



R-PACE: A GAME-CHANGER FOR NET-ZERO ENERGY HOMES

INSIGHT BRIEF

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||||||| HIGHLIGHTS

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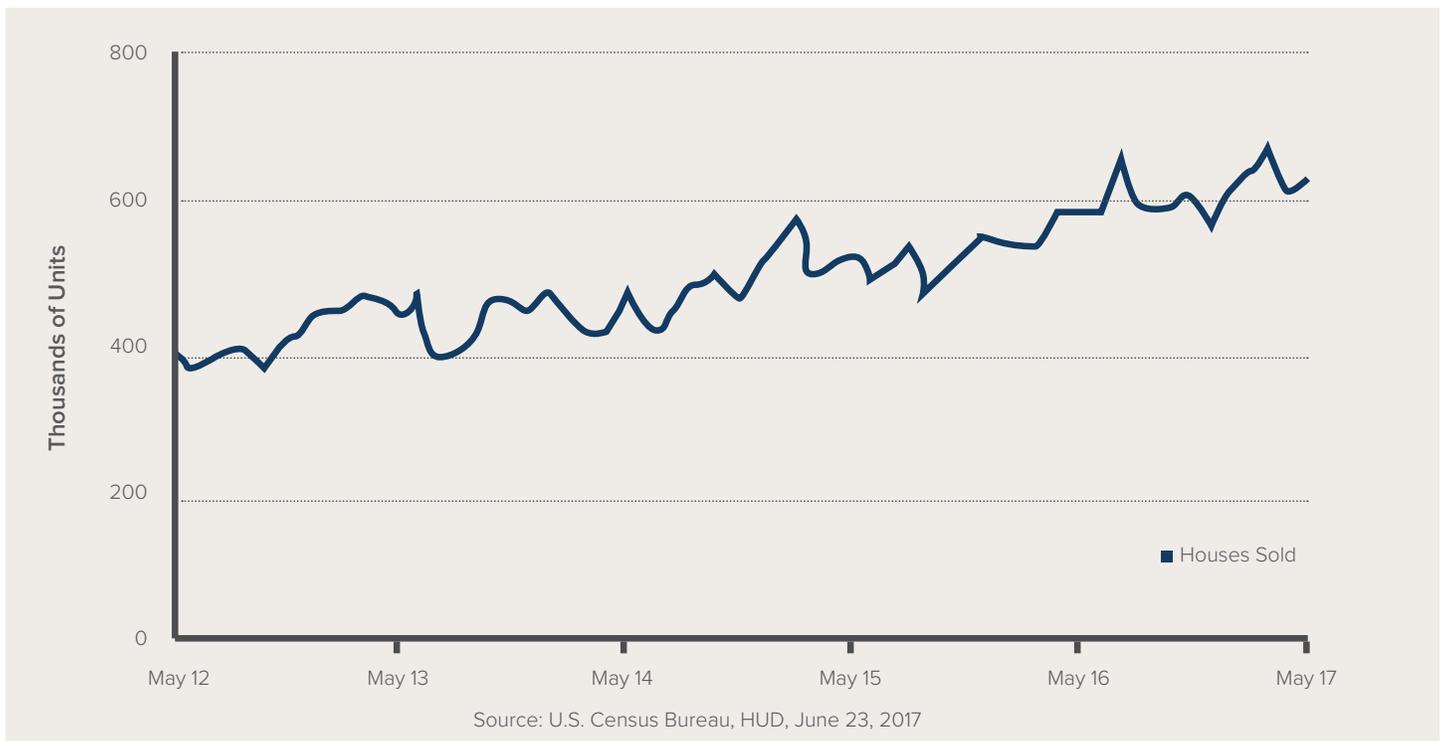
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- Residential property assessed clean energy (R-PACE) financing is a game-changing financing mechanism that can help states deliver high-performance, net-zero energy (NZE) homes at no additional up-front cost.
- With a potential incremental market opportunity of over \$33 billion by 2037, NZE residences offer favorable outcomes to homeowners and real estate developers, while also benefitting the economy and the environment.
- Leading states and cities have an opportunity to invest in scaling NZE development by enabling R-PACE for new construction.

||||||| INTRODUCTION

The U.S. residential real estate market is booming, with new home sales steadily rising over the last few years. In March 2017, over **621,000 new single-family homes were sold** (see figure 1) at a median sales price of \$345,800. Imagine if most of these new home developments were net-zero energy (NZE),ⁱ not only providing the homeowner net monthly energy savings but also delivering superior performance, better comfort, and grid resilience.

Figure 1: Sale of New Homes in the U.S. (Seasonally Adjusted)



ⁱFor the purpose of this insight brief, we define net-zero energy (NZE) homes as single-family homes with one to four units that are sustainably designed, highly energy-efficient buildings, which produce or procure enough zero-carbon renewable energy to offset their annual fossil fuel energy consumption

Now suppose residents in your state could afford these high-performance NZE homes at **no additional up-front cost** using an innovative financing tool that would **annually save them more money than they pay out toward the financing**. Rocky Mountain Institute's (RMI's) research findings confirm that this dream scenario can be made a reality through a special application of residential property assessed clean energy (R-PACE) financing—a game-changing financing mechanism that has already financed energy efficiency retrofits in over **158,000** homes in California, Florida, and Missouri.

This insight brief demonstrates the business case of using R-PACE for financing the rapid development of NZE new construction in states and cities across the U.S. We are working toward a future where **R-PACE can enable U.S. homes to be more resilient, affordable, innovative, efficient, and high-performing and at the same time cost less than an average home.**ⁱⁱ With a potential incremental market opportunity of over \$33 billion by 2037,ⁱⁱⁱ NZE residences promise a future that is propitious not only for homeowners and real estate developers but also for the U.S. economy and planet as a whole.

||||| WHY FOCUS EFFORTS ON SCALING NZE HOMES?

NZE homes are going to be the next big frontier for innovation and competition in the residential real estate market. While mainstream real estate players are still playing catch-up, corporations like **Tesla** and **Toyota** are looking to disrupt the market with ideas that will enable our future homes to be smarter, more connected, and grid resilient. Competition in the sector is only going to rise with the pace of technological advances, and it is likely that big technology organizations will make a play for the sector in the near future. There are four important reasons why leading states and cities should invest in development of NZE homes:

1. CONSUMERS INCREASINGLY DEMAND HIGH-PERFORMING NZE HOMES:

Consumers are driving the demand for energy-efficient NZE homes and are increasingly looking for superior energy performance along with comfort, safety, accessibility, and affordability in their future homes. The 2016 National Association of Housing Builders (NAHB) survey reaffirms that energy-saving features in a newly constructed home are top of mind for buyers, who are willing to spend, on average, an **additional \$10,732 on the up-front price of a home** to save on utility costs. This demand is driven primarily by Millennials, who make up the **largest share (32 percent)** and **fastest growing group of homebuyers**, according to a recent generational trends report by the National Association of REALTORS® (NAR). While older generations sought out homes with luxury amenities and rooms with one specific purpose, younger buyers are seeking affordable and high-performing homes. Unsurprisingly, a recent study from NAR found that **9–10 percent of millennials** cite green/energy-efficiency as the main reason for buying a particular home. With consumers driving the demand, NZE home development will only continue. Presently, there are over **6,000 zero-energy and zero-energy-ready homes** and apartments in North America, a **103 percent increase** nationally over the past two years, signalling a transformative change in consumer needs and market paradigms.

ⁱ This conclusion is based on RMI's business case analysis of six key states in the U.S. The details of this analysis are discussed in the Appendix.

ⁱⁱ Market opportunity estimate assumptions: New home sales in the United States averaged 650,950 from 1963 until 2017. Median sales price of new homes in 2017 was \$345,000.

Sales price increased by 4.6% between 2012–2017. Therefore, assuming a nominal increase in sales price of 4.6% compounded annually over the next 20 years (life of typical equipment). We are also assuming the average incremental cost for building an NZE home to be constant at 10% and that NZE homes will make up 60% of new home sales after 20 years.

2. NZE HOMES MAKE BUSINESS SENSE AND HAVE SIGNIFICANT MARKET POTENTIAL:

Investment in construction of new residential buildings contributes between **3 and 5 percent** of GDP. The business case and market potential for NZE new construction is compelling. A case in point is Efficiency Vermont's Net Zero Feasibility Study, which demonstrates that **NZE homes make for the best investment** before rebates or incentives, both in year one and over a 30-year loan period. In terms of market potential, Pike Research estimates that by 2035, **\$1.3 trillion** will be spent on zero-energy homes and buildings worldwide. RMI's research confirms that NZE homes present an incremental market opportunity of **\$33 billion** for the U.S. real estate industry by 2037.^{iv} These are compelling statistics that will eventually translate into more jobs for the U.S. economy overall.

3. NZE DEVELOPMENT CAN HELP FULFILL AMBITIOUS STATE OR CITY CARBON REDUCTION GOALS:

Fifty-eight percent of U.S. states have implemented ambitious renewable energy portfolio requirements in the form of **renewable portfolio standards (RPS) or alternative energy portfolio standards (AEPS)** and/or instituted state-wide **climate and sustainability goals**. Since buildings consume **40 percent of U.S. energy consumption** and account for over **39 percent of U.S. CO₂ emissions**, these states and cities are unlikely to meet their goals without making concerted efforts to drive building energy efficiency. While the commercial residential sector is making steady progress, the residential sector is still catching up. Several cities and states recognize this challenge and are already mandating stricter building codes and energy disclosure requirements that support NZE home development to further their climate commitments through a market-ready approach. For instance, California's building codes are expected to require all new home construction to be **"zero energy ready"** by 2020. At the same time, the state of Washington designed its state energy building codes to encourage **zero-energy home development by 2031**. Cities like Montpelier, Vermont, are also driving ambitious projects. **Net Zero Montpelier** aims to transform Montpelier's energy system in an effort to make it the nation's first state capital where all the energy will be produced or offset by renewable energy sources.

It is also important to note that the aggressive carbon-reduction goals set by states such as Colorado, Connecticut, Vermont, Massachusetts, and others are likely to be achieved only when the majority of their new building stock is NZE. The policies implemented by these cities and states will have a profound impact on the growth of NZE home development and are likely to pave the way for others to adopt similar strategies.

4. AGING BUILDING STOCK AND COMPELLING NEW CONSTRUCTION-PROJECT ECONOMICS PRESENT AN OPPORTUNITY FOR NEW NZE DEVELOPMENT:

According to the 2015 American Community Survey, the median age of the U.S. building stock is **37 years**. In RMI's experience, the incremental cost of efficiency measures for new construction is usually one-third of the estimated cost in a typical energy retrofit scenario, which by its nature necessitates the replacement of existing functioning systems in order to achieve the deep

^{iv} Refer to calculations in the section above.

efficiency gains necessary to achieve NZE performance. Therefore, the more immediate, cost-effective, and straightforward approach to building smarter cities for the future is to scale the adoption of NZE new construction first, closely followed by planning major construction renovations to aging existing buildings where energy retrofits have compelling project economics. Encouraging and incentivizing all new construction to be NZE or NZE-ready is not just an effective policy tool but an imperative.

||||||| MARKET BARRIERS FOR SCALING NZE HOME CONSTRUCTION

There are several market, policy, and implementation barriers to scaling NZE residential development in the U.S. However, for the purpose of this insight brief, we will be addressing the three most prominent market barriers affecting the growth of this sector: incremental up-front capital costs, valuation uncertainty regarding energy performance, and builder/homeowner split incentives.

- **Large up-front capital costs for both the builder and homebuyer:** Depending on state policies, climatic conditions, and construction costs, constructing an NZE home could cost more up front than constructing an average home. RMI's research, discussed in the Appendix, suggests that the incremental up-front cost to construct an NZE home could vary anywhere from **5.2 percent to 11.5 percent** (without incentives and tax rebates) of the total construction cost across California, Missouri, Florida, New York, Colorado, and Georgia, which collectively comprise almost one-third of the single-family housing market. This up-front capital cost is one of the major deterrents for builders and developers looking to invest in NZE real estate development. At the same time, even if the builders employed their equity to finance this incremental up-front cost, this cost would ultimately have to be transferred onto the homebuyer for whom this is a substantial financial burden and barrier at point of sale.
- **Home valuations do not reflect NZE performance:** Most NZE homes demonstrate superior energy performance over average homes while accruing substantial energy savings to the homeowner year-on-year. These energy cost savings should ideally translate to an increase in value of NZE homes. However, it is less clear how energy performance of NZE homes is presently valued by appraisers, lenders, or even homebuyers. This valuation uncertainty is a major market failure and one of the reasons for the latent consumer demand for NZE homes.
- **Builder/homebuyer cost-benefit split incentive and transaction uncertainty:** According to NAHB's analysis of the Census Bureau's Survey of Construction, in 2015 more than **73 percent of the homes in the U.S. were built by builders** for sale while only 22 percent of the homes were custom built by homeowners. Builders, who control almost three-fourths of this market, have been unwilling to invest up-front equity for installing energy-efficient appliances or ensuring renewable energy integration during the home construction process since they do not directly benefit from the operational cost savings and have no incentive to maximize them. Moreover, even if builders did invest in these improvements, they don't have sufficient certainty that homebuyers will be willing to pay more up front for long-term savings at the time of sale to justify the additional project costs. The misaligned builder incentives and weak market signals have also been a significant barrier to NZE new construction.

||||||| HOW RESIDENTIAL PACE CAN SCALE THE NZE HOME MARKET

Residential PACE (R-PACE) is an innovative financing mechanism used to finance energy efficiency, renewable energy, resilience, and water-saving home improvements. R-PACE assessment is typically attached to a property's tax bill secured by the same type of lien against the property as tax bills and is repaid through property taxes. It is unique in that it is transferable upon sale of the property because the financing is tied to the property rather than the property owner. Overall, R-PACE has been extremely effective in tackling a **significant market failure** by increasing American households' access to financial resources so that they can realize the benefits of cost-saving and resilient high-performance homes. R-PACE has successfully financed over **158,000 retrofits** in three states since 2008, which demonstrates its market acceptability, scalability, and potential as a transformational market financing tool. It is worth noting that R-PACE has seen unprecedented growth in California, which has been largely driven by enabling state legislation. This growth has now started to spread across other states like Florida and Missouri.

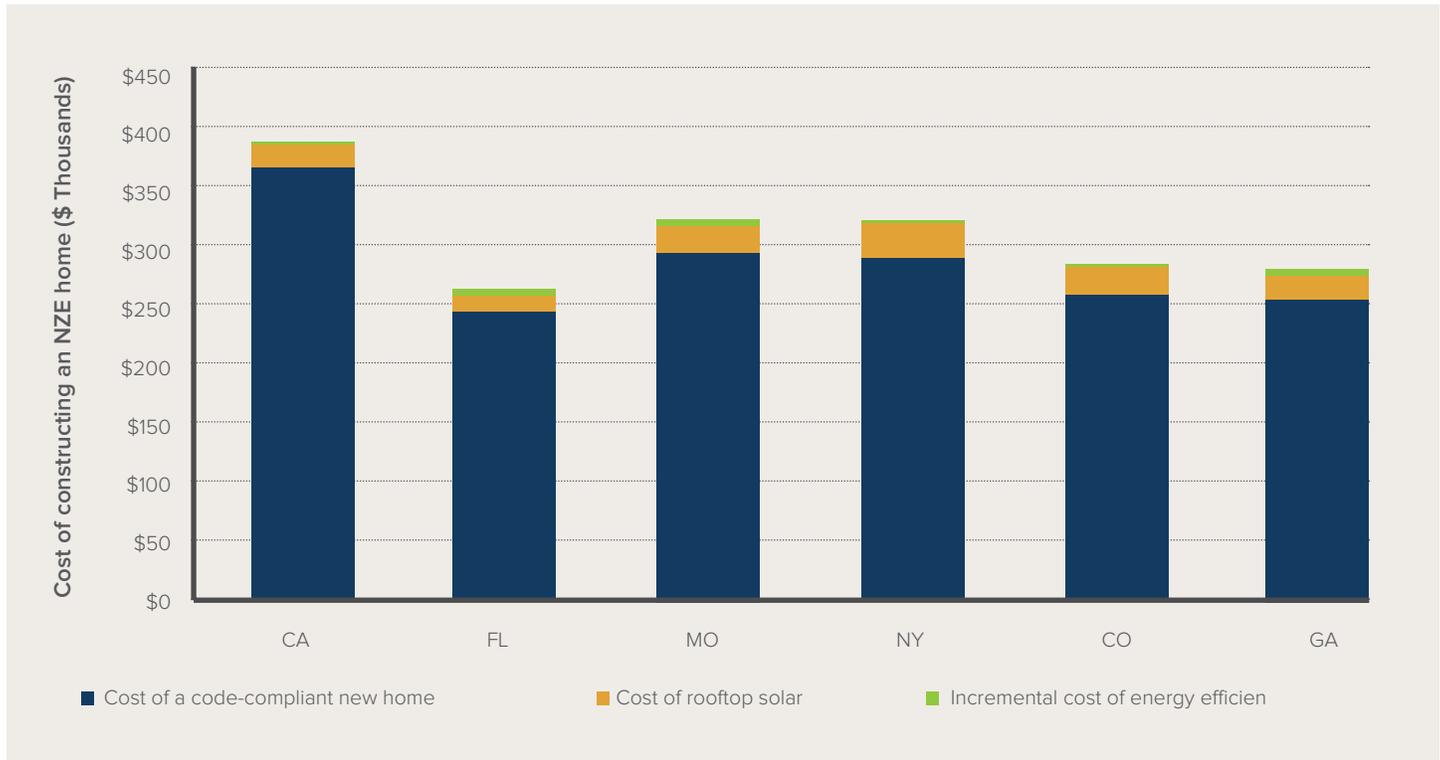
Presently, R-PACE has been primarily used for home improvement retrofits, and new construction is not eligible as an option to most builders or developers within the existing state-enabled programs of California, Florida, and Missouri.^v

RMI strongly believes that R-PACE has the potential to resolve the most prominent market barriers to scale NZE new construction development for the following reasons:

1. R-PACE PROVIDES INCREMENTAL UP-FRONT CAPITAL INVESTMENT FOR NZE HOME CONSTRUCTION: R-PACE can solve a major market failure by providing both homeowners and builders/developers the requisite up-front capital to finance the measures for NZE home construction. This mechanism is especially well suited to new construction since it allows the incremental costs to be repaid over a long period of time as the savings are realized. At the same time, this assessment is attached to the property rather than the individual, so in case of a sale, the new property owner pays the "amortized" costs as he or she enjoys the savings. RMI's analysis, summarized in the Appendix, confirms that while the average incremental up-front cost for constructing an NZE single-family home was \$24,811 (excluding the federal investment tax credit and other state-specific incentives), it is likely to vary between 5.2 percent and 11.5 percent of the construction cost depending on the state (see figure 2 below). The results of our analysis emphasize the need for policy drivers to support financing instruments like R-PACE to help finance the incremental capital construction costs to drive the growth of NZE development.

^v In California, under the HERO program, new construction is not eligible, unless ownership has been transferred from the developer to the property owner.

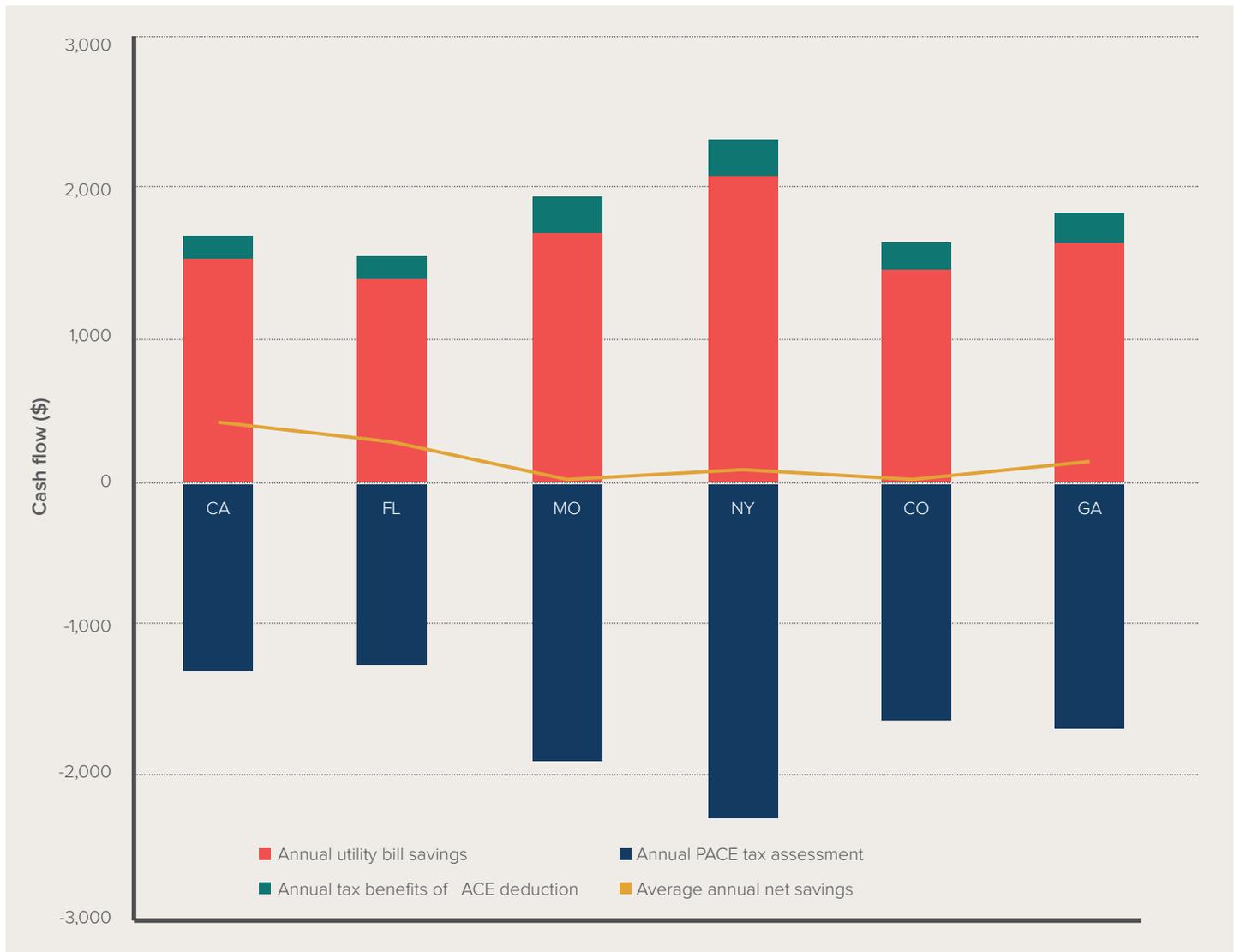
Figure 2: Business case for constructing NZE Homes across six key states in the U.S.



2. ANNUAL COST SAVINGS FROM AN NZE HOME ARE MORE THAN THE R-PACE ASSESSMENT PAYOUTS:

RMI's analysis confirms that across all six states, on an annual basis, NZE homes financed by PACE are likely to provide homeowners more annual cost savings than the amount they pay for their annual PACE assessments (see figure 3 below). In other words, **an R-PACE financed NZE home is a great investment as it ultimately costs the homebuyer less than an average home year-on-year with no incremental up-front cost.** It is important to note, however, that in this analysis we have not accounted for the intangible benefits of the superior home performance of an NZE home, which would make the business case even more compelling.

Figure 3: Homeowner's annual cash flow for an R-PACE financed NZE Home



3. R-PACE RESOLVES THE COST/BENEFIT SPLIT INCENTIVE: The unique aspect of PACE is that it allows the initial incremental capital costs borne by the builder/developer at the time of construction to be transferred to the homeowner upon the sale of the property because it is ultimately the homeowner that stands to benefit from net-zero building operation costs over the next 20 years. This helps resolve the imminent cost/benefit split incentive concerns. Moreover, PACE, like any other assessment, is attached to the property—not the individual—which means it can be transferred upon sale to the new occupants who continue to pay the remaining portion of the assessment on an annual basis while enjoying the benefits of annual net savings year after year. **RMI's analysis confirms that, on average, a homeowner will yield average net monetary benefits of \$160 annually even after deduction of his or her PACE obligations** (see Appendix).

4. R-PACE LOWERS THE NEED FOR ADDITIONAL CONSTRUCTION LOANS AND BUILDER/DEVELOPER EQUITY: R-PACE assessments can solve the most critical financial barrier to NZE home development by providing the incremental up-front capital to builders/developers to finance energy-efficient appliances and materials, the repayment of which can be passed on to the homeowner through property tax bills. It also lowers builder/developer equity and/or the need for additional construction loans, a major concern during the construction process.

5. R-PACE OFFERS THE HOMEOWNER LONGER PAYBACK TERMS, LOW ANNUAL REPAYMENT COSTS, AND FLEXIBILITY TO PREPAY: PACE offers several flexibilities and advantages to the homeowner. It has long loan tenors and payback periods that could range from 5 to 20 years, depending on the useful life of the improvements. Depending on the assessment tenure, the annual repayment costs could be lower than several alternative financing options. **Moreover, RMI's analysis confirms that in NZE homes, energy cost savings are greater than the annual PACE repayment costs leading to a net gain for the homeowner every single year** (see Appendix). Additionally, most PACE programs allow for prepayment without fees or penalties. This prepayment flexibility is a useful option for homeowners who would like to either prepay their assessments or refinance them at a later stage. This flexibility ensures that the housing transactions are not impacted because if a potential buyer doesn't want PACE, the seller can prepay the assessment with proceeds from the sale. In summary, PACE financing does not impede property resale and ensures seamless property transfer.

6. R-PACE FINANCING COULD HELP IMPROVE THE OVERALL AFFORDABILITY, PERFORMANCE, ASSET VALUE, HEALTH, AND COMFORT OF THE NEW HOUSING STOCK: As local and state governments look for policy ideas to modernize infrastructure, improve affordability, and revitalize the housing stock, they will need to think of financing solutions that de-risk their investment while also providing homeowners superior performance, safety, and comfort. NZE residences funded by R-PACE will not only promote affordability and superior performance but also ensure **lower risk of mortgage default**, as indicated in the Institute for Market Transformation and UNC Center for Community Capital Study, because households that have lower utility bills have more cash flow to cover their scheduled mortgage payments. Therefore, promoting NZE development using R-PACE can help de-risk real estate investments and strengthen future real estate sector growth.

7. USING R-PACE FOR NZE BUILDINGS IS A RELIABLE POLICY PROPOSAL TO HELP STATES AND CITIES MEET THEIR AMBITIOUS CARBON-REDUCTION GOALS: Several leading states and cities have committed themselves to ambitious emission reduction goals. Promoting NZE new construction financing through R-PACE can be a transformative market-based policy instrument toward achieving their set targets. However, this mechanism would be most effective when combined with incentives and rebates to encourage adoption.

||||||| RMI'S PROPOSED FRAMEWORK TO ENABLE PACE FOR NZE NEW CONSTRUCTION

Presently, states like **California**, **Missouri**, and **Florida**—where R-PACE has operational programs—have either placed some restrictions or have limited the use of R-PACE for new construction. However, commercial PACE (C-PACE) assessments are presently being used to

fund several new building construction projects across the country, and several states allow its use to finance energy efficient new construction.

R-PACE for new construction is a powerful new application of PACE that could transform the U.S. housing market and encourage innovation. To this bring this about, RMI proposes specific “R-PACE for new construction” implementation considerations for states and local governments considering policy instruments to bolster new NZE residential development. Our proposed framework captures the best practices of C-PACE for new construction while making some major strategic revisions to the model to ensure that the instrument is leveraged to strengthen NZE development. Key policy and performance considerations for states and local governments looking to design their “R-PACE for new construction” programs are as follows:

POLICY CONSIDERATIONS

1. **Amend legal state provisions and the underwriting process to allow R-PACE to be used for new construction:** In the case that R-PACE’s use for new construction is not currently authorized or eligible under state/local-government bylaws, amending these provisions to allow R-PACE for new construction would scale its applicability to new NZE or NZE-ready construction projects. The provisions would need to be incorporated in a way such that the approvals can be granted at any stage of the construction phase. Further, underwriting standards should make new construction eligible in order for PACE administrators to be able to award these assessments seamlessly.
2. **Define limits to construction cost:** Based on RMI’s analysis, the maximum amount of eligible loan or “total eligible construction cost” should be based on and limited to 10 to 15 percent of the construction cost depending on the home’s expected performance based on the International Energy Conservation Code (IECC) 2015, ASHRAE 90.2 2013, or an equivalent state energy performance requirement. The limits should be selected based on construction costs, rather than being based on home valuation (as is normally the case for traditional R-PACE assessments), and the range should be based on state-specific construction cost. Defining these limits based on performance criteria and construction costs would also encourage builders to optimize energy efficiency through passive design aspects rather than just scoping a larger solar system for NZE home development.
3. **Require lender consent:** As in the case of C-PACE, it might be useful to require builders/developers to seek a lender’s consent for employing R-PACE capital during the construction period. This policy measure would promote transparency and credibility to the project and build trust with the lenders in the process.

PERFORMANCE CONSIDERATIONS

4. **Define "eligible measures" list:** Eligible measures (as specified by the respective state energy office or as per the **ENERGY STAR program requirements**) are energy/water conservation measures that could count as qualifying expenses under R-PACE for new construction. Any expenses that do not qualify under the list should not be financed or accounted for within the assessment. While the recommended approach is to allow R-PACE financing only for the incremental cost of the eligible measures vis-à-vis the state code requirement, the state could choose to allow R-PACE to finance the full cost of the qualifying expenses under this program as well. Both approaches, when combined with performance criteria, could work well to serve the ultimate objective.

5. **Mandate performance criteria:** Any R-PACE new construction project should require a savings-to-investment ratio (SIR) of incremental construction costs to be greater than 1.^{vi} The SIR should be calculated before awarding the assessment using an energy model for getting approval for the project. Requiring all PACE for new construction assessments to meet or exceed the IECC 2015/ASHRAE 90.2 2013/equivalent state energy performance code requirement will encourage a performance-based design approach. Further, the assessment amount could be made to vary depending on the modeled asset performance to reward and incentivize higher performance. States that want to use R-PACE solely for NZE development should design their performance criteria accordingly.
6. **Certify performance post-implementation:** A post-implementation energy certificate should be produced by the builder that lists all the eligible measures installed within the home. This certificate is important because it would build credibility in the process and help increase the home's valuation at the time of sale. Additionally, provisioning a budget for this certification within the assessment could be another requirement in the law for post-implementation performance verification purposes.

||||||| R-PACE CAN SCALE NZE HOMES—A \$33 BILLION MARKET OPPORTUNITY

NZE homes are going to be the next big frontier for innovation and competition in the U.S. real estate market and can be rapidly scaled across the U.S. by leveraging R-PACE for new construction—a powerful financing mechanism that has the potential to catalyze investment in the sector. As states and local governments decide on their strategy to build smarter cities and revitalize their aging infrastructure, they must consider the unprecedented opportunity that R-PACE provides to scale high-performing NZE homes that are more comfortable, affordable, and resilient to power outages and weather extremes. NZE homes are an incremental \$33 billion market opportunity for the U.S. real estate industry by 2037, which will also help states and local governments meet their carbon goals while improving housing stock and real estate value. R-PACE is an effective market-based mechanism that can achieve state/city policy objectives, remove market barriers, and provide a high-performing asset to the average U.S. homeowner at a lower net cost.

RMI strongly believes that states and local governments should work together to enable R-PACE for new construction in their jurisdictions to scale new NZE development and make a concerted effort to facilitate enabling policy design and stakeholder engagement to support the mechanism. This effort would not only promote innovation and development in the real estate sector, but would also help leverage the abundant solar potential in states, encourage more local job creation, and increase employment overall. This is a win-win market-based solution with a business case for states, local governments, developers, and homebuyers across the country.

Imagine a future where a homebuyer in your state or city has the opportunity to choose a smart NZE high-performance home for the same up-front cost as any other home while also securing higher savings on his or her investment every year—a dream that can be made possible through R-PACE. We at RMI believe this future can be a reality. R-PACE, when thoughtfully deployed for

^{vi} SIR is defined as the present value of net savings in energy and non-fuel or non-water operation and maintenance costs attributable to the proposed energy conservation measure (ECMs) divided by total ECM costs. An SIR of greater than 1 is a standard practice for C-PACE new construction.

NZE home construction with robust state-level consumer protection measures will scale NZE home development rapidly across our states, cities, and communities and will also set an example for others to emulate.

||||||| TAKE ACTION TODAY

RMI is working with states, cities, and local governments to pilot, scale, and promote NZE development by enabling R-PACE for new construction. Please reach out to us at financethefuture@rmi.org if you would like to know more.

To learn more about our work, please visit our website: <https://rmi.org/our-work/buildings/residential-energy-performance/finance-the-future>.

||||||| APPENDIX

RMI'S BUSINESS CASE ANALYSIS FOR NZE NEW CONSTRUCTION IN SIX U.S. STATES

RMI carried out a thorough financial and energy modeling analysis to understand the business case for R-PACE in NZE new construction homes. We modeled and analyzed the incremental costs for constructing a new two-story, two-car garage, 1,823 square foot NZE single-family home in six key states within the U.S. to understand the financial implications of using R-PACE across a broad spectrum of climatic conditions and geographies.

We chose California, Missouri, and Florida for the analysis because R-PACE is enabled and has active programs in these states. We chose New York, Colorado, and Georgia for their climatic and geographic diversity and PACE-enabling legislation even though they do not yet have any active R-PACE programs. Together, these states represent almost 30 percent of the U.S. single-family housing market.

This analysis compared the cost and energy associated with a code-compliant home to an NZE home. The energy savings were analyzed using Building Energy Optimization (BEopt) energy modeling software, and the energy conservation measure (ECM) costs were determined using the **National Residential Efficiency Measures Database** created by the National Renewable Energy Laboratory. Construction costs were adjusted by city using location factors found in RSMeans, a construction cost database created by Gordian.

The code-compliant home was considered the baseline home in each of these cities. It was modeled to have a split air-conditioning (A/C) system, standard efficiency furnace, standard efficiency appliances, a conventional gas-fired hot water heater, and an envelope performance that met the local building code.

The proposed model of NZE homes in all cities was assumed to be electric with a high-efficiency air source heat pump that serves the space heating and cooling needs of the residence and a separate heat pump that serves the domestic hot water needs of the home. Additionally, we included LED lights, smart thermostats, low-flow water fixtures, and ENERGY STAR washing machines in the NZE

home models across all six cities. The remaining ECMs were associated with the envelope and varied by climate zone. As the rooftop PV costs have significantly decreased over the years, the cost to include more energy efficiency had to be balanced by the cost to increase rooftop solar capacity. Although the analysis was not fully cost optimized, we analyzed several NZE packages in each city to ensure cost effectiveness.

Incremental cost was modeled to be the difference between a newly constructed code-compliant baseline home vis-à-vis a newly constructed NZE home. Interestingly, RMI's analysis determined that the incremental cost to build an NZE home with improved energy efficiency measures was not substantial due to a number of reasons:

- **Labor rates largely remain the same regardless of standard efficiency or high efficiency equipment:** Labor makes up roughly 50 percent of the entire ECM cost. This is one reason constructing an NZE home is much more cost-effective than performing an NZE retrofit to an existing home.
- **An air source heat pump replaced both the typical split A/C system and furnace:** Since we are replacing two pieces of equipment with one, the construction costs are actually lower for the air source heat pump than the standard code-compliant equipment.
- **Cost-effective low-hanging retrofits:** The combined cost of LED lights, low-flow fixtures, smart thermostats, and an ENERGY STAR washing machine was in most cases less than \$500 more than conventional appliances. At the same time, these measures had a significant impact on reducing energy costs.
- **The incremental cost for the hot water heat pump was not substantial:** Incremental costs associated with an efficient hot water heat pump was less than \$500 greater than the standard efficiency gas hot water heater. Heat pump hot water heaters typically use less than half the energy of a standard gas water heater, dramatically reducing energy consumption in the home considering hot water heating is typically one of the largest loads.
- **The incremental cost associated with envelope upgrades is relatively minor:** The baseline code already requires significant envelope upgrades, including insulation between the studs and continuous insulation for the walls and the attic. Therefore, the incremental cost associated with envelope upgrades only includes adding more insulation, which isn't too expensive if it is cost optimized with solar. Further, code requires windows to be double pane and thermally broken, so the baseline windows were already high performance. Improving envelope performance beyond a certain extent was cost prohibitive compared with installing rooftop PV.
- **Rooftop PV was extremely cost-effective:** Since the cost of rooftop solar PV installation was substantially lower than the more deep energy efficiency measures, such measures were excluded from the selected NZE design to optimize for the incremental construction cost.

The details of RMI's analysis and findings have been summarized in the table below.

	R-PACE Programs Exist in State			PACE Legislation Enabled in State		
	California	Florida	Missouri	New York	Colorado	Georgia
Percent of 1–4 Unit Homes in U.S. Market ¹	10%	6.0%	2.2%	5.2%	1.7%	3.1%
Analysis City	San Francisco	Miami	St. Louis	Syracuse	Fort Collins	Atlanta
Baseline Building Code ²	Title 24 2016	IECC 2015	IECC 2009	IECC 2015	IECC 2012	IECC 2009
IECC Climate Zone ³	3C (warm, marine)	1A (very hot, moist)	4A (mixed, moist)	5A (cool, moist)	5B (cool, dry)	3A (warm, moist)
Baseline Energy Use Intensity (EUI)	24.3 kBtu/sf	20.5 kBtu/sf	43.8 kBtu/sf	43.0 kBtu/sf	48.0 kBtu/sf	34.0 kBtu/sf
Net Zero Carbon EUI	11.3 kBtu/sf	11.5 kBtu/sf	14.6 kBtu/sf	14.9 kBtu/sf	16.3 kBtu/sf	13.4 kBtu/sf
Average Cost to Construct New Home ⁴	\$373,000	\$249,000	\$300,000	\$293,000	\$264,000	\$259,000
Solar Required to Achieve Net-Zero Carbon	5.5 kW	6.0 kW	7.5 kW	9.5 kW	7.4 kW	6.5 kW
Cost of Solar/Watt ⁵	\$3.26/W	\$2.57/W	\$2.96/W	\$3.21/W	\$3.05/W	\$2.95/W
Solar Costs	(\$17,930)	(\$15,420)	(\$22,200)	(\$30,495)	(\$22,570)	(\$19,175)
Incremental** Energy Efficiency ECM Costs	(\$1,565)	(\$2,700)	(\$5,530)	(\$3,296)	(\$2,889)	(\$5,095)
Total Incremental** Cost to Construct NZE Home	(\$19,495) [5.2%]	(\$18,120) [7.3%]	(\$27,730) [9.2%]	(\$33,791) [11.5%]	(\$25,459) [9.6%]	(\$24,270) [9.4%]
Incremental Cost After Incentives ⁶	(\$13,566) [3.6%]	(\$13,344) [5.4%]	(\$20,170) [6.7%]	(\$24,167) [8.2%]	(\$17,093) [6.5%]	(\$17,952) [6.9%]
Annual Utility Bill Savings ⁷	\$1,529	\$1,389	\$1,712	\$2,091	\$1,446	\$1,645
Annual PACE Assessment ⁸	(\$1,280)	(\$1,260)	(\$1,904)	(\$2,281)	(\$1,613)	(\$1,695)
Annual Tax Benefits of PACE Deduction	\$150	\$148	\$224	\$268	\$190	\$199
Average Annual Net Savings to Homeowner	\$398	\$277	\$32	\$78	\$23	\$149

**Incremental cost is the difference in construction costs between an NZE home and a new code-compliant average home in a specific state.

SOURCES AND ENDNOTES

¹ Source: <https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=CF>

² Source: <https://www.energycodes.gov/status-state-energy-code-adoption>

³ Source: <https://basc.pnnl.gov/images/iecc-climate-zone-map>. Climate zones range from 1 (very hot) to 8 (subarctic). "A" = Moist, "B" = Dry, and "C" = Marine.

⁴ Average costs for a 2,300 sf home from Home Advisor, cost to build, and RSMean square foot costs. Used location factor from RSMean.

⁵ Source: <http://news.energysage.com/how-much-does-the-average-solar-panel-installation-cost-in-the-u-s/>. Used lower end of range of solar prices for analysis.

⁶ Incentives include 30 percent solar investment tax credit (ITC) and local utility incentives.

⁷ Using state average \$/kWh and \$/therm from EIA. This is based on today's fuel costs and is subject to change as these costs increase or decrease.

⁸ Assume 7% interest rate over 20 years, which is the life of the average retrofit package.