE programs will continue to grow.

Future research could be extended to compare the yields of PACE green bonds to other types of green bonds. The structure of a PACE loan is generally more secure for the lender. Future research could also examine whether PACE green bonds are priced at a lower yield. Furthermore, another future research direction could focus on public–private partnership in PACE financing. As discussed in this paper, PACE programs are not yet available in many states. It is helpful to examine how to enhance this partnership and implement PACE programs nationwide. Public–private partnership will be beneficial to the securitization of PACE loans as well, as evidenced by the mortgage-backed securities market.

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Abbreviations

PACE (Property Assessed Clean Energy); RPACE (Residential Property Assessed Clean Energy); CPACE (Commercial Property Assessed Clean Energy); SDGs (Sustainable Development Goals); EEM (Energy-Efficient Mortgage).

References

1. Deason, J.; Murphy, S.; Goldman, C.A. Empirical estimation of the energy impacts of projects installed through residential property assessed clean energy financing programs in California. *Energies* **2021**, *14*, 8060. [CrossRef]
2. Hart, M.; Camisa, H.; Cortes, M.; Leroy, O. An Introduction to Property Assessed Clean Energy Program. *Holland & Knight Retail and Commercial Development and Leasing Blog*, 9 March 2023. Available online: https://www.hklaw.com/en/insights/publications/2023/03/an-introduction-to-property-assessed-clean-energy-financing (accessed on 18 January 2024).
3. Olophant, Z.; Culhane, T.; Haldar, P. *Public Impacts of Florida's Property Assessed Clean Energy (PACE) Program*; Working Paper; Patel College of Global Sustainability, University of South Florida: Tampa, FL, USA, 2020.
4. Rose, A.; Wei, D. *Impacts of Property Assessed Clean Energy (PACE) Program on the Economies of California and Florida*; Working Paper; USC Schwarzenegger Institute: Los Angeles, CA, USA, 2019.
5. Rose, A.; Wei, D. Impacts of property assessed clean energy (PACE) program on the economy of California. *Energy Policy* **2020**, *137*, 111087. [CrossRef] [PubMed]

6. Pozdena, R.; Josephson, A. *Economic Impact Analysis of Property Assessed Clean Energy Programs (PACE)*; ECONorthwest: Portland, OR, USA, 2011.
7. Goodman, L.; Zhu, J. PACE loans: Does sale value reflect improvements? *J. Struct. Financ.* **2016**, *21*, 4. [CrossRef]
8. National Association of State Energy Officials. *Accelerating the Commercial PACE Market*; National Association of State Energy Officials: Arlington, VA, USA, 2016.
9. National Association of State Energy Officials. *Residential Property Assessed Clean Energy (RPACE): Key Considerations for State Energy Officials*; National Association of State Energy Officials: Arlington, VA, USA, 2018.
10. Kirkpatrick, A.J.; Bennear, L.S. Promoting clean energy investment: An empirical analysis of property assessed clean energy. *J. Environ. Econ. Manag.* **2014**, *68*, 357–375. [CrossRef]
11. Winecoff, R.; Graff, M. Innovation in financing energy-efficient and renewable energy upgrades: An evaluation of property assessed clean energy for California residences. *Soc. Sci. Q.* **2021**, *101*, 2555–2573. [CrossRef]
12. McAlister, S.; Sandler, R. *Property Assessed Clean Energy (PACE) and Consumer Financial Outcomes*; Consumer Financial Protection Bureau: Washington, DC, USA, 2023.
13. Polsky, C.; Christensen, C.; Ho, K.; Ho, M.; Ismailos, C. *The Dark Side of the Sun: How PACE Financing Has Under-Delivered Green Benefits and Harmed Low-Income Homeowners*; U.C. Berkeley Environmental Law Clinic: Berkeley, CA, USA, 2021.
14. Kohler, J.; Coryne, H. Clean-Energy Loans Trapped Black Homeowners in Debt, the Legislatures just Started to Fix the Problem. *Propublica*, 6 March 2021. Available online: https://www.propublica.org/article/clean-energy-loans-trapped-black-homeowners-in-debt-the-legislature-just-started-trying-to-fix-the-problem (accessed on 19 January 2024).
15. Millar, M.I.; White, R.M. Do residential property assessed clean energy (PACE) financing programs affect local housing price growth? *J. Environ. Econ. Manag.* **2024**, *124*, 102936. [CrossRef]
16. Fannie Mae. *2020 Green Bond Impact Report*; Fannie Mae: Washington, DC, USA, 2021.
17. Argento, R.; Bak, X.F.; Brown, L.M. *Energy Efficiency: Value Added to Properties & Loan Performance*; Freddie Mac: Washington, DC, USA, 2019.
18. Kaza, N.; Quercia, R.G.; Tian, C.Y. *Home Energy Efficiency and Mortgage Risks*; Working Chapter; UNC Center for Community Capital: Institute for Market Transformation: Washington, DC, USA, 2013.
19. Richardson, S.; Drinkwater, J. *Creating an EEM for Europe*; Technical Report; World Green Building Council: London, UK, 2017.
20. Guin, B.; Korhonen, P. *Does Energy Efficiency Predict Mortgage Performance?*; Staff Working Chapter No. 852; Bank of England: London, UK, 2020.
21. Kahn, M.E.; Kok, N. The capitalization of green labels in the California housing market. *Reg. Sci. Urban Econ.* **2014**, *47*, 25–34. [CrossRef]
22. Walls, M.; Gerarden, T.; Palmer, K.; Bak, X.F. Is energy efficiency capitalized into home prices? Evidence from three U.S. cities. *J. Environ. Econ. Manag.* **2017**, *82*, 104–124. [CrossRef]
23. Shimizu, C. Sustainable Measures and Economic Value in Green Housing. *Open House Int.* **2013**, *38*, 57–63. [CrossRef]
24. Zhang, L.; Liu, H.; Wu, J. The price premium for green-labelled housing: Evidence from China. *Urban Stud.* **2016**, *54*, 3524–3541. [CrossRef]
25. Fitch Ratings. *Green Securitization: Development and Challenges*; Special Report; Fitch Ratings: New York, NY, USA, 2021.
26. International Capital Market Association. *The Green Bond Principles*; International Capital Market Association: Zurich, Switzerland, 2021.
27. Nuveen Green Capital. Nuveen Green Capital closes third and largest rule 144A securitization of C-PACE assets. *News Release*, 12 April 2023.
28. Ygrene. Ygrene completes $344 million securitization of PACE assets. *News Release*, 18 March 2022.
29. Baker, M.; Bergstresser, D.; Serafeim, G.; Wurgler, J. *Financing the Response to Climate Change: The Pricing and Ownership of U.S. Green Bonds*; NBER Working Papers 25194; National Bureau of Economic Research, Inc.: Cambridge, MA, USA, 2018.
30. Gianfrate, G.; Peri, M. The green advantage: Exploring the convenience of issuing green bonds. *J. Clean. Prod.* **2019**, *219*, 127–135. [CrossRef]
31. Hyun, S.; Park, D.; Tian, S. The Price of Greenness: The Role of Greenness in Green Bond Markets. *Account. Financ.* **2019**, *60*, 73–95. [CrossRef]
32. Glavinskas, V. The Inflation Reduction Act Is a Victory for the Climate, Here's What Comes Next. *Environmental Defense Fund News*, 6 September 2002. Available online: https://www.edf.org/article/inflation-reduction-act-victory-climate-heres-what-comes-next?ub_tg=372&ub_o=26&ub_cta=4&utm_source=google&utm_campaign=edf_ira_upd_pmt&utm_medium=ad&utm_id=1666800832&gad=1&gclid=EAIaIQobChMInde1-8CsgAMVvxKzAB1powAVEAAYAiAAEgJLd_D_BwE&gclsrc=aw.ds (accessed on 20 February 2024).