EXECUTIVE SUMMARY REPORT

COST-BENEFIT ANALYSIS OF KEY CLIMATE READY STRATEGIES

REPORT AUTHOR

Autocase

PREPARED FOR

CITY OF SAN ANTONIO
OFFICE OF SUSTAINABILITY

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ABOUT

Autocase™ (created by Impact Infrastructure) is a team of professionals across North America that have developed best-practice cost-benefit analysis approaches and tools while being involved in all facets of infrastructure development.

The firm has worked with corporations and all levels of government to support decision making, project prioritization, and stakeholder outreach. Our primary goal is to create a standardized suite of business case analysis tools to promote the development of more sustainable and resilient communities. The firm's professional economists conduct rigorous economic assessments to help decision makers prioritize worthy but competing projects based on maximum economic, environmental and community benefits.

EXECUTIVE SUMMARY & TECHNICAL APPENDIX

The climate action policies prioritized within the plan are multi-faceted, and the underlying modeling to value the numerous economic impacts are complex. As such, this Executive Summary aims to cater to a general reader's understanding by presenting high level conceptual overviews of how each impact (benefit and cost) is calculated, along with their lifetime present value, defined as the discounted sum of future cash flows.

A Technical Appendix is also available to provide interested readers with a comprehensive and transparent understanding of the detailed methodologies, data, and sources. A more detailed set of inputs are also presented in the Technical Appendix, along with structure and logic diagrams to illustrate the modeling concepts used in this analysis.

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ACKNOWLEDGEMENTS

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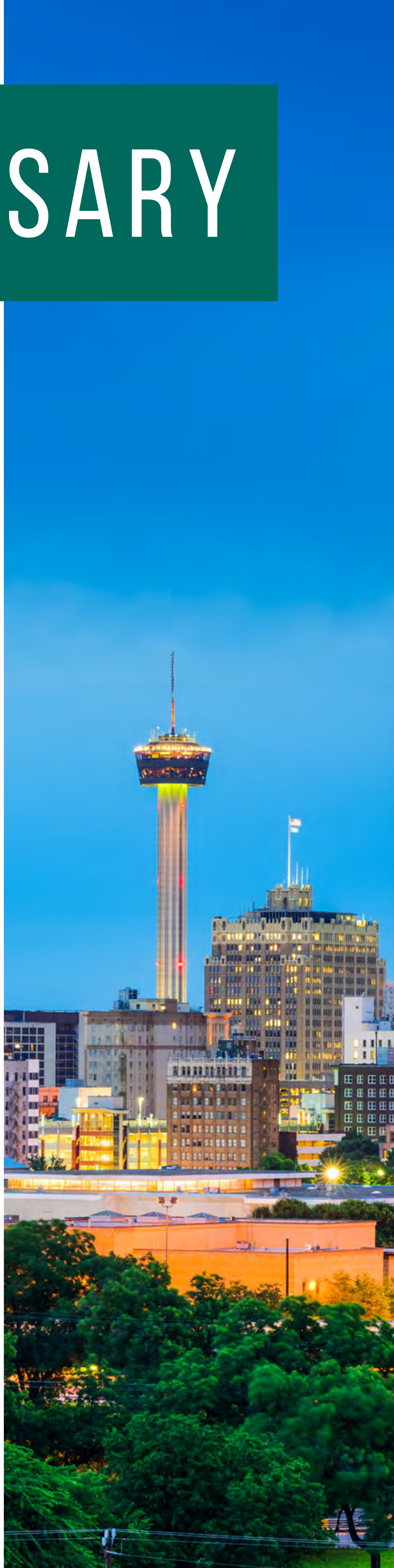
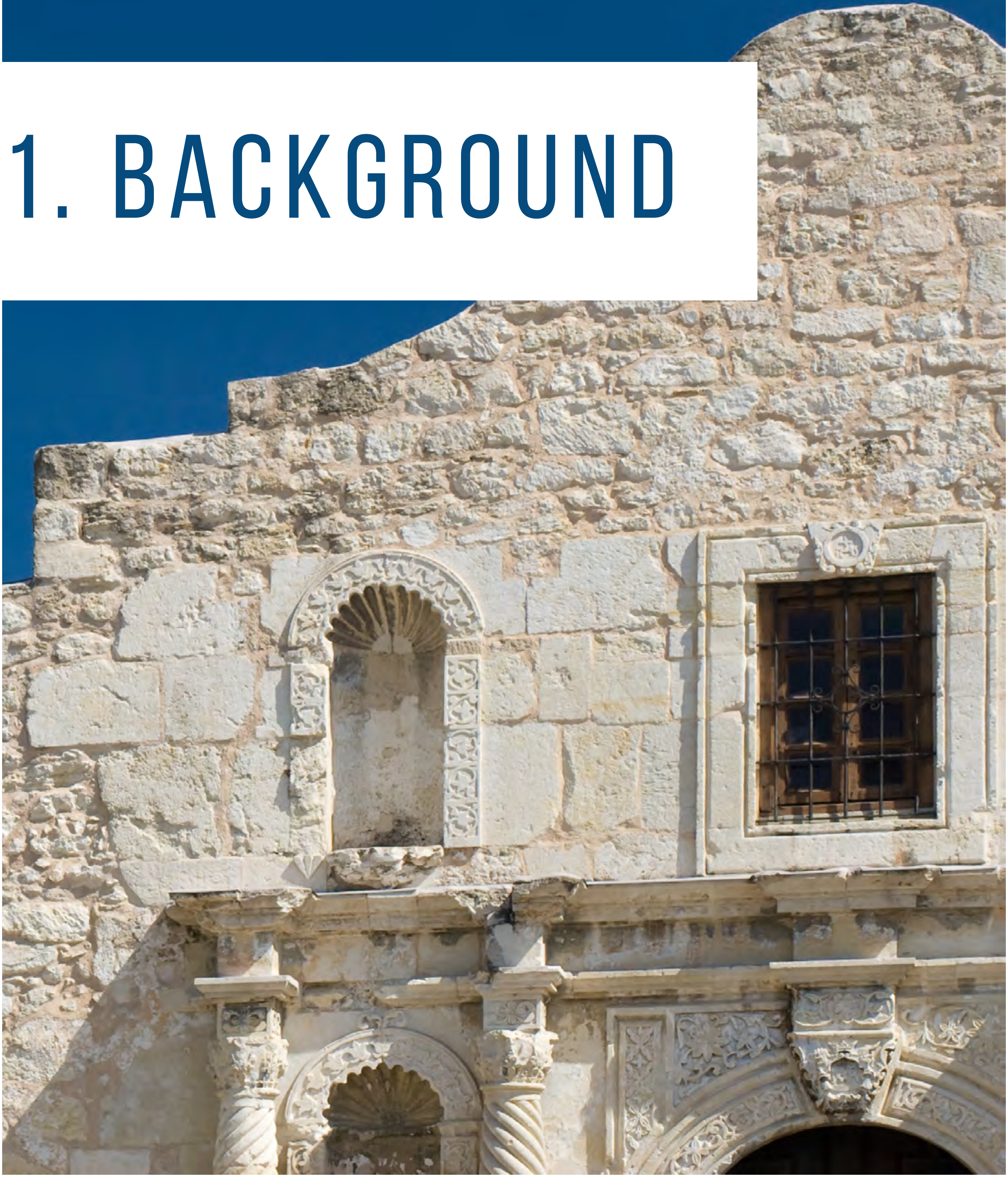
ACRONYM GLOSSARY



AACOG - Alamo Area Council of Governments
CBA - Cost-Benefit Analysis
BCR - Benefit-Cost Ratio
CAAP - SA Climate Ready Climate Action & Adaptation Plan
CAPEX - Capital Expenditures
CO2 - Carbon Dioxide
DOE - U.S. Department of Energy
eGRID - Emissions & Generation Resource Integrated Database
EIA - Energy Information Administration
EPA - Environmental Protection Agency
EUI - Energy Use Intensity
EV - Electric Vehicle
EVSE - Electric Vehicle Supply Equipment
FPCSA - Food Policy Council of San Antonio
GHG - Greenhouse Gas
ICE - Internal Combustion Engine
kWh - Kilowatt-Hour [Unit of Energy]
NAAQS - National Ambient Air Quality Standards
NOx - Nitrous Oxide
NPV - Net Present Value
NRDC - Natural Resources Defense Council
NREL - National Renewable Energy Laboratory
OS - Office of Sustainability
PH-EV - Plug-In Hybrid Electric Vehicle
PV - Photovoltaic
SAC - San Antonio College
SO2 - Sulfur Dioxide
Sq ft - Square Feet
Sq m - Square Meter
TBL - Triple Bottom Line
TBL-BCR - Triple Bottom Line Benefit-Cost Ratio
TBL-CBA - Triple-Bottom-Line Triple-Bottom-Line Cost-Benefit Analysis
TBL-NPV - Triple-Bottom-Line Net Present Value
TOU - Time of Use
UHI - Urban Heat Island
USDOT - US Department of Transportation
VSL - Value of Statistical Life

1. BACKGROUND



1.1 WHY NOW?

As one of the fastest growing cities in the US, the City of San Antonio faces a number of key questions and considerations, including developing a robust and sophisticated set of policies around sustainability and climate change to ensure that growth is driven with community benefits and future risks in mind. The SA Tomorrow Sustainability Plan and the SA Climate Ready Climate Action & Adaptation Plan (CAAP) have been developed with a view for prudent planning and action towards these mitigation and adaptation challenges.

The City of San Antonio was selected as a participant in the American Cities Climate Challenge, where 25 American cities entered into a 2 year acceleration program to implement the Paris Agreement and beat their near term climate goals, with an overarching goal of achieving carbon neutrality by the year 2050. The City was designated in marginal nonattainment for ground-level ozone standards, a public health and economic issue, by the Environmental Protection Agency (EPA) in July 2018. Part of the process to achieve ground-level ozone attainment status is to develop a plan to control emissions through community and municipal climate mitigation strategies. As the City continues work on the American Cities Climate Challenge, it is vital to enact a plan that prioritizes reducing greenhouse gases, outlines strategies to prepare San Antonio for climate risks, and ensures the framework is centered on climate equity for all community members.

CLIMATE INITIATIVE
Powered by San Antonio

In 2019, the City adopted SA Climate Ready, its first Climate Action & Adaptation Plan. In this plan, the City maps out a pathway to achieving net zero carbon emissions by 2050, while prioritizing clean air, public health, water quality and conservation, good jobs, transportation choices, clean and secure energy, and emergency preparedness. To realize the economic impacts of achieving the ambitious carbon neutrality goals, the City wishes to explore broad-based outcomes from a variety of CAAP policy strategies.

These mechanisms include building code changes to incentivize private action, and reinventing city buildings and open spaces as environmental and resilience generating locations. Economic analysis is a valuable approach to help draw quantitative insights towards trade-offs amongst these varied climate action policies. Five policies have been identified by the Office of Sustainability as priority mitigation strategies due to their potential climate action impact and are evaluated herein to provide additional context for decision-makers. Urban Agriculture is a major component of 'Protecting Local Food Security,' a prioritized adaptation strategy within the CAAP (outlined in adaptation strategies 34-40). All mitigation and adaptation strategies are outlined in the SA Climate Ready Plan, and can be found at this **link**. For easy reference, the mitigation strategies are also contained in Appendix B

The six key CAAP policies analyzed in this report are:

1. Energy Benchmarking for Commercial and Multifamily Buildings
2. White Roofs and Energy Insulation Building Code
3. Electric Vehicle (EV) Charger Readiness Building Code
4. Photovoltaics (PV) Roof Readiness Building Code
5. Zero Net Energy (ZNE) Municipal Buildings
6. Urban Agriculture

1.2 CLIMATE ACTION POLICY PROPOSALS

1.2.1 ENERGY BENCHMARKING FOR COMMERCIAL AND MULTIFAMILY BUILDINGS

Energy benchmarking and disclosure policies require certain building typologies (multifamily and commercial buildings) to report building characteristics such as size and their annual energy consumption. Standardizing building performance across peer groups enables building owners and operators to be aware of inefficient components in their buildings that use excess energy. As the benchmarking policy becomes widely adopted across a region's building stock, the availability of consistent and standardized summary metrics of building related performance would become available to real estate stakeholders. Although the policy in itself will not lead to direct energy savings, it is expected to spur indirect savings through tenants and prospective buyers demanding efficient building performance.

The CAAP Community Mitigation Strategies #4 and #5 both highlight this consideration by recommending that building energy information be used to inform customer decision-making. As such market transformations occur, building owners are anticipated to be incentivized to make investments in energy reduction measures in order to take advantage of both rental and real estate premiums potential. Wide scale implementation of benchmarking disclosure policies allows for efficient pricing of real estate properties, along with achieving significant decarbonization of the building stock. Benchmarking policies can also aid public decision makers to more effectively guide policy to address the most polluting buildings in their region or municipality.

1.2.2 WHITE ROOFS AND ENERGY INSULATION BUILDING CODE

A low cost method of creating climate resilience is requiring white or highly reflective roofs on all new construction. San Antonio is experienced with such a program on a smaller scale in the form of the ‘Under 1 Roof’ program, where a white roof and energy barrier is installed.

Urban heat island is a major concern in the hot climate of San Antonio, where temperatures exceed normal human tolerance for multiple days a year and are predicted to increase given heat-related climate projections. Oftentimes, low income residents suffer the most, as they do not have easy access to air conditioning and medical care. Elderly are also at risk, as pre-existing conditions and social isolation make them particularly susceptible.

With the twin rise of global warming and an aging population, tackling urban heat island should be a priority resilience measure for the city. Mitigating and adapting to urban heat island addresses CAAP Community Mitigation Strategy #20, which is aimed at analyzing and quantifying urban heat island in San Antonio and developing an implementable and impactful plan with a focus on vulnerable populations and ecosystems. Households with white roofs reduce their energy bills while also reducing the overall temperature of the city, leading to lower mortality and morbidity from heat events in San Antonio.

1.2.3. ELECTRIC VEHICLE (EV) CHARGER READINESS BUILDING CODE

The City of San Antonio is evaluating a new building code policy that would require newly constructed residential buildings to have EV and plug-in hybrid electric vehicle (PH-EV) charger-ready parking spaces. Commercial building code changes are also being considered by the City, however, are excluded from the scope of this analysis. The policy dictates that all new construction permits should be EV ready and capable - defined as having capacity and space to support a minimum 40-ampere, 240-volt branch circuit to support future installation and utilization of Electrical Vehicle Supply Equipment (EVSE). Early stage building infrastructure readiness codes are critical to achieving widespread EV adoption by effectively lowering the upfront costs required to migrate to cleaner transportation.

Expansion of electric vehicle charging infrastructure directly addresses the CAAP Community Mitigation Strategy #9, which is aimed towards promoting an accelerated adoption of cleaner and more efficient vehicle technologies. EV Ready building codes are an effective tool to support this accelerated shift to cleaner vehicles. Household access to EV ready parking spaces is also a crucial component in supporting current and projected market trends in consumer preference for electric vehicles. Reducing the initial costs to adopt green interventions, such as ready EVSE infrastructure, allows for greater participation in the projected market for EVs. This consideration aids in an equal distribution of public benefits across all household income levels.

1.2.4. PHOTOVOLTAICS (PV) ROOF READINESS BUILDING CODE

The City of San Antonio is evaluating a new building code policy that would require newly constructed residential buildings to have Solar Ready building codes. Solar Ready building codes include appropriately sloped roofs free of vents and obstructions. When implemented for new construction, infrastructure installation costs are reduced when compared with retrofitting existing roofs, a hidden cost of Photovoltaic (PV) system installation. Preparing homes to have the capability to utilize solar energy keeps San Antonio competitive and resilient in the solar market.

Early stage building infrastructure readiness codes are critical to achieving PV system adoption by effectively lowering the upfront cost required to adopt cleaner technologies. This directly addresses CAAP Community Mitigation Strategy #6, which is aimed at adopting a Zero Net Energy code for all new buildings and substantial rehabilitations, taking into consideration technical and economic feasibility. Reducing the initial costs to adopt green interventions, such as PV, allows for a greater proportion of market participants to be incentivized by the Solar Ready roof policy, including participants from across household income levels. Residences having access to renewable energy through solar panels helps reduce energy bills and greenhouse gas emissions.

1.2.5. ZERO NET ENERGY (ZNE) MUNICIPAL BUILDINGS

Zero Net Energy (ZNE) municipal buildings are a progressive solution to eliminating carbon emissions derived from building operations. The aim of this policy is to set the standard for building performance across the City of San Antonio's municipally owned buildings. As outlined by the CAAP Municipal Mitigation Strategy #3, San Antonio's municipal government will take the lead on GHG mitigation efforts by proposing to achieve ZNE for all municipal buildings by 2040.

The policy demonstrates the financial feasibility of retrofit investments along with other social and environmental co-benefits accrued to the community. By investing in cost effective retrofit interventions geared towards a combination of both operational and capital investments, benefits accrue in the form of utility rate savings to the City, reduced grid emissions from electricity use, and improved occupant comfort from improvements in the indoor environment of municipal spaces. Additionally, the ZNE municipal buildings policy demonstrates fiscal responsibility, saving taxpayer funding by addressing inefficient and high cost buildings across the city.

1.2.6. URBAN AGRICULTURE

Urban Agriculture is a strategy for undeveloped or underutilized land which can revitalize the urban landscape and forge networks of resiliency, health, and well-being. The program evaluates a prototypical half acre farm within the city of San Antonio, with food production and community engagement at the site. Reflecting CAAP Adaptation Strategy #36, San Antonio is looking to assess urban agriculture and facilitate the cultivation of vacant or underutilized land, including City-owned and other public land.

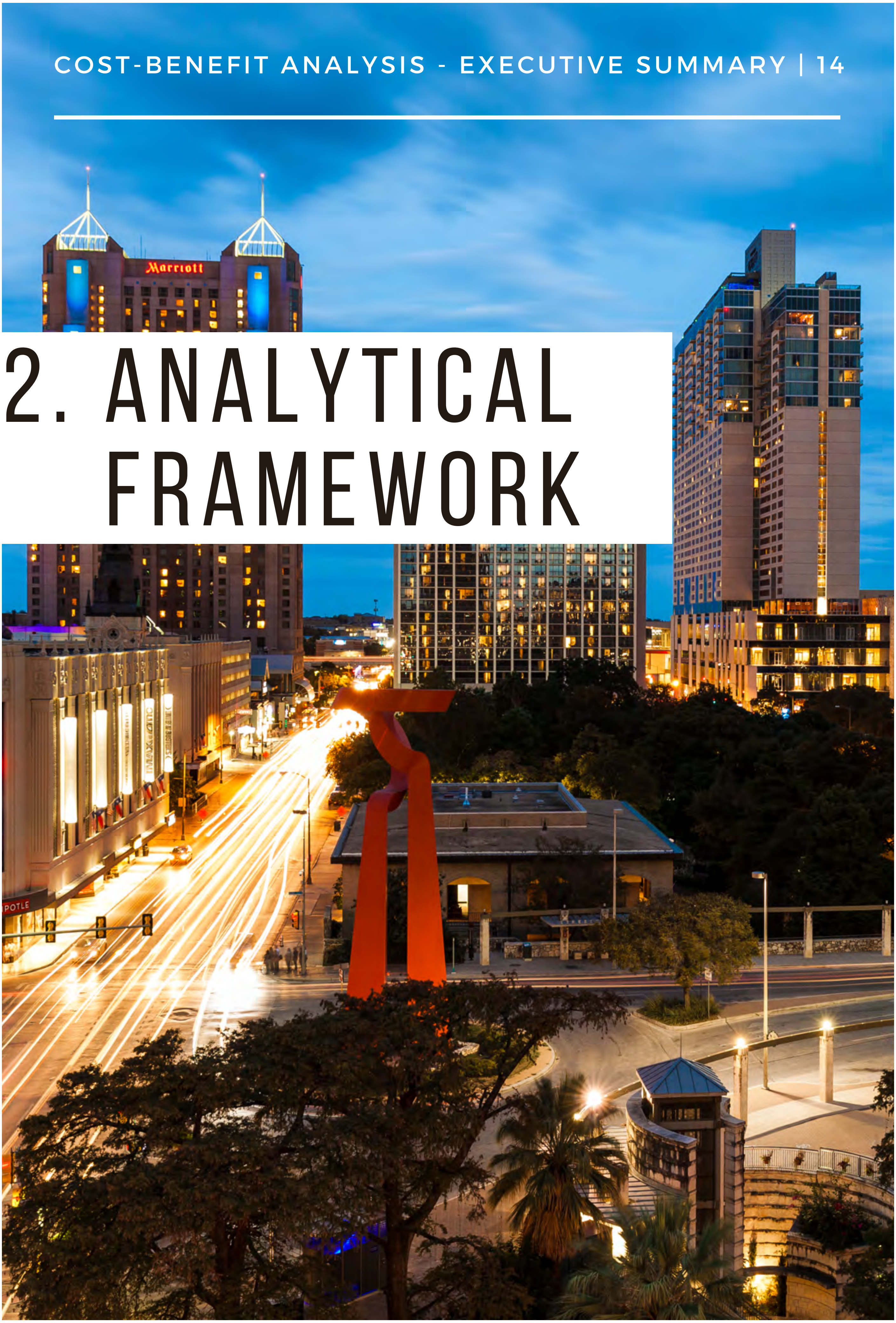
As a climate resilience tool, urban agriculture reduces stormwater runoff and urban heat island impacts. As a climate change mitigation strategy, urban agriculture provides significant carbon sequestration benefits and reduces greenhouse gases (GHGs) associated with transportation and food waste. Urban Agriculture has a multitude of positive impacts on the community, beyond financial and economic revenues. The specific natural environment of urban agriculture has been shown to provide the additional health benefits of increased fruit and vegetable consumption, increased physical activity, and improved mental health. These spaces also offer a number of social benefits by providing informal gathering spaces to build and reinforce social networks and reduce isolation.

1.3 CONTRIBUTIONS BY AUTOCASE™

A significant contribution to this analysis comes from the Autocase™ software. Autocase™ is a cloud based platform for valuing built environment design options for a more sustainable and resilient future. The team of economists behind Autocase™ endeavor to create models which address pertinent environmental concerns, with full transparency of methodologies and calculations. The primary model employed in this analysis is the Urban Heat Island (UHI) model. This model calculates the change in temperature of a city's surface area given changes in roof reflectance and transmittance, with materials such as white roof shingles. This analysis also incorporates temperature forecasts from academically approved projections, and links temperature forecasts to heat related mortality events. Autocase™ values the expected incremental benefit from UHI mortality reduction, and provides an informed perspective with the help of economics.

Autocase™ is a comprehensive software package which gathers location specific economic and environmental data with the use of APIs and constant research. The software is designed to stay abreast of the latest information in order to produce reliable and trustworthy analyses. Autocase™ is used in this analysis as a straightforward and reliable source for San Antonio specific information such as health, wages, social costs of pollutants, and material engineering values.

2. ANALYTICAL FRAMEWORK



Consistent with the SA Climate Ready Plan, the Office of Sustainability (OS) initiated the development of this report to ensure a fact-based financial assessment of current priority strategies. As part of this evaluation, OS will integrate these economic findings into the decision support and stakeholder engagement process. These analytical efforts can create an objective, defensible, and transparent screening process for both the financial and broader societal impacts of various integrated sustainability and resiliency planning, policy, and infrastructure options available.

When planning for climate mitigation and adaptation policies and projects, it is essential to consider, not only the upfront cost of a project or policy, but what benefits will society as a whole see from implementing those projects or policies.

Cost-Benefit Analysis (CBA) is an established economic approach for comparing the benefits and costs of a given project or activity. CBA involves identifying, quantifying, monetizing and summing in dollars, to the extent possible, the value of incremental costs and benefits over the life of a project. It provides a systematic evidence-based economic business case approach to quantify and attribute monetary values to the direct financial impacts, as well as broader social, environmental, and equity impacts resulting from an investment using empirical data and peer- reviewed literature. The importance of CBA for decision makers is that its results provide a quantitative measure of a project's worthiness. The analysis involves a comprehensive account of a project's benefits and costs over the entire project life cycle and a "side-by-side" comparison of net benefits for alternative investments. The benefit-cost framework offers an opportunity to recognize and include in the evaluation all social and economic impacts in an objective manner.

While not a decision-making tool, CBA is an industry standard decision-support tool used to inform and improve public policy, programs and projects. Essentially, this approach helps prioritize projects in a standardized way, as well as provide insights as to the impacts on various project stakeholders. For example, the US, Europe, and the UK mandate legislative requirements to use CBA to evaluate policies and policy reforms, and CBA is required for a variety of merit-based federal grant funding programs. Additionally, the World Bank and other multilateral financial institutions, such as the Inter-American Development Bank and Asian Development Bank widely use CBA to help bring about a better allocation of resources, to provide insights into overall societal welfare gains, direct financial impacts, sustainability impacts, and assess project risks.

The methodological framework of CBA can be used as a screening-level lens in which to better understand the long-term trade-offs for greater upfront investment in climate mitigation and adaptation actions from a development and policy standpoint and the future implications to those investments. This framework can be utilized to support decision-makers identify, prioritize, and focus planning efforts and financial resources, in this case specifically towards:

- Energy benchmarking and disclosure requirements for commercial and multi-family properties greater than or equal to 50,000 square feet
- White shingles and cool roof requirements for new construction
- Electric vehicle and solar-ready requirements for new construction
- ZNE building codes for municipal buildings
- Urban agriculture on available City land

Triple Bottom Line Cost-Benefit Analysis expands the traditional financial reporting framework (such as capital, and operations and maintenance costs) to take into account social and environmental performance, using empirical data and peer-reviewed literature. The intent would be for the City of San Antonio to use an objective, evidence-based approach as part of the broader overall process of targeting and prioritizing policies and investments. Results are presented in innovative ways that help teams prioritize projects, better understand trade-offs, and evaluate climate risks.

2.1 KEY STUDY PARAMETERS

The City of San Antonio Office of Sustainability has suggested a study period from 2020 to 2050, which reflects a 1 year construction period for the various climate action policies proposed to occur in 2020, and a 30 year operational period. Annual cash flows (benefits and costs) are accounted for throughout the entire study period. This study period aligns with the timeline of the City's climate action plan goal to achieve carbon neutrality by 2050. To discount the future cash flows into today's dollars, a discount rate of 3% was selected for the analysis to align with the City's average cost of capital funding. By utilizing the real discount rate across the economic analysis, annual cash flows are not required to be inflated as this discount rate is net of expected annual inflation.

2.2 INTERPRETING RESULTS

Results are presented in Triple Bottom Line-Net Present Value (TBL-NPV) and Triple Bottom Line-Benefit Cost Ratio (TBL-BCR). Using the two metrics together, one can get a sense of the scale of the impact (NPV), as well as, the value generated per unit invested (BCR).

TBL-NPV is the present value of benefits net costs over the project's useful life, which are discounted into current dollars at rates of 3%. TBL-NPV is the principal measure of an investment's economic worth:

- TBL-NPV > 0, means benefits are larger than costs.
- TBL-NPV < 0, means costs are larger than benefits.

TBL-BCR is estimated as the present value of benefits divided by the present value of costs. TBL-BCR is intended to illustrate the benefits that are achieved for every dollar invested.

- 0 < TBL-BCR < 1, project delivers less than $1 in benefit for every $1 in costs.
- TBL-BCR = 1, project delivers $1 in benefits for every $1 in costs.
- TBL-BCR > 1, project delivers more than $1 in benefits for every $1 in costs

3. TBL-CBA RESULTS OVERVIEW

3.1 CARBON EMISSIONS

The proposed climate action policies outlined in Section 1.3 are expected to drive significant reductions in carbon emissions. To reach the City's goal of carbon neutrality by the year 2050, a progressive and dynamic approach must be undertaken through targeted policy interventions. The City of San Antonio's Office of Sustainability has proposed climate action policies that are geared towards energy efficiency, on-site renewables generation, transportation electrification, and urban agriculture. If all six of the proposed key CAAP strategies were implemented simultaneously it is estimated to have the potential to drive significant GHG emission reductions (Figure 1). To better understand which policy proposals have the greatest potential for GHG emissions reductions, the climate action policy proposals are segmented into household (Figure 2) and building related climate action policies (Figure 3). New commercial buildings and household growth forecasts used in this analysis are present in the Appendix (Table A1).

Cumulative CO2 emission reduction potential (in tons) of key CAAP policies:

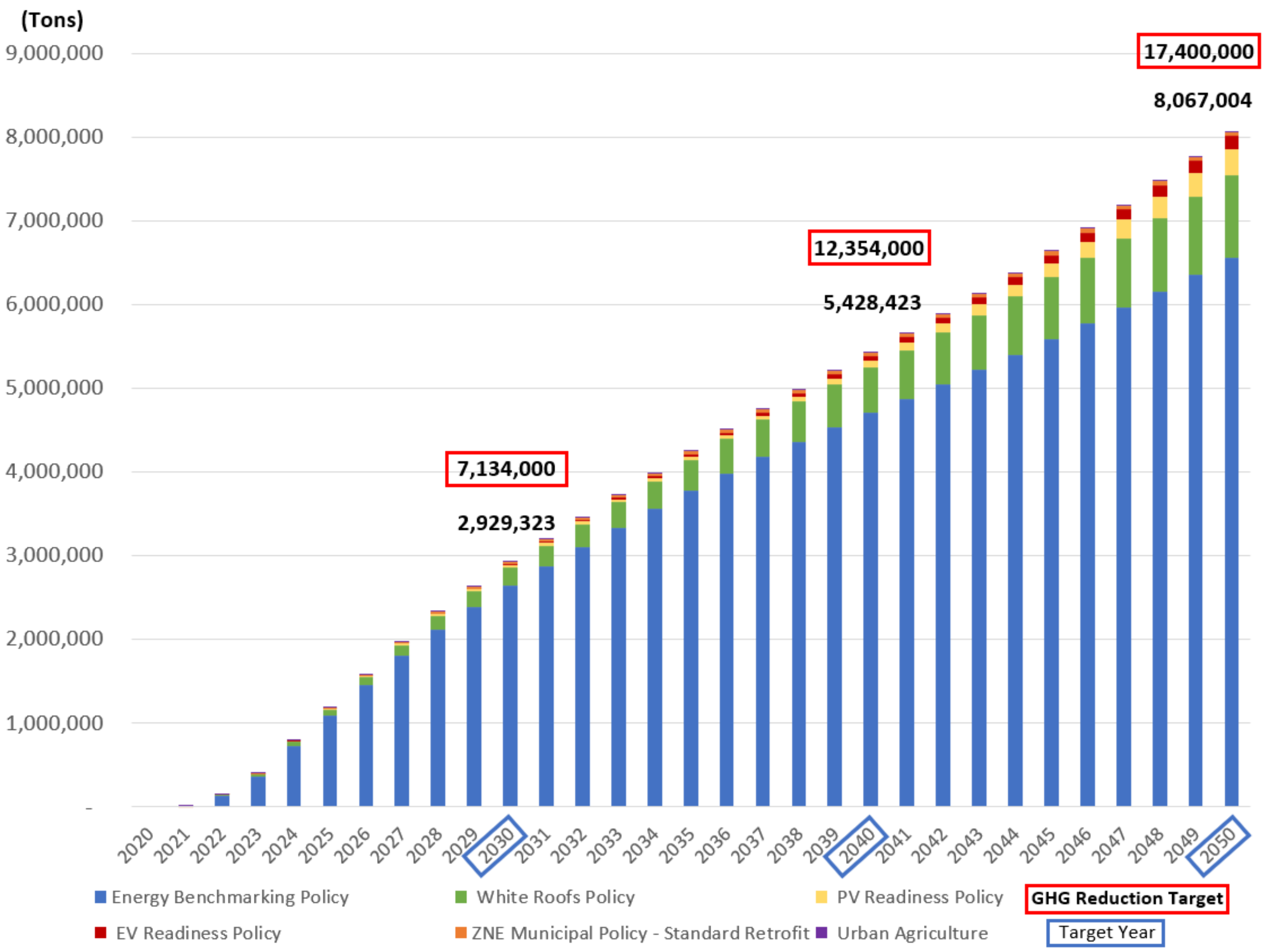
- 2,929,323 by 2030
- 5,428,423 by 2040
- 8,067,004 by 2050

Although these projections do point to significant reductions in the emissions inventory across the city, there is still great efforts to be taken to achieve the GHG emission reduction targets. Relative to the 2016 CO2 emissions inventory stock, the CAAP's milestone GHG emission reduction targets are set for 2030, 2040, and 2050, and are required to achieve net carbon emissions reductions of 41%, 71%, and 100%, respectively, which are highlighted by the red boxes in Figure 1.

CAAP's milestone CO2 emission reduction targets (in tons):

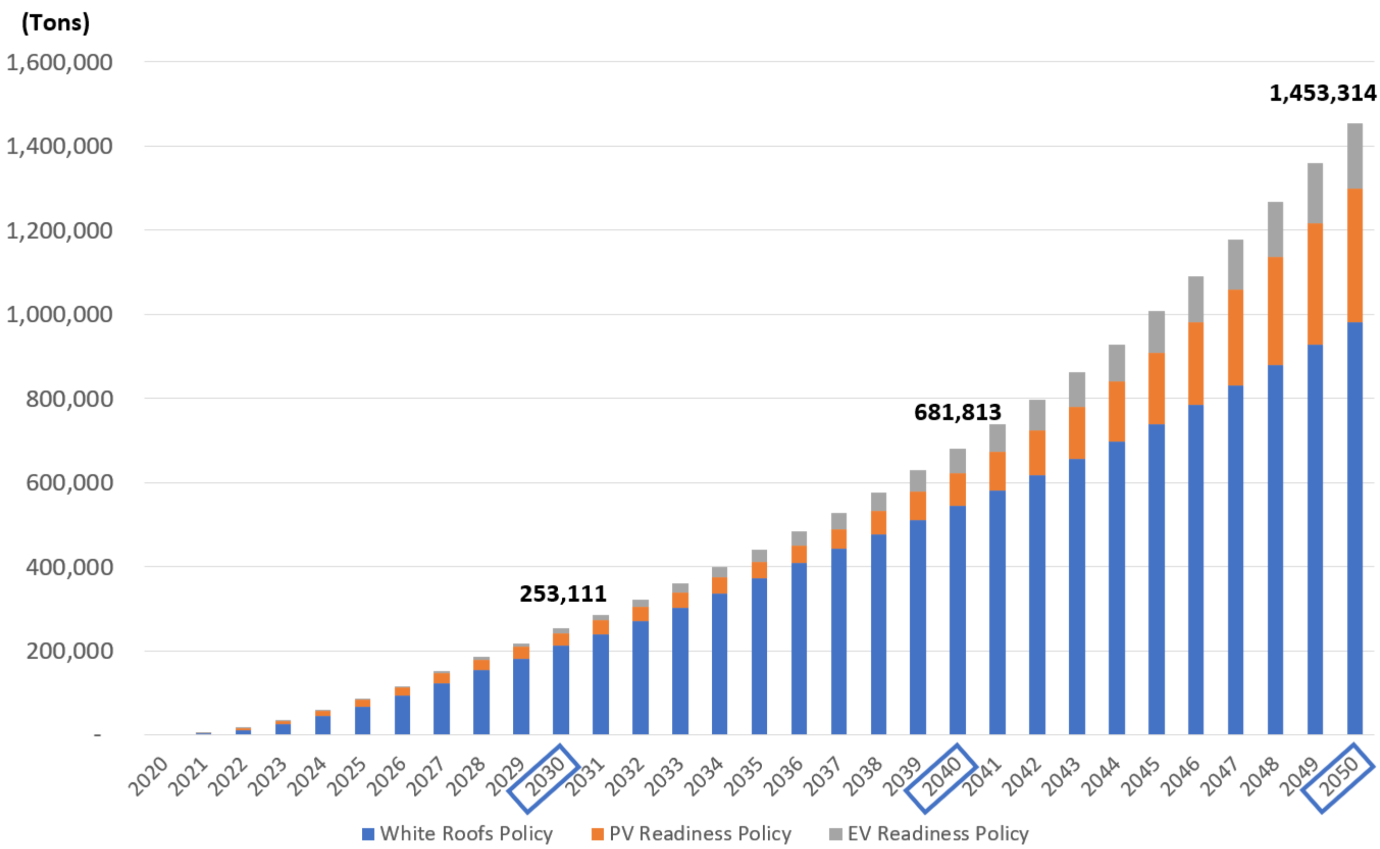
- 7,134,000 by 2030
- 12,354,000 by 2040
- 17,400,000 by 2050

FIGURE. 1 CUMULATIVE CO2 EMISSIONS REDUCTION - SIX KEY CAAP POLICY PROPOSALS



Household related policies include White Roofs, Solar, and EV ready building codes that target energy efficiency, on-site renewable generation, and transportation electrification, respectively. The White Roofs and Energy Insulation policy has the greatest impact on reducing emissions of single family households, and is expected to total 211,888 tons of avoided carbon by 2030; 545,612 tons by 2040; and 981,091 by 2050, cumulatively (Figure 2). This is the target year for reaching carbon neutrality across the City. Solar readiness interventions would increase on-site renewable energy and thus offset electricity use from the utility grid. By incentivizing more households to install PV panels, the policy is estimated to drive reductions of 30,327 tons of CO2 by 2030; 78,020 tons by 2040; and 317,822 tons by 2050, cumulatively. Although EVs indirectly emit carbon dioxide through electricity use from the grid, there remains significant emission reduction potential when compared incrementally against conventional gasoline vehicles. The EV ready building code is expected to avoid 10,896 tons of carbon emissions by 2030, 58,181 tons by 2040, and 154,401 tons by 2050, cumulatively. In aggregate the household related climate action policy proposals are expected to reduce 1,453,314 tons of fossil fuel related GHG emissions by 2050, cumulatively.

FIGURE. 2 CUMULATIVE CO2 EMISSIONS REDUCTION - HOUSEHOLD RELATED POLICIES

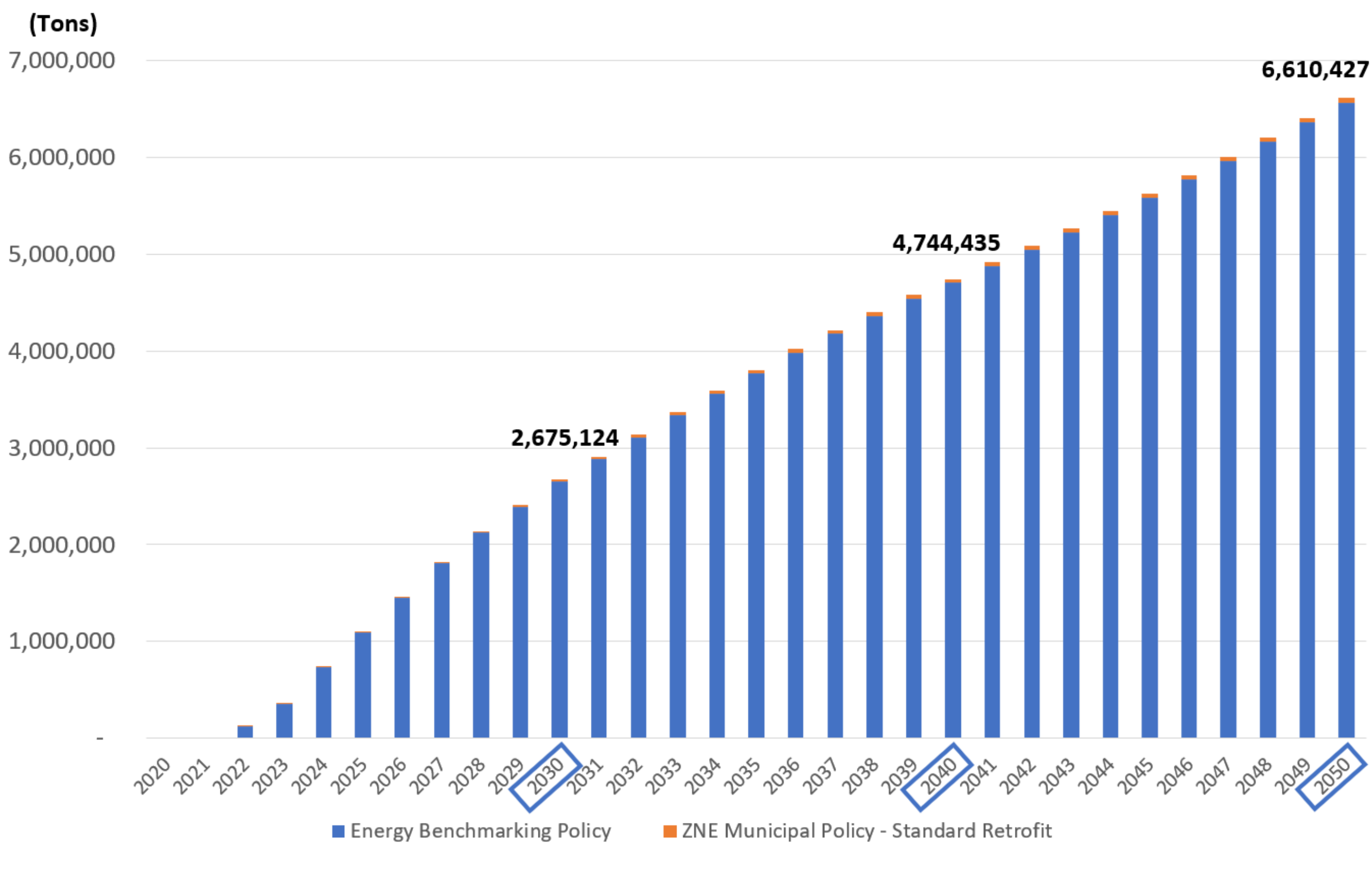


Climate action policies related to buildings are defined by the energy benchmarking and ZNE municipal building interventions that target investments in energy efficiency and on-site renewable generation. Energy benchmarking of multifamily and commercial buildings is anticipated to drive the largest carbon emission reductions across all policy interventions, mainly attributed to the scale of building area covered by the policy. By 2030, energy benchmarking is expected to reduce carbon emissions by 2,650,744 tons; rising to 4,705,383 tons by 2040; and avoiding 6,560,841 by the end of 2050. Since only 6 buildings were included in the ZNE analysis, the carbon reduction potential remains significant, but much less than the totals presented for the benchmarking policy. If more municipal buildings were assumed to become ZNE compliant, the expected environmental benefits from avoided carbon emissions would increase proportionally. Under the current portfolio of 6 properties, the ZNE standard retrofit proposal is estimated to avoid 24,380 tons of carbon by 2030; 39,051 tons by 2040; and 49,586 tons by 2050. Moreover, if both building related policies were implemented simultaneously, by 2050 they are anticipated to cumulatively reduce carbon emissions by 6,610,427 tons (Figure 3).

A noteworthy observation from Figure 3 is the gradual plateau of carbon emissions when projected into the future. This trendline can be best described by the underlying grid emission factors used to calculate the emission quantities. Due to CPS Energy's progressive Flexible Path emission factor projections, emissions from the grid gradually decrease as more renewable power plants come online.

Air pollutant reductions are expected to aid the City in reaching 'attainment' status for Federal Ground-Level Ozone Standards as outlined by the EPA in the National Ambient Air Quality Standards (NAAQS). The interaction between projected emission reductions and improvements to ambient air quality across the City were investigated with advisors from the Alamo Area Council of Governments (AACOG). Modeling changes to ambient air quality requires dynamic processes that account for variations in seasonal temperatures, as well as wind patterns that affect a geographic area. The potential impact on attainment status falls outside the scope of this analysis, and is not quantified due to the inherent intricacies involved in modeling changes to ground-level Ozone inventory levels.

FIGURE 3. CUMULATIVE CO2 EMISSIONS REDUCTION - BUILDING RELATED POLICIES

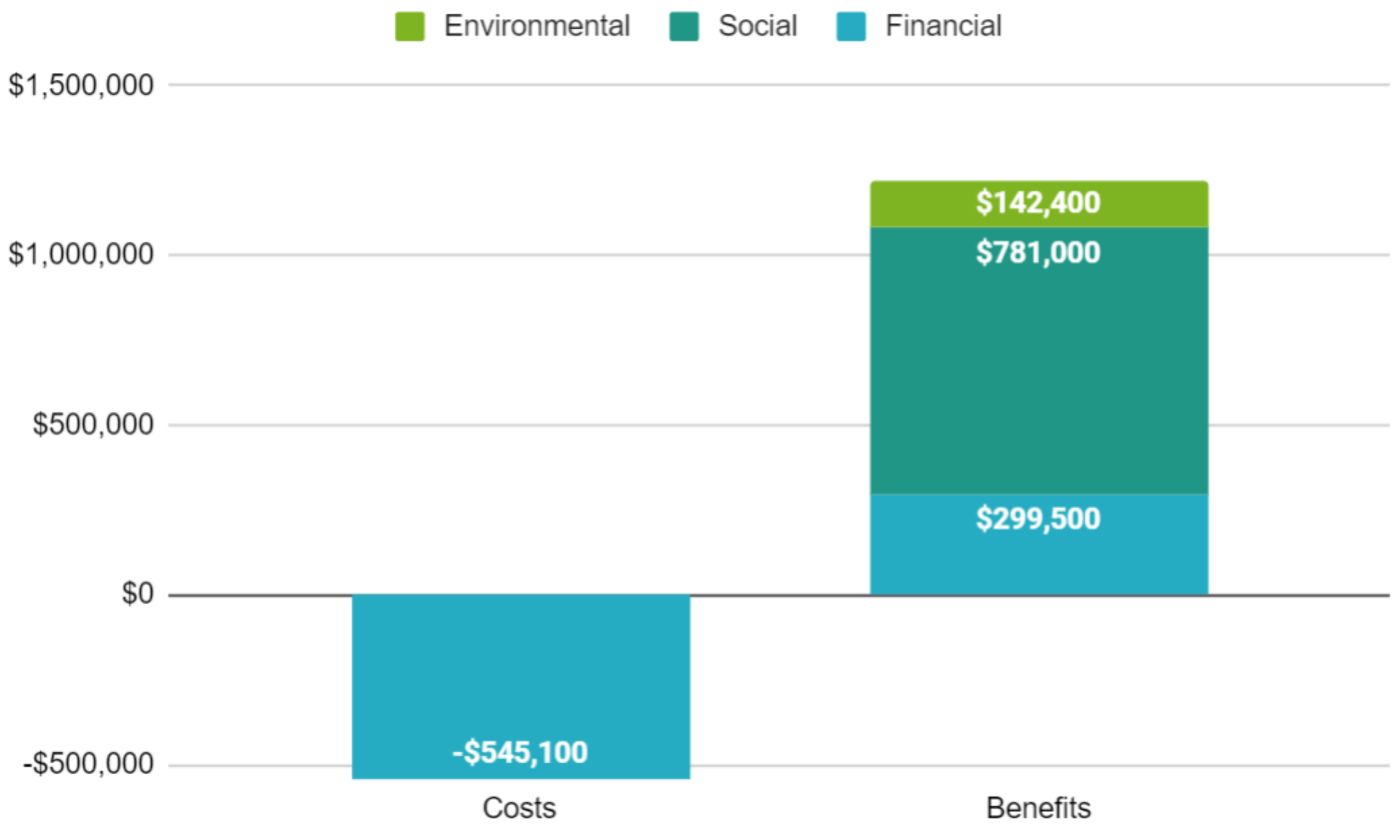


3.2 CLIMATE ACTION AND COMMUNITY RESILIENCE THROUGH URBAN AGRICULTURE

The COVID-19 pandemic brought about a devastating and ongoing impact on regional food security, and revealed weaknesses in transportation and trade networks. San Antonio's Office of Sustainability worked with several urban agriculture experts in the City, the Food Policy Council of San Antonio (FPCSA), the San Antonio Housing Authority, and the economic modeling team at Autocase™ to identify a full range of benefits (economic, social, and environmental) associated with a prototypical urban agriculture site in San Antonio. External stakeholder engagement includes interested parties from across San Antonio, such as the Garcia Street Urban Farm, a 4-acre urban farm that recently opened in conjunction with San Antonio College (SAC).

This policy is being considered for its risk mitigation of the City's foreseen and unforeseen challenges. Foreseen challenges include climate change, which urban agriculture helps mitigate by being a resilience tool for flood and urban heat island control, reducing carbon emissions, and improving the well-being and education of the community. Unforeseen challenges include food distribution and nutrition risks as shown by the COVID-19 pandemic. The events of the breakdown in trade and the lockdown of the COVID-19 pandemic highlights the presence of food insecurity, and that natural disasters will disproportionately affect people who are less economically and socially affluent. Urban agriculture mitigates food and nutrition risks by providing a ready source of sustenance independent of international supply chains, which are susceptible to unforeseen external disruptions. These benefits can be materialized within the city if there are generous incentives provided to mitigate the high capital and operational costs of urban agriculture as shown in Figure 4.

FIGURE. 4 COSTS AND BENEFITS FOR A PROTOTYPICAL FARM REPLACING AN IMPERVIOUS SURFACE - NPV OVER 30 YEARS DISCOUNTED AT 3%



Urban agriculture provides substantial environmental benefits if the initial site converted to a farm is an asphalt or concrete parking lot. If built on an unsustainable impervious site, urban agriculture reduces stormwater impact on the flood zone of the City, and reduces the urban heat island effect in a worsening climate. The prototypical farm also provides significant carbon sequestration benefits, and ecosystem pollination benefits. Benefits that do not depend on the initial site stem from the reduction of greenhouse gases (GHGs) associated with transportation, the social benefits of recreation, property value uplift, opportunities for elementary to university level students, community cohesion benefits from volunteering, and health improvements.

The ultimate goal of urban farms is to create holistic spaces, where communities participate in the creation of local food, and actively contribute in making cities ecologically sustainable and nutritionally self-sustaining. The crops planted in this prototypical site are proven to grow well in San Antonio and will provide meals for the community which can be analyzed as a benefit measure. Analyzing the nutritional value in terms of vitamins and minerals, along with contributions to daily nutritional requirements, helps make sense of the scale and benefits of a half-acre farm operation.

On a per meal basis, with an average of 500 calories per meal, the prototypical urban farm can provide over 2000 meals a year (Table 1). Vegetables are a primary food source for some people, but they often contribute to a larger meal. This can be measured with macronutrient yearly recommended requirements, which shows that the prototypical site contributes in the range of 3 people for protein to 300 people for Vitamins A and C.

These benefits are possible because of considerable upfront costs. The highest costs for an urban agriculture site are capital, land, and labor. Costs such as machinery rental, water, seeding, and fertilizer are inherent in managing such an operation. Others are created by the nature of farming in a major urban setting, and may include higher land rent, labor, and capital costs. The tangible benefits to the city discussed above are achievable. However, there is a need for start-up and operational incentives from the municipality. If these active measures to improve resiliency and increase well-being are to be located inside San Antonio's borders, incentives are required to lower the capital and operational costs of urban agriculture.

The city could incentivize urban farming by providing support for the high startup costs of converting unsustainable, unused paved sites into healthy and living ecosystems. Incentives can also include providing lease agreements with first right of sale, mitigating the effects of high property prices in the City's boundaries. Operating cost support can also extend to creating a network of urban farmers, with shared resources for tools, equipment, and processing facilities to create the best environment for urban agriculture to farm.

TABLE 1. NUTRITIONAL VALUE OF A ½ ACRE FARM FOR 1 PERSON PER YEAR

Urban Agriculture - Yearly Nutritional Value for San Antonio Resident Average Requirements											
	Calories	Protein	Sodium	Potassium	Carbohydrates	Fiber	Vitamin A	Vitamin C	Calcium	Iron	Magnesium
Carrot	67%	51%	77%	176%	183%	263%	2850%	206%	80%	65%	92%
Broccoli	35%	97%	23%	109%	79%	153%	66%	1947%	71%	99%	100%
Lettuce	19%	41%	9%	65%	47%	94%	71%	81%	36%	74%	45%
Zucchini	23%	55%	7%	119%	49%	78%	28%	516%	32%	66%	114%
Cucumber	30%	43%	3%	99%	84%	57%	21%	119%	47%	74%	121%
Tomato	15%	24%	3%	65%	37%	56%	72%	239%	12%	29%	42%
Total	188%	312%	123%	632%	480%	702%	3108%	3108%	278%	406%	514%

3.3 TBL-CBA RESULTS

This investigation reveals several options for optimal policy decisions based on net present value and benefit-cost ratio. The results of the six policies and 10 scenarios are presented in Table 2. A total TBL-NPV is presented, along with a TBL-NPV per home for EV Ready Building codes, PV System Readiness, and White Roofs. TBL-NPV per square foot for Energy Benchmarking, Zero Net Energy Municipal Buildings, and Urban Agriculture is also presented. This standardized approach of presenting TBL-NPV values per home and per square foot facilitates the comparison of separate policies on even terms.

Results show that the Energy Benchmarking policy has the highest return on investment, with a TBL-BCR of 4.78. The TBL-NPV of this policy is substantial, with over $1.6 billion in discounted returns over 30 years. Retrofitting municipal buildings for ZNE gives the next highest return, with a TBL-BCR of 2.11 and 2.25 in the Standard and Deep Retrofits, respectively. Both packages amount to a moderate $11.8 million and $12.2 million in TBL-NPV over 30 years. Urban Agriculture is a worthwhile investment, with a TBL-NPV of $446,000 if the farm replaces unmanaged turf, and $678,000 if the site replaces paved impervious cover. Depending on the original site, the TBL-BCR of this investment would be 1.98 or 2.24 respectively.

Weighing the policies on a per square foot basis, ZNE retrofits contain the highest potential for NPV if implemented across buildings in the city. It is noteworthy to mention that this analysis was estimated for only 6 municipal buildings, with varying typologies. As such, these results may change when applying them to the full municipal building inventory. Urban Agriculture TBL-NPV header results are low, but there are considerable triple-bottom-line (TBL) returns per square foot of municipal land converted to urban farming. TBL-NPV returns for Energy Benchmarking are the highest given the low cost and large scope of multifamily and commercial buildings covered by the policy, but returns per square foot are the lowest when compared to the other two policy initiatives.

The impact of a white roof policy depends on the assumed scenario. Implementing the 'Under 1 Roof' program across all new construction by requiring white roofs and energy barriers, gives a TBL-BCR of 0.79. This policy has a TBL-NPV of -$376.3 million, as the costs of installing the energy barrier are not offset by academically derived reduced energy utility rates and environmental emissions. The alternative scenario is a mandate of only white shingles for new construction, which involves no added cost to the builder, and gives social and environmental benefits of $533.9 million. Since there is no cost for this scenario as the net of the design case and base case shingle is zero, there is no BCR ratio. Electric Vehicle Ready policies are also profitable across TBL impacts, with a TBL-BCR of 1.75 in the EV building code scenario alone, and improving to 1.78 when including the TOU rate scenario. The TBL-NPV of these two scenarios is $70.3 million and $72.3 million respectively. PV Roof Readiness policies have a lower return, with a TBL-BCR of 1.02 and a TBL-NPV of $12.6 million.

On a per home basis, the EV Ready building code has the highest TBL-NPVs of over $3000 in returns for both scenarios. The White Roof policy in the shingles only scenario is the second most profitable, showing a $3000 per home benefit with no costs. PV roof readiness follows with a modest TBL-NPV return per home of $165. Given the high initial roof readiness costs for all new buildings, this program incentivizes substantial PV system adoption to become a worthwhile investment. The lowest return is the TBL-NPV loss per home of $2300 for the white roof with an energy barrier policy, which is not positive given the high labor costs of installation and moderate energy savings.

TABLE 2. SAN ANTONIO SUSTAINABILITY POLICY RESULTS

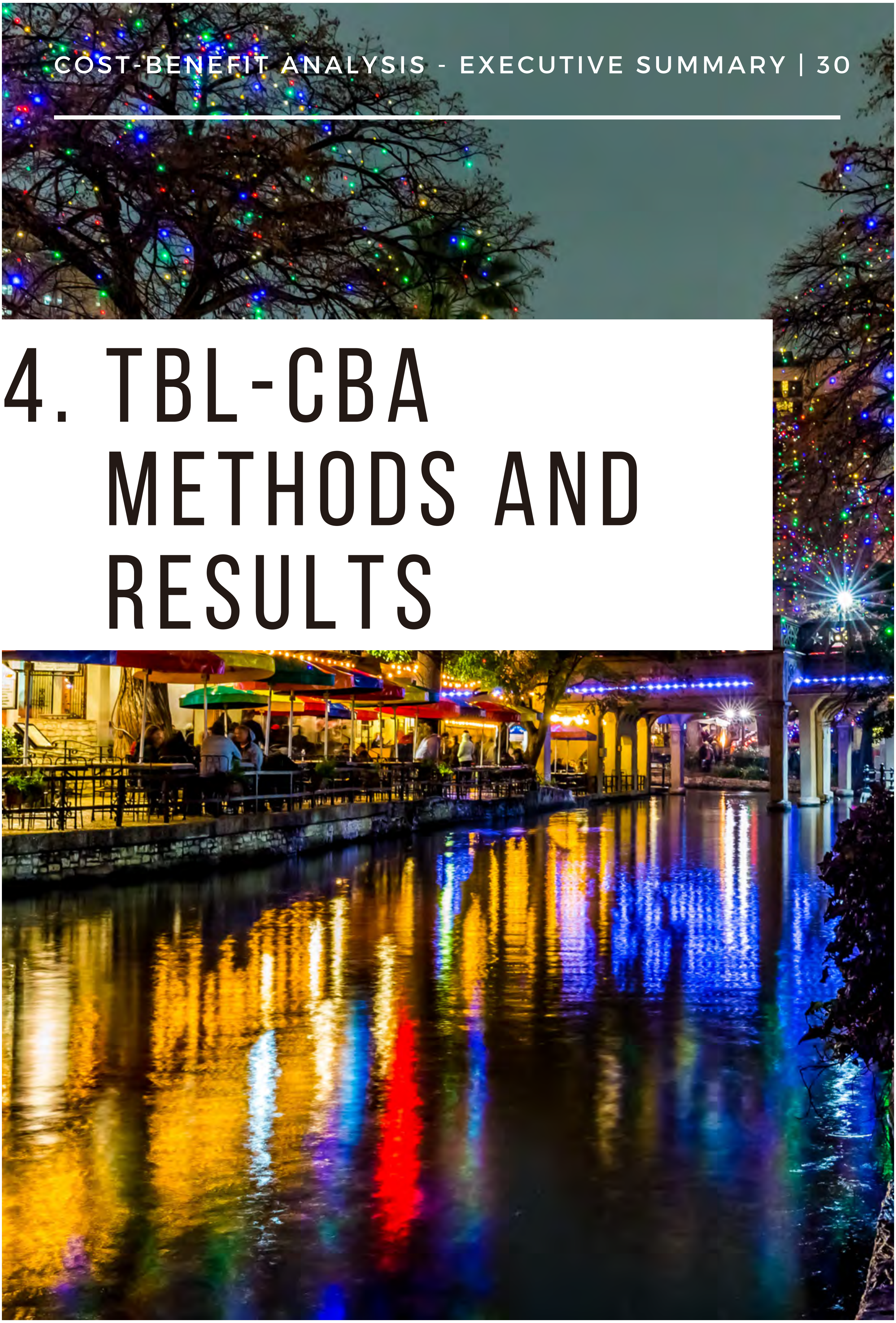
San Antonio Sustainability Policy Results				
Discount Rate				*3%*
Time Period				*30 Years*
Policy	*Scenario*	*TBL-NPV*	*NPV / Sq Ft*	*TBL-BCR*
Energy Benchmarking	Commercial and Multifamily	$ 1,632,222,000	$ 2.93	4.78
Zero Net Energy Municipal Buildings	Standard Retrofit: Small + Large	$ 11,802,000	$ 24.10	2.11
Zero Net Energy Municipal Buildings	Deep Retrofit: Small + Large	$ 12,229,000	$ 24.98	2.25
Urban Agriculture	Unmanaged Turf Conversion	$ 446,000	$ 5.12	1.98
Urban Agriculture	Paved Cover Conversion	$ 678,000	$ 7.78	2.24
Policy	*Scenario*	*TBL-NPV*	*NPV / Home*	*TBL-BCR*
White Roofs	White Shingle & Energy Barrier	-$ 376,268,000	-$ 2,272	0.79
White Roofs	White Shingles Only	$ 533,851,000	$ 3,008	N/A
Electric Vehicle Readiness Code	Readiness Policy	$ 70,239,000	$ 2,966	1.75
Electric Vehicle Readiness Code	Readiness Policy + TOU Rates	$ 72,324,000	$ 3,093	1.78
Photovoltaic Roof Readiness Code	Readiness Policy	$ 12,621,000	$ 165	1.02

This analysis investigates several options for optimal policy decisions based on net present value and benefit-cost ratio. The costs and benefits of the six policies and 10 scenarios are summarized in Table 3. Costs are representative of the total life cycle costs accrued over the project duration.

TABLE 3. SAN ANTONIO SUSTAINABILITY POLICY SUMMARY TBL-CBA SUMMARY METRICS

San Antonio Sustainability Policy Results			
Discount Rate			*3%*
Time Period			*30 Years*
Policy	*Scenario*	*Costs*	*Benefits*
Energy Benchmarking	Commercial and Multifamily	-$ 432,278,000	$2,064,500,000
Zero Net Energy Municipal Buildings	Standard Retrofit: Small + Large	-$ 10,669,000	$ 22,471,000
Zero Net Energy Municipal Buildings	Deep Retrofit: Small + Large	-$ 9,777,000	$ 22,006,000
Urban Agriculture	Unmanaged Turf Conversion	-$ 455,800	$ 901,600
Urban Agriculture	Paved Cover Conversion	-$ 545,100	$ 1,222,900
Policy	*Scenario*	*Costs*	*Benefits*
White Roofs	White Shingle & Energy Barrier	-$1,827,114,000	$1,450,846,000
White Roofs	White Shingles Only	$ -	$ 533,851,000
Electric Vehicle Readiness Code	Readiness Policy	-$ 93,178,000	$ 163,417,000
Electric Vehicle Readiness Code	Readiness Policy + TOU Rates	-$ 93,178,000	$ 165,502,000
Photovoltaic Roof Readiness Code	Readiness Policy	-$ 675,194,000	$ 687,815,000

4. TBL-CBA METHODS AND RESULTS



4.1 ENERGY BENCHMARKING FOR COMMERCIAL AND MULTIFAMILY BUILDINGS

4.1.1 OVERVIEW

SA Climate Ready identifies the reduction of building energy consumption as a driver for achieving our community's climate goals, noting that 48% of San Antonio's GHG emissions come from buildings and over half of that energy use (27%) is attributed to commercial and industrial buildings specifically. To reach the goal of carbon neutrality by 2050, emissions contributed by the building energy sector must be reduced 41% by 2030 and 74% by 2040. The City already oversees several successful programs to advance local energy efficiency in the community. With a long legacy of prioritizing energy efficiency in operations, benchmarking represents the foundation for the City's progress in advancing efficiency.

Decarbonization of the building stock remains a critical aspect to mitigating climate change and should be at the forefront of solutions to reducing carbon emissions. In response, SA Climate Ready identifies a policy that would require the energy benchmarking of commercial and multifamily buildings over 50,000 square feet (sq ft) to report their energy use intensity (EUI) or their energy star score via the U.S. EPA's ENERGY STAR® Portfolio Manager® tool.

This intensity value is calculated as a function of the buildings energy use (in kWh) divided by the floorspace of the structure (in sq ft) to give a ratio of (kWh / sq ft), which can be interpreted as the incremental amount of energy usage required for an additional unit of area in the building. This common metric allows buildings to be compared on an equal footing and incentivizes building owners/operators to investigate how their building ranks relative to a portfolio of comparable buildings with similar size and occupational characteristics.

In addition to commercial buildings, this policy is also intended to apply to all existing and new multifamily residential buildings within San Antonio. Data from the Texas Demographer's Office was used to collect current values and to forecast future home construction in Bexar County. Initial 2019 single-family and multi-family home split was used to linearly forecast 2030 and 2040 household numbers (Economic Planning & Systems, 2015). Similarly, for commercial building spaces, current building inventory and distributions across building areas (sq ft) were used to forecast future commercial building growth - assumed to be an annual growth rate of 2.4% (Economic Planning & Systems, 2015). To achieve meaningful and sustainable energy reductions building owners and operators are expected to undergo some level of operational and/or capital improvements to their buildings to meet the projected EUI reductions attributable to the energy benchmarking policy. The act of reporting annual energy consumption will not in itself drive energy reductions. However, it is the first step in understanding how different components of a building's efficiency stack up relative to its peer group. When building owners are presented with information about the additional energy costs incurred for building operations, it is expected of owners and operators to act on this information and address efficiency solutions through building investments.

Other municipalities across the country have already enacted similar energy benchmarking policies (IMT, 2020), and reported significant financial, social, and environmental benefits accruing to local communities in the form of utility rate savings and avoided grid-associated emissions. Building owners and operators are expected to accrue financial cost savings in the form of reduced annual utility bills. The decrease in electricity usage from commercial and multifamily buildings also drives reductions in grid emissions following the projections outlined by CPS Energy's FlexPath emission factors. FlexPath emissions are CPS Energy's forecast for future grid emissions which takes into consideration planned action and climate change, such as the reduction in polluting generating methods and shifts to more sustainable sources of solar, wind, and natural gas power. Emission factors (per kWh) are monetized by their respective social costs, with CO2 emissions monetized by values of carbon developed from the Interagency Working Group (2016), forecasted from 2020 to 2050. NOx and SO2 social costs are developed by Heo et al. (2016) and the USDOT (2015).

4.1.2 RESULTS

The TBL-NPV of the energy benchmarking policy proposal is estimated to accrue over $1.6 billion in benefits over a 30 year operational period, discounted at a real rate of 3% (Table 4). Benchmarking compliance costs faced by building owners and operators is expected to amount to over $11 million, reflecting the costs incurred for disclosing building performance. Municipal administration costs are estimated to be approximately $2.8 million and accounts for the staffing requirements pre- and post-policy implementation. Measurement and verification costs are expected to total over $167 million reflecting the costs incurred for verifying the energy performance of the efficiency investments. Capital and operational investments are categorized as the efficiency investments induced from the benchmarking policy and are estimated to cost building owners/operators a combined total of approximately $250 million.

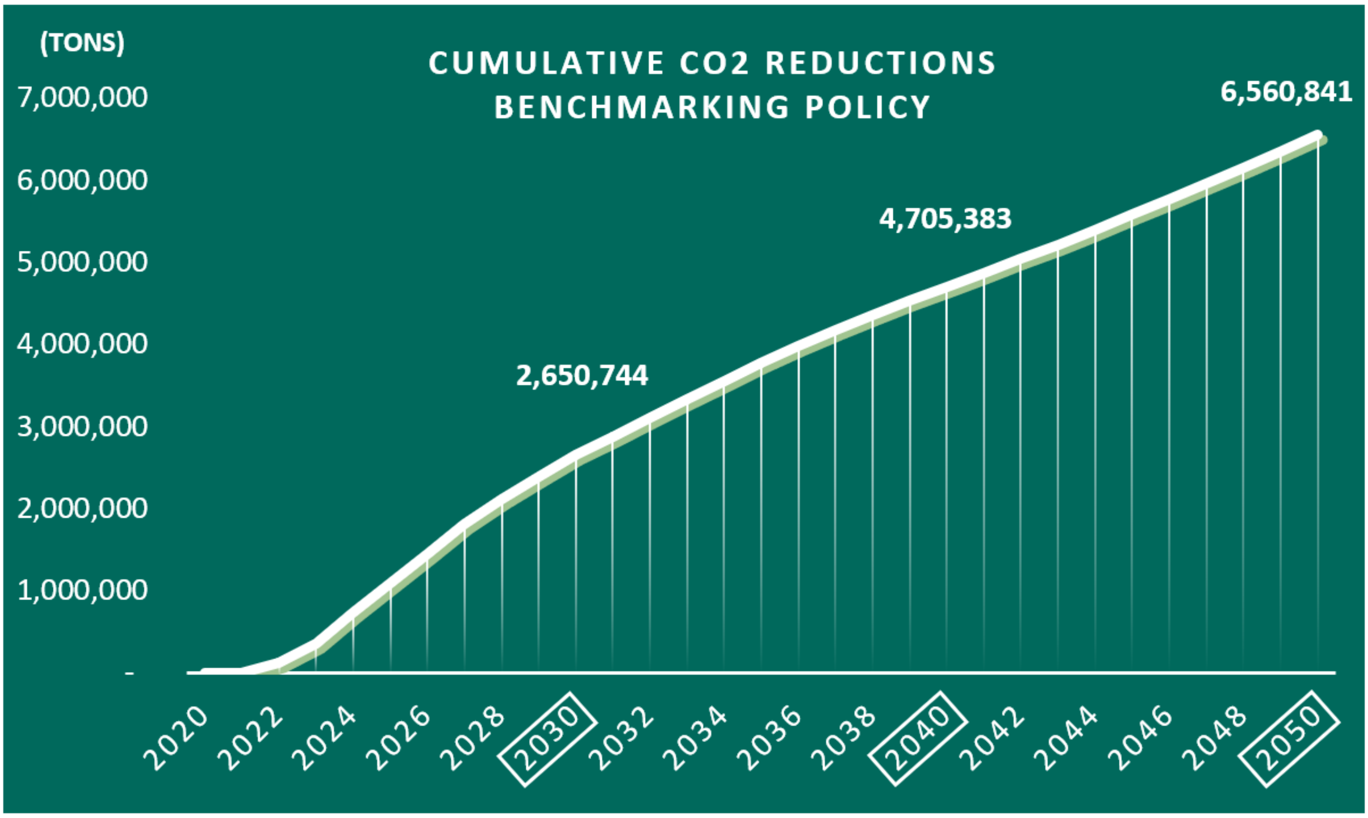
The largest benefit expected from the benchmarking policy proposal stems from user rate savings from avoided electricity use, and is estimated at over $1.6 billion. Reductions in energy use from the grid also drives reductions in emissions associated with electricity generation. The avoided electricity use translates to roughly $316 million in carbon emissions avoided and over $70 million in other air pollutant reductions. More specifically, carbon emission reductions from energy benchmarking is estimated to avoid 2.6 million tons by 2030; 4.7 million tons by 2040; and over 6.5 million tons by the culmination of the City's carbon neutrality goal in 2050 (Figure 5).

This policy has a TBL-BCR of 4.78, which can be interpreted as generating $4.78 in benefits to the community, for every $1 spent in costs associated with the policy.

TABLE 4. TBL-NPV COMMERCIAL & MULTIFAMILY BUILDING BENCHMARKING POLICY RESULTS

Energy Benchmarking Policy		
Discount Rate		*3%*
Time Period		*30 Years*
CPS Energy Emissions Forecast		*Flexible Path*
Social Cost of Carbon		*Central*
Total Costs	**-$**	**432,278,000**
Benchmarking Compliance	-$	11,275,000
Municipal Administration	-$	2,881,000
Measurement & Verification	-$	167,696,000
Operational Retrofit Investments	-$	123,840,000
Capital Retrofit Investments	-$	126,586,000
Total Benefits	**$**	**2,064,500,000**
Energy Rate Savings	$	1,676,959,000
Carbon Reduction	$	316,945,000
Air Pollutant Reduction	$	70,596,000
Triple Bottom Line - Net Present Value	**$**	**1,632,222,000**
Triple Bottom Line - Benefit-Cost Ratio		**4.78**

FIGURE 5. CUMULATIVE EMISSIONS REDUCTIONS FROM ENERGY BENCHMARKING POLICY



4.2 WHITE ROOFS

4.2.1 OVERVIEW

White roofs are an innovative and simple way to generate urban environment benefits by lowering average heat across a city and within homes. The benefits of a white roofs policy for new construction manifest along two streams: 1) Urban Heat Island (UHI) reduction; measurable decreases in mortality and morbidity from heat related health events, and 2) home energy use; which reduces utility rate bills and environmental emissions from avoided energy production. There are residual costs recuperated as a benefit category. With a lifespan of 25 years, the majority of the benefits from each investment is not fully realized and for homes built later in the study period substantial benefits are not realized. Residual value accounts for this discrepancy between costs and benefits. This policy is intended to apply to all new residential construction within San Antonio. Data from the Texas Demographer's Office on population growth over the study period was used to forecast future single-family home construction in Bexar County.

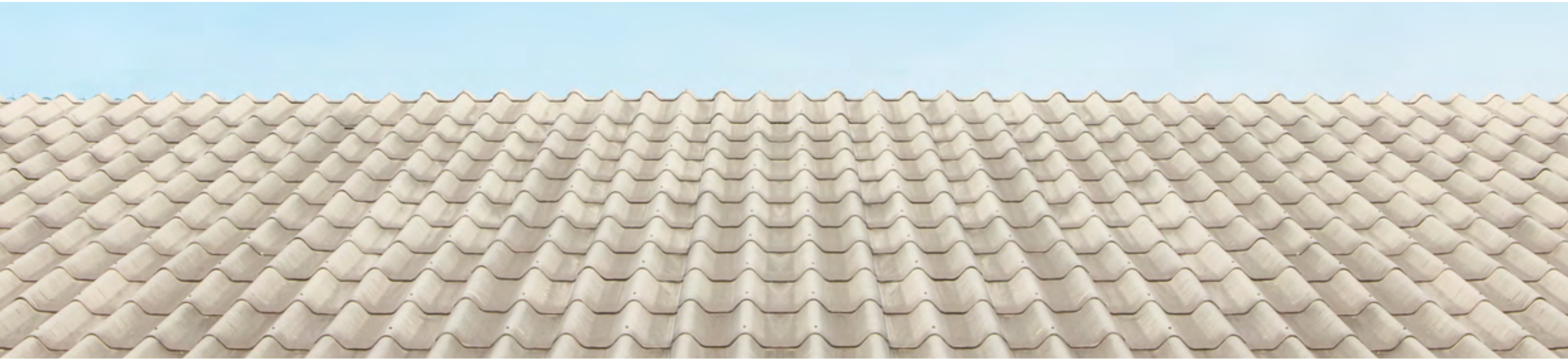
Details of this proposed policy follow on data gathered for the 'Under 1 Roof' program, a San Antonio initiative under which low income households are given the opportunity to replace worn and aging roofs with new energy efficient roofs. In 2020 this program will modernize, repair, and replace over 500 roofs of qualifying homes with white shingles. Part of the program costs also include an energy insulation layer to increase energy efficiency, which is a greater expense as labor costs for this installation are high. The program is aimed at refurbishing and renovating the roofs of low-income households in need of repairs, with the addition of the energy insulation as an energy use intensity reduction measure and livability improvement. This analysis is only from the perspective of white roof addition, and its effect on energy use and urban heat island. Benefits to households in the form of retaining and repairing their home which the 'Under 1 Roof' program provides are not analyzed in this report.

Details of an alternative policy follow discussions on the lowest net cost policy possible with considerable benefits for the city. The modified building construction policy requires only white roof shingles (without the energy insulation layer) instead of black shingles, which provides social, environmental, and financial benefits for no incremental cost. Construction companies advise that there is no incremental cost of installation for a white roof shingle vs. a black roof shingle alone. Since this is an incremental analysis, over a do-nothing scenario there are zero net construction costs. The benefit categories remain the same. Similar low-cost programs are implemented by New York, with the 'NYC CoolRoofs' initiative. Incentives are offered for applying white paint for flat roofs with parapets on city buildings. This can be an easily replicated measure for urban housing with large UHI and Energy Use Intensity (EUI) reduction potential. However, modeling such a policy should consider paint re-application and potential pollution from degrading paint.

4.2.2 RESULTS

A policy of requiring white roofs and energy insulation for new construction gives a negative TBL-NPV (Table 5). The net present value is -$376.3 million, with a TBL-BCR of 0.79. The BCR can be interpreted as generating $0.79 in benefits to the community, for every $1 spent in costs associated with the policy. Cumulative grid emission reductions are estimated to be 211,800 tons of carbon by 2030; 545,600 tons by 2040; and 981,100 tons by 2050 (Figure 6). The majority of the benefits come from the residual value of the roof, with $641 million in capital costs returned. The next highest category is UHI mortality reduction, with value of statistical life (VSL) related benefits of $394.5 million stemming from the white roof component. These benefits cannot surpass the substantial costs of energy insulation installation, which is labor intensive and provides modest benefits in terms of utility rate savings at $365.2 million. Environmental benefits from carbon reduction amount to $41.7 million.

The policy of mandating only white roof shingles for new construction gives benefits of $533.9 million (Table 6). There is no residual value in this analysis where the incremental cost is zero. Cumulative grid emission reductions are estimated to be 69,900 tons of carbon by 2030; 180,000 tons by 2040; and 323,800 tons by 2050 (Figure 7). The largest contributor is UHI mortality reduction; the same benefits of $394.5 million stemming from the white roof component of the previous policy.



Energy use reduction is lower, and has a utility benefit of $120.5 million and CO2 reduction environmental benefits of $13.8 million. These benefits are still present due to the presence of insulation from a roof color change alone. Though the benefits in dollars may be higher for the shingles-only policy, the social benefits and cumulative emissions reductions are significantly reduced. The temperature data used to run the urban heat island benefits is sourced from the Canadian Centre for Climate Modelling and Analysis (2017). The Representative Concentration Pathway 4.5 (RCP 4.5) is a mild climate scenario where global action on climate change results in emission rates to peak around 2040, then begin to decline.

TABLE 5. TBL-NPV WHITE ROOF & ENERGY INSULATION NEW CONSTRUCTION POLICY RESULTS

White Roofs and Energy Insulation Policy		
Discount Rate		*3%*
Time Period		*30 Years*
Social Cost of Carbon		*Central*
CPS Energy Emissions Forecast		*Flexible Path*
Climate Scenario		*RCP 4.5*
Total Costs	**-$**	**1,827,114,000**
Capital Expenditure	-$	1,681,891,000
Replacement Cost	-$	145,223,000
Total Benefits	**$**	**1,450,846,000**
Residual Value	$	641,094,000
Urban Heat Island - Mortality Reduction	$	394,458,000
Urban Heat Island - Morbidity Reduction	$	3,454,000
Energy Rate Savings	$	365,201,000
Carbon Emissions	$	41,671,000
Air Pollutants	$	4,968,000
Triple Bottom Line - Net Present Value	**-$**	**376,268,000**
Triple Bottom Line - Benefit-Cost Ratio		**0.79**

TABLE 6. TBL-NPV WHITE ROOFS NEW CONSTRUCTION POLICY RESULTS

White Roofs (Shingles Only) Policy		
Discount Rate		*3%*
Time Period		*30 Years*
Social Cost of Carbon		*Central*
CPS Energy Emissions Forecast		*Flexible Path*
Climate Scenario		*RCP 4.5*
Total Costs	**$**	**-**
Capital Expenditure	$	-
Replacement Cost	$	-
Total Benefits	**$**	**533,851,000**
Residual Value	$	-
Urban Heat Island - Mortality Reduction	$	394,458,000
Urban Heat Island - Morbidity Reduction	$	3,454,000
Energy Rate Savings	$	120,544,000
Carbon Emissions	$	13,755,000
Air Pollutants	$	1,640,000
Triple Bottom Line - Net Present Value	**$**	**533,851,000**
Triple Bottom Line - Benefit-Cost Ratio		**N/A**

FIGURE 6. CUMULATIVE EMISSIONS REDUCTIONS FROM WHITE ROOFS AND ENERGY INSULATION

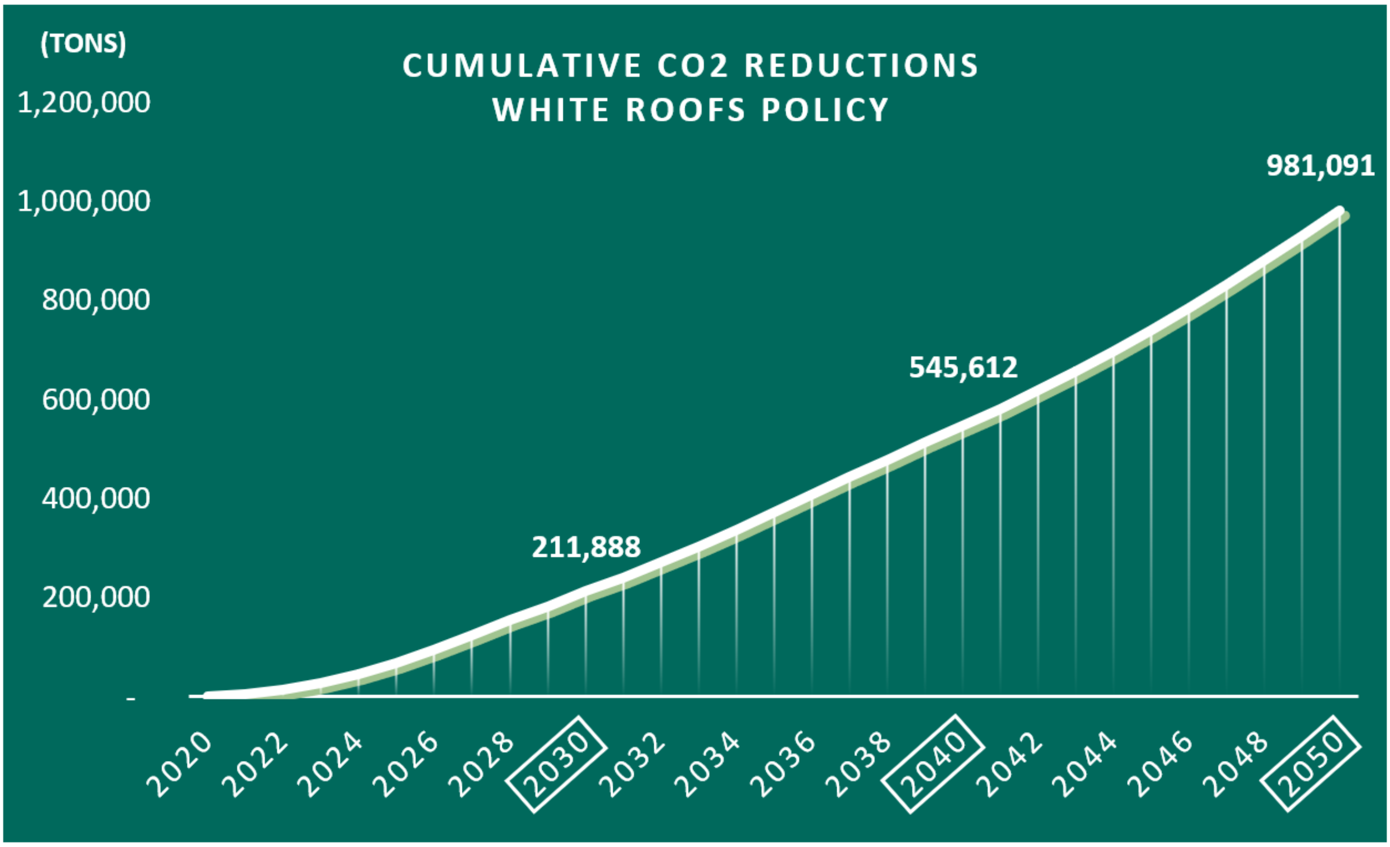
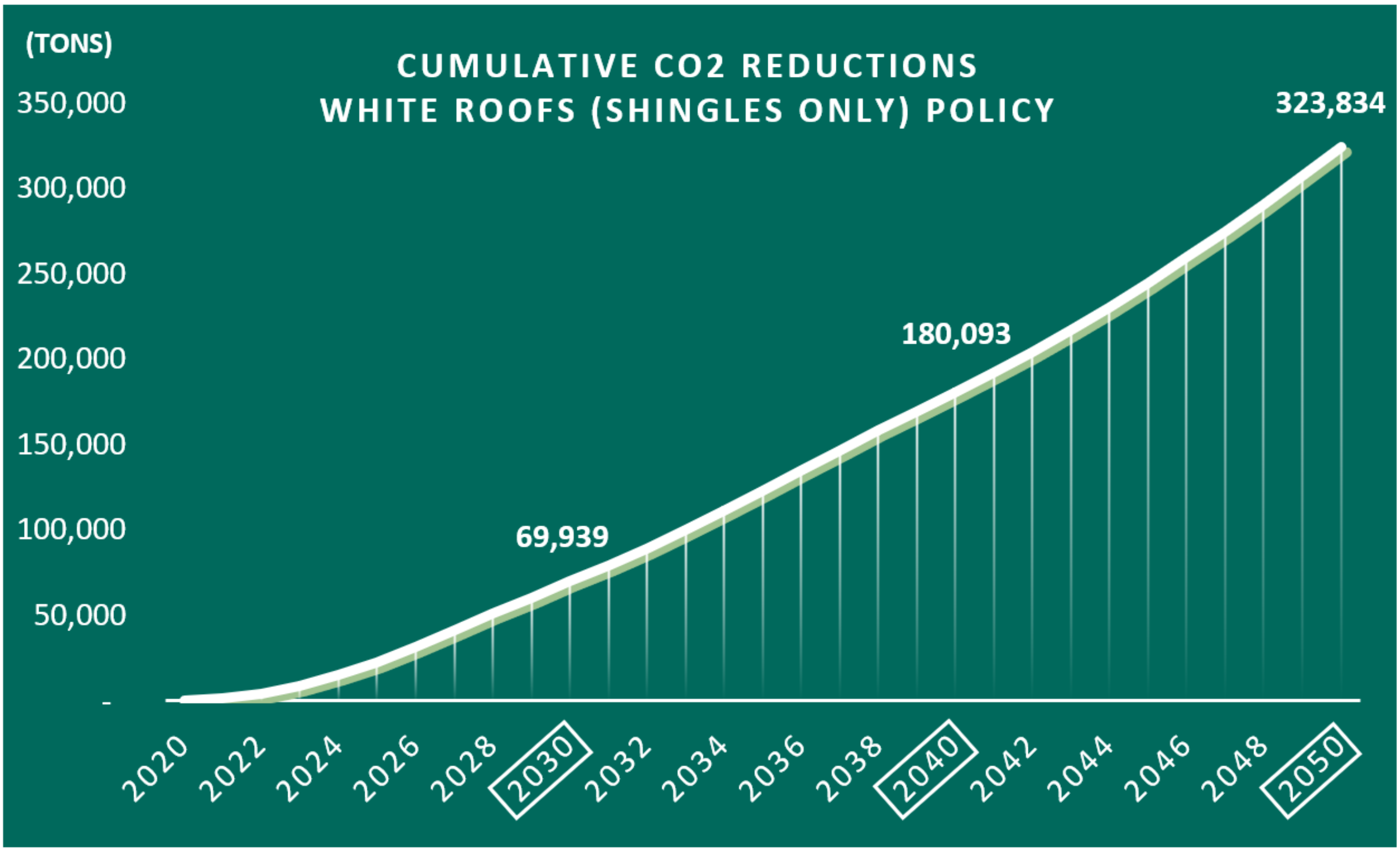


FIGURE 7. CUMULATIVE EMISSIONS REDUCTIONS FROM WHITE ROOFS SHINGLE POLICY



4.3 ELECTRIC VEHICLE (EV) CHARGER READINESS

4.3.1 OVERVIEW

The City of San Antonio is evaluating a new building code policy that would require newly constructed residential buildings to have EV and plug-in hybrid electric vehicle (PH-EV) charger-ready parking spaces. Commercial building code changes are also being considered by the City, however, are excluded from the scope of this analysis. The policy dictates that all new construction permits should be EV ready and capable - defined as having capacity and space to support a minimum 40-ampere, 240-volt branch circuit to support future installation and utilization of Electrical Vehicle Supply Equipment (EVSE). EV capable parking spaces are required to be allocated a minimum of 20% of all available vehicle parking spaces applicable to both new commercial and multifamily residential construction permits, whereas single family dwellings are required to have at least one EV ready parking space per unit.

The aim of this policy is to incentivize and promote the future adoption of electric vehicle charging infrastructure by lowering the installation costs of EV level 2 chargers, as compared to the baseline adoption of internal combustion engine (ICE) vehicles. By requiring all new buildings be equipped with EVSE, this policy effectively lowers the costs to EV adopters as they do not need to incur the future cost of retrofitting non-EVSE ready buildings. There are substantial hard and soft costs involved in retrofitting non-ready residences, often requiring breaking of concrete to lay conduit and electrical panel upgrades. The savings difference between the EV ready construction cost and the retrofit costs for installing charging infrastructure is treated as a cash subsidy, assumed to promote wide-scale EV adoption across the City.

There are several benefits attributed to EV adoption that can be differentiated by financial, social, and environmental impacts. Financial impacts stem from the cost savings introduced by the readiness policy, which apply both to incentivized and non-incentivized EV adopters. For the EV owners who were incentivized to buy an electric vehicle from the policy, there are implied benefits to the drivers since EVs are less costly to maintain on an annual basis when compared to ICEs. Since new households would have ready infrastructure in place to install an EV charger from the policy, non-incentivized owners would have an implied cost savings (or benefit) when compared to residing in a non-EV ready residence - avoiding the high retrofit costs of installing EVSE.

Transportation shifts from ICEs to EVs are necessary for the City to achieve its carbon net neutrality target by 2050. Emissions from vehicle miles traveled make up nearly 37% of the total carbon emitted annually across the city. Although EVs do have emission factors associated with the energy use during battery charging cycles, the quantity of pollutants released into the atmosphere is dictated by how “dirty” (or fossil fuel dependent) the composition of the local energy grid is. Fortunately, in conjunction with progressive goals set out by CPS Energy (the primary utility provider to San Antonio) in their ‘Flexible Path’ for the future, there is significant carbon emissions reduction potential under the proposed EV ready building policy.

4.3.2 RESULTS

The EV ready building code proposal is estimated to generate a TBL-NPV of $70 million in net benefits over a 30 year analysis duration, discounted back into today's dollars using a real rate of 3%. Total capital expenditures (CAPEX) represent the sole costs attributed to the program at $93 million which represents the costs of the EV ready building code incurred to all annual household projections across a 30 year period. As noted in the overview section, the level 2 charger costs themselves are already accounted for in the incremental life cycle differences used to calculate the financial savings accrued from EV / PH-EV ownership, and thus are not directly accounted for as a cost in Table 7. The most benefits stem from financial cost savings from retrofit installations of EVSE at $62 million and the annual difference in ownership costs compared to regular ICEs estimated to be approximately $39 million. Unsurprisingly, due to lower baseline PH-EV market shares, there remains significant yet muted (in compared to EVs) total benefits of over $8 million to PH-EV owners. This is due to the fact that EVs are projected to proliferate the passenger vehicle market at a much higher rate in comparison.

Reduction in CO2 and other air pollutants are estimated to return over $5 million to the environment over the project period, which is the social value of reduced emissions from 30 years of cleaner transportation. An incentivized shift to electric passenger vehicles is estimated to cumulatively avoid 10,896 tons of carbon emissions by 2030; 58,181 tons by 2040; and 154,401 tons by 2050 (Figure 8).

At the end of the study period in 2050, there remains residual value of the EVSE ready infrastructure, which is expected to be over $46 million in financial benefits to all new homeowners. Overall, this EV ready policy proposal achieves a TBL-BCR ratio of 1.75. This value can be interpreted as for every $1 spent on construction cost for the EV infrastructure ready, the policy is estimated to generate $1.75 in triple bottom line benefits. Such benefits are accrued to both the community and the environment in the form of financial savings and reduced emissions.

Annual projections of the market penetration for both EVs and PH-EVs across the City of San Antonio are presented in Figures 9 and 10. Baseline values indicate the proportion of non-incentivized passenger EVs and PH-EVs that are expected to adopt, regardless of implementation of the proposed EV ready policy intervention. Incentivized households are denoted by the orange bar graph, which represents the increased EV and PH-EV adoption attributed to the EV ready building code. Values presented in Figures 9 and 10 are representative of the vehicles adopted by new households since the EV ready policy proposal only applies to new builds.

TABLE 7. TBL-NPV EV READINESS CODE POLICY RESULTS

Electric Vehicle (EV) Charger Readiness Policy		
Discount Rate		*3%*
Time Period		*30 Years*
Unincentivized EV Market Share Growth		*Reference*
Social Cost of Carbon		*Central*
CPS Energy Emissions Forecast		*Flexible Path*
Total Costs	**-$**	**93,178,000**
Capital Expenditures	-$	93,178,000
Total Benefits	**$**	**163,417,000**
Residual Value	$	46,541,000
Incentivized EV Adoption - Financial Savings	$	39,976,000
Incentivized PH-EV Adoption - Financial Savings	$	273,000
Unincentivized EV Adoption - Installation Savings	$	62,942,000
Unincentivized PH-EV Adoption - Installation Savings	$	7,929,000
Carbon Reductions	$	5,590,000
Air Pollutant Reductions	$	166,000
Triple Bottom Line - Net Present Value	**$**	**70,239,000**
Triple Bottom Line - Benefit-Cost Ratio		**1.75**

FIGURE 8. CUMULATIVE EMISSION REDUCTIONS FROM EV READINESS CODE POLICY

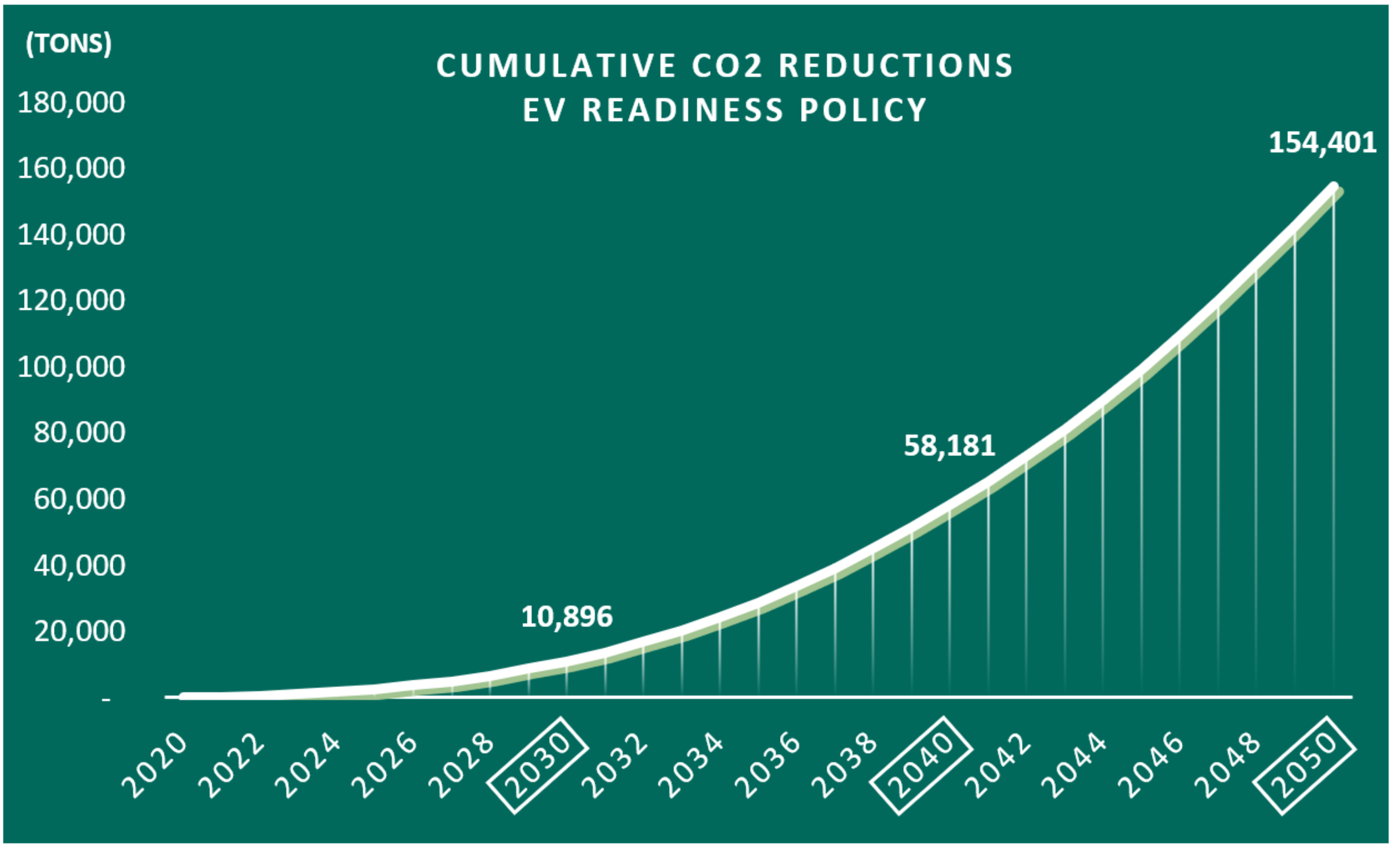


FIGURE 9. EV READINESS POLICY - PROJECTED MARKET PENETRATION GRAPH

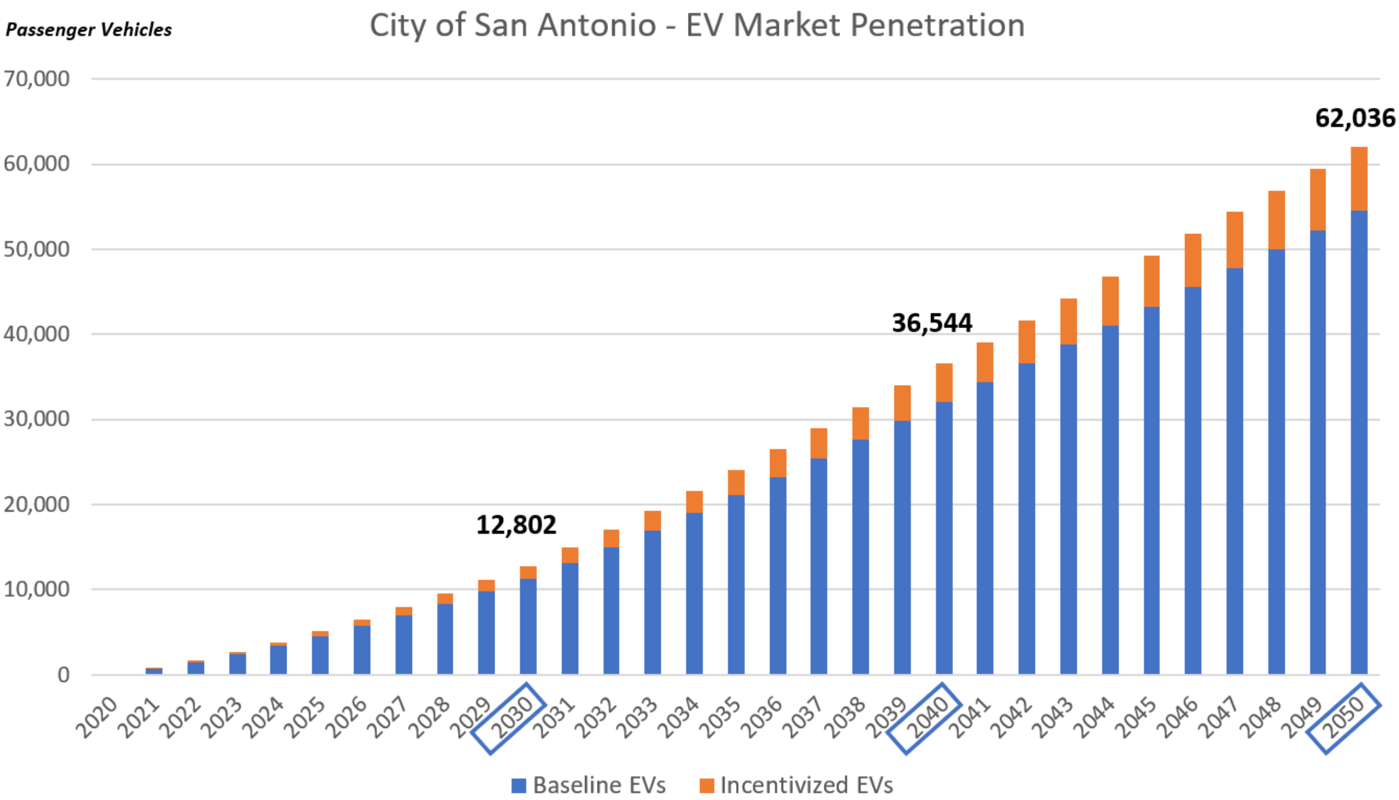
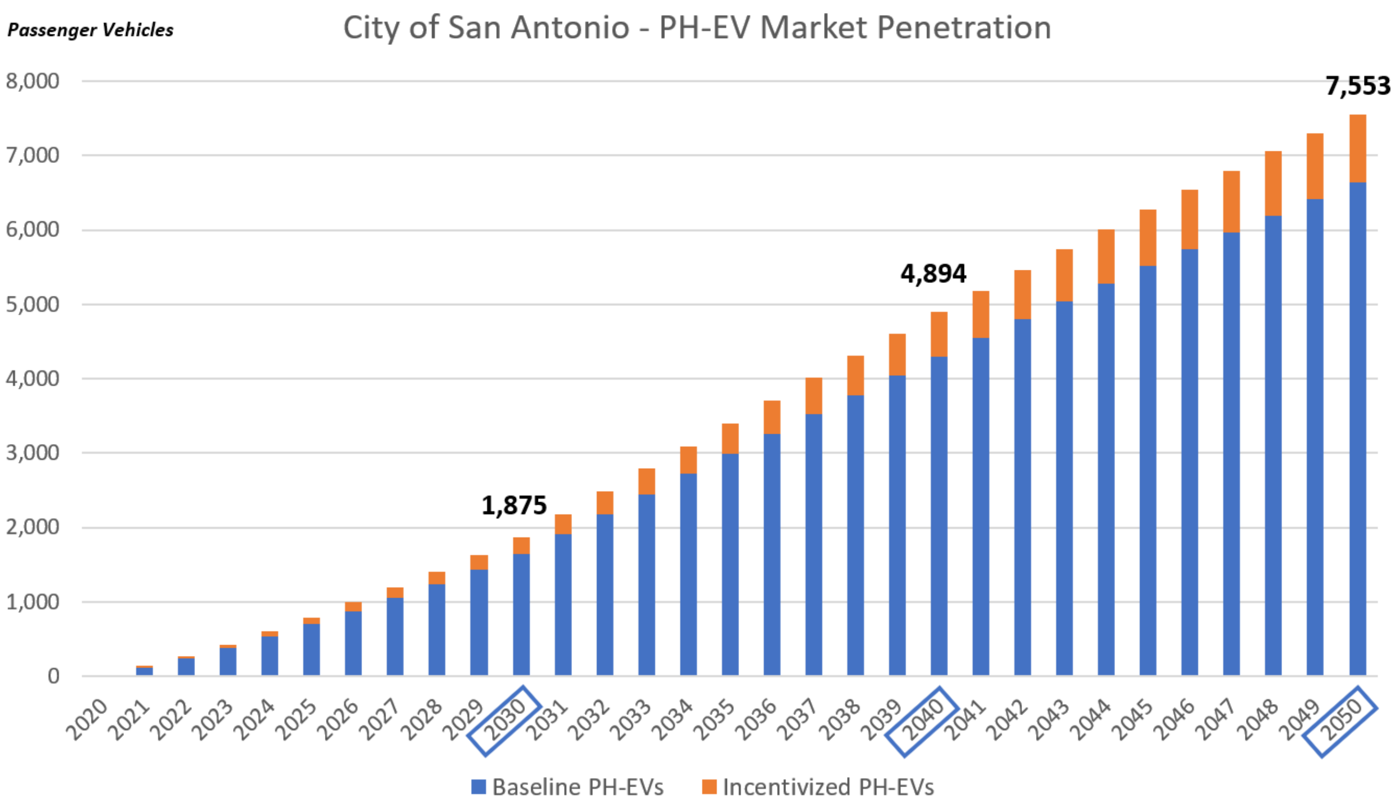


FIGURE 10. PH-EV READINESS POLICY - PROJECTED MARKET PENETRATION GRAPH



4.3.3 TIME OF USE (TOU) RATES - OVERVIEW

The increase in adoption of both EVs and PH-EVs will inevitably lead to greater demand for electricity that is required to charge the battery packs. Without proper pricing incentives, sudden surges in demand could lead to greater usage from the electricity grid further compounding peak energy loads. Increases in peak energy demand has serious implications for utility providers in terms of future infrastructure planning, which requires careful investment of peak capacity to meet the growing demand. Such infrastructure investments would be expected to be passed on to end consumers in the form of increased utility rates in the future. From an environmental perspective, peak energy usage from the grid is also more intensive in the emissions associated with electricity generation to meet sudden demand spikes. Not all power plants operate alike. Renewable energy such as photovoltaic solar panels and wind turbines are only effective energy sources during optimal conditions, and cannot be simply switched 'on' to meet sudden demand spikes. Fossil fuel power plants, such as natural gas and coal plants, can be commissioned more rapidly to meet peak demand loads. Without proper incentivization structures imposed by utility providers, increases in peak energy consumption from EV adoption is expected to drive utility rates higher, and result in greater emissions from the energy grid.

Fortunately, there are proven economic mechanisms that mitigate the externalities induced by increased EV charging loads. Time of Use (TOU) rate pricing schemes can be adopted by utility providers that incentivizes consumers to charge their EVs during off-peak demand periods at a reduced energy rate. Shifting consumers from peak to off-peak periods will minimize the need for future infrastructure investments to meet future energy demand. Additionally, incentivized rate users will experience a financial benefit accrued from utility rate savings from the TOU pricing intervention. This incentivized demand shift will also reduce the emissions derived from electricity generation. Emissions from electricity generation are estimated using data obtained from the EPA's Emissions & Generation Resource Integrated Database (eGRID) 2018 database (EPA, 2018). The baseload and non-baseload emission factors are collected for CPS Energy power stations and are used to estimate the expected difference reduction in emissions resulting from a shift from peak to off-peak energy loads. Baseload emission factors are used to represent grid emissions during off peak periods, while non-baseload factors denote the grid emissions during peak demand.

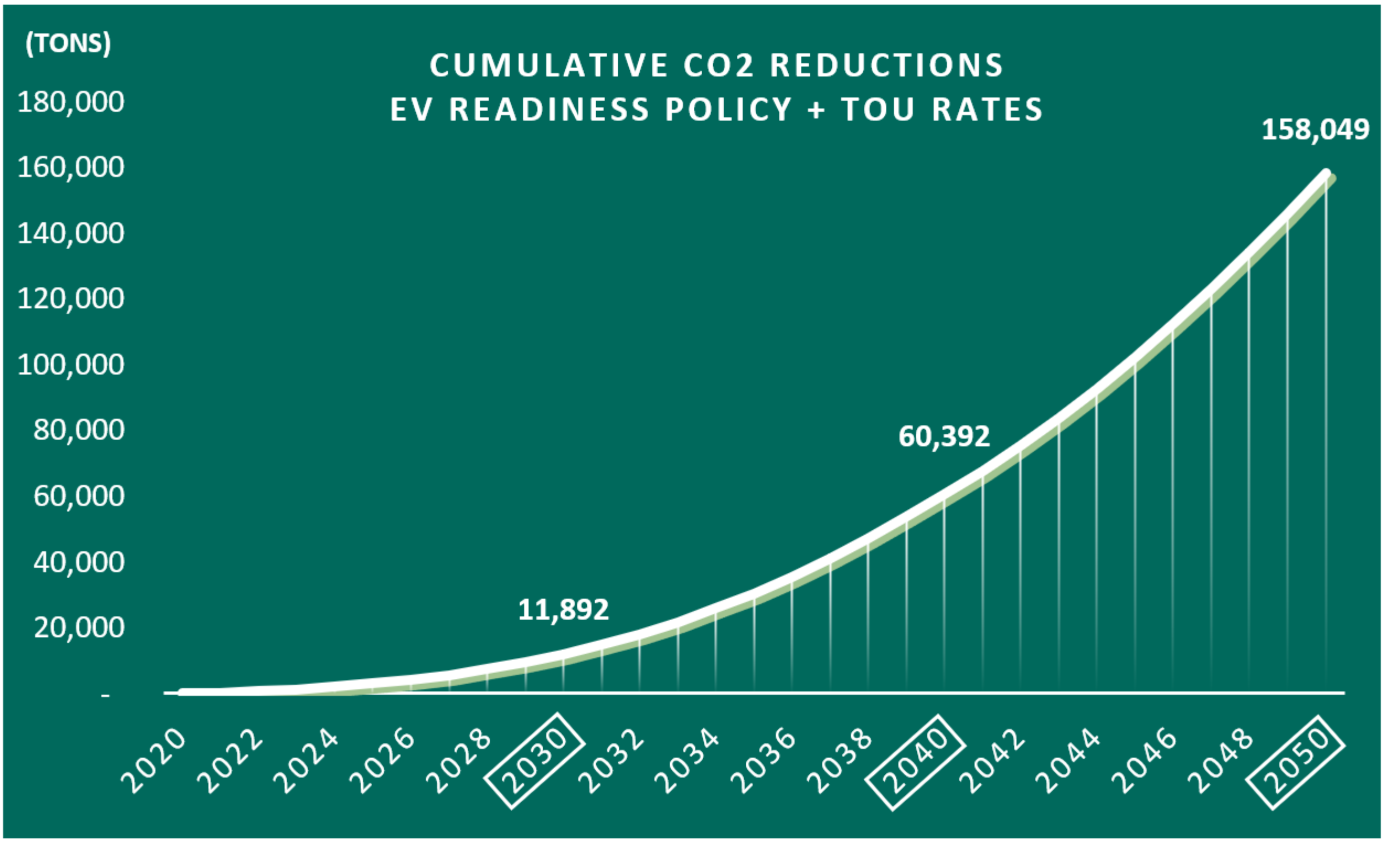
4.3.4 TIME OF USE (TOU) RATES - RESULTS

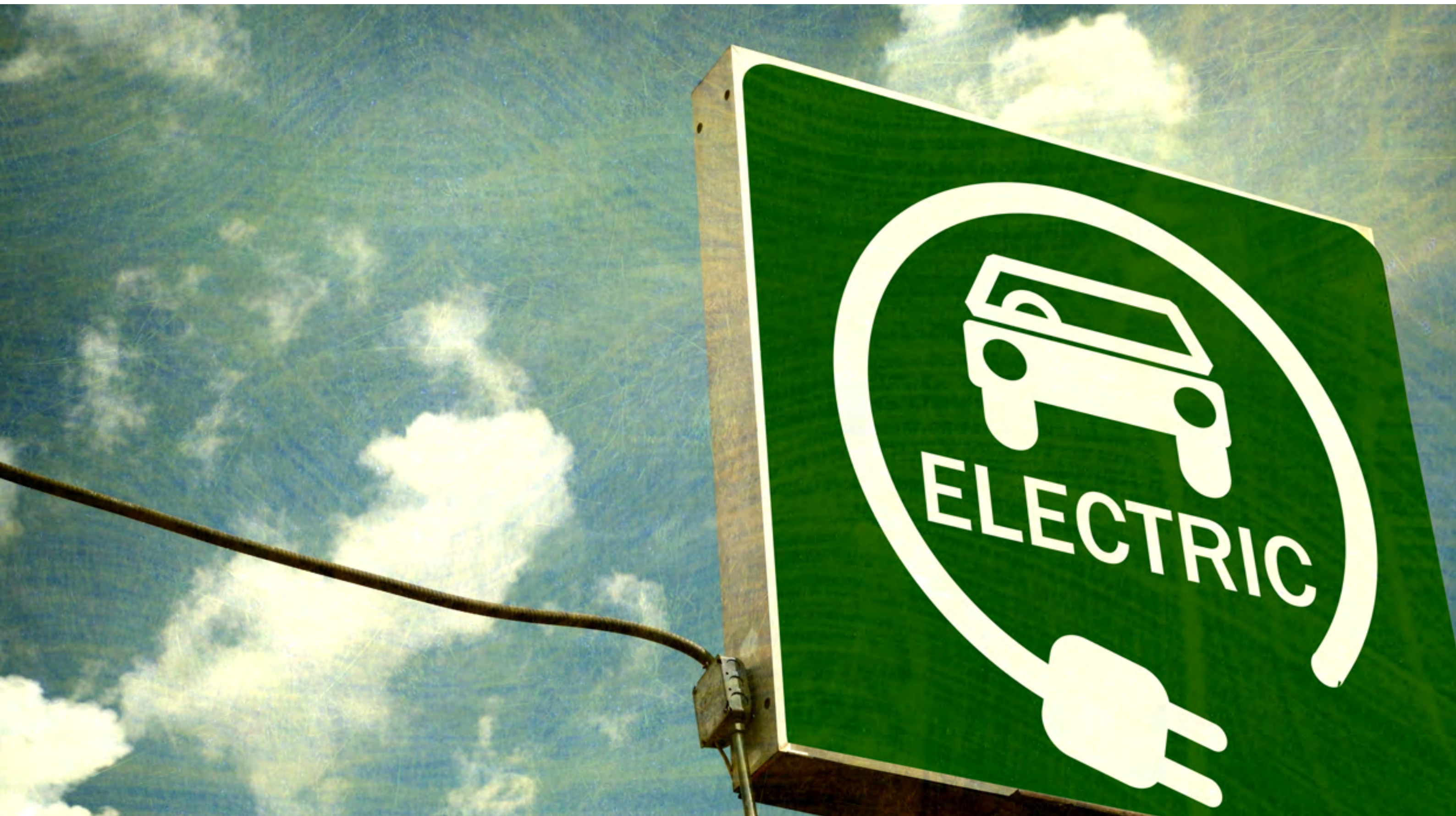
The annual projected EVs and PH-EVs within the City are used to estimate the benefits accrued from a proposed TOU utility rate incentivization structure that is aimed to mitigate on-peak utility grid demands. Assuming a 30 year study period discounted at a real rate of 3%, the TBL-NPV of this TOU analysis results in an additional $2 million above and beyond the benefits expected from the EV Ready policy (Table 8). Incentivized TOU consumers are estimated to experience $1.9 million in financial rate savings from charging during off-peak periods. By shifting a portion of EV charging demand loads to semi-baseline emission factors, the environment and community are expected to benefit from avoided carbon emissions amounting to $150,000 over the project duration. This translates into an additional cumulative reduction of 3,648 tons of carbon dioxide from the TOU rate implementation, resulting in a total reduction potential of 158,049 tons in cumulative emissions avoided by 2050 with the EV readiness code (Figure 11).

TABLE 8. TBL-NPV EV READY CODE POLICY + TIME-OF-USE (TOU) RATE INCENTIVE RESULTS

Electric Vehicle (EV) Charger Readiness Policy with TOU Rates		
Discount Rate		*3%*
Time Period		*30 Years*
Unincentivized EV Market Share Growth		*Reference*
Social Cost of Carbon		*Central*
CPS Energy Emissions Forecast		*Flexible Path*
Total Costs	**-$**	**93,178,000.00**
Capital Expenditures	-$	93,178,000
Total Benefits	**$**	**165,502,000**
Residual Value	$	46,541,000
TOU Rate Savings to EV Owners	$	1,935,000
Incentivized EV Adoption - Financial Savings	$	39,976,000
Incentivized PH-EV Adoption - Financial Savings	$	273,000
Unincentivized EV Adoption - Installation Savings	$	62,942,000
Unincentivized PH-EV Adoption - Installation Savings	$	7,929,000
Carbon Reductions	$	5,731,000
Air Pollutant Reductions	$	175,000
Triple Bottom Line - Net Present Value	**$**	**72,324,000**
Triple Bottom Line - Benefit-Cost Ratio		**1.78**

FIGURE 11. CUMULATIVE CARBON EMISSION REDUCTIONS FROM EV READY POLICY + TOU RATES





4.4 PHOTOVOLTAIC (PV) SYSTEM ROOF READINESS

4.4.1 OVERVIEW

The City of San Antonio is also evaluating a new building code policy for solar readiness in order to incentivize adoption of photovoltaic systems and aid in the creation of a carbon free electricity grid. While PV systems contribute greatly to reducing carbon emissions from reduced dependency on fossil fuel-based energy, they entail steep costs, which are often hidden as ancillary preparedness costs. One of these costs is roof readiness, involving modifications of the roof to have adequate space for the installation of solar panels, free of obstacles, with proper vent positioning and orientation towards the sun's path. Preparing homes for solar is estimated to be much cheaper in the construction phase, as opposed to a retrofit (Watson et al., 2012). As such, this policy implicitly provides a subsidy for PV system adopters, and can be used alongside government subsidy incentive literature to estimate the number of PV systems adopted by lowering the costs of solar roofs.

This policy is intended to apply to all new residential construction within San Antonio. Data from the Texas Demographer's Office on population growth over the study period was used to forecast future single-family home construction in Bexar County. Forecasts for expected PV system growth in the Texas regional entity are obtained from the Energy Information Administration (EIA), from 2020 to 2050, growing at an annualized 8.6% in the reference economic growth case (U.S. Energy Information Administration, 2020). The growth rates of the solar system market in Texas are applied to existing San Antonio PV system distribution (Pforzheimer et al., 2020).

Benefits from this policy exist in the form of utility rate and environmental emission reduction benefits, as well as cost savings for all PV system adopters, whether incentivized by the policy or already willing to purchase solar panels. Since there will be structural alteration to the building, providing value to a typical home's roof, there is a residual value benefit to the asset, which is the remaining value of homes lasting beyond 2050. The total value of this policy is depreciated linearly for the lifespan of the home, and returned to the homeowner at the end of the study period.

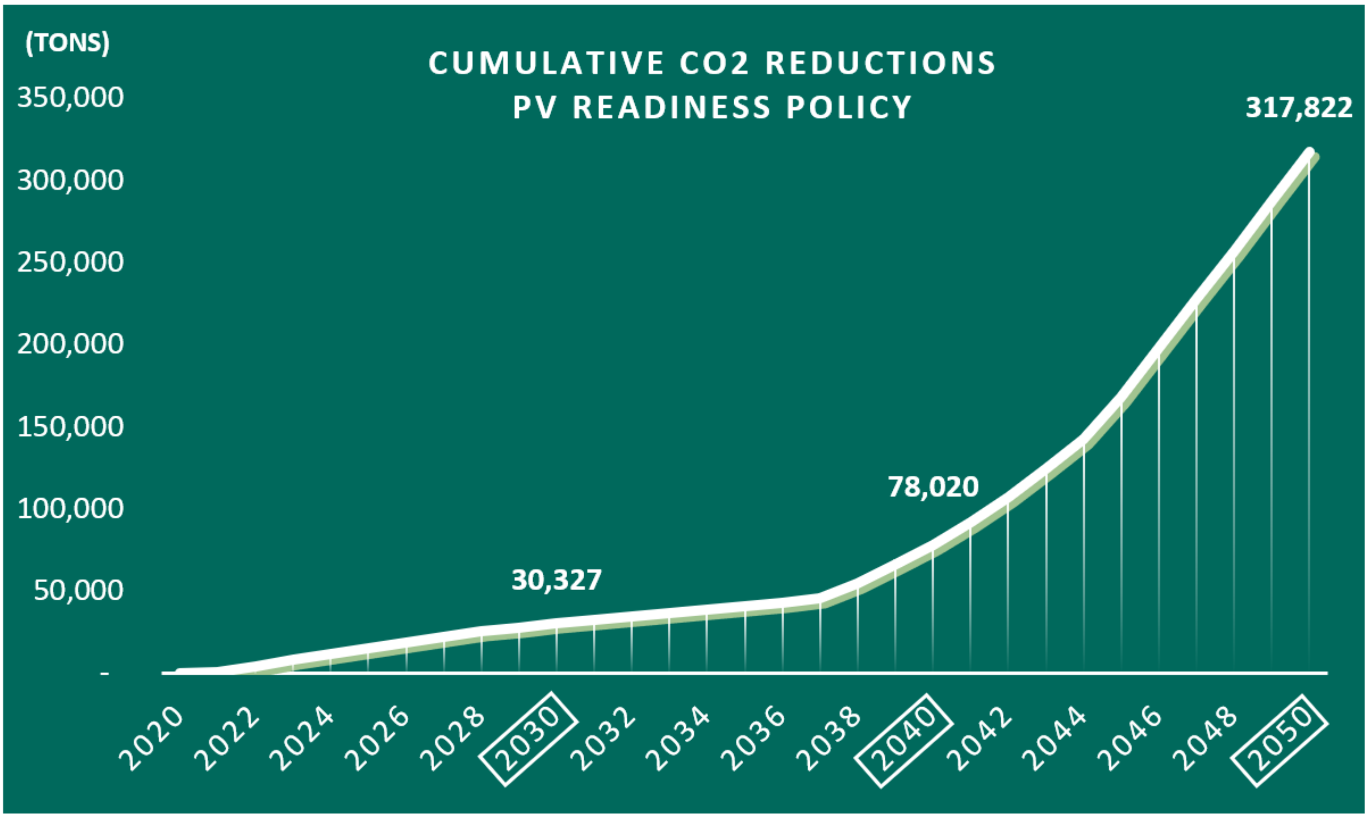
4.4.2 RESULTS

Solar roof readiness as a new construction code policy has a positive net present value when applied to all projected new single-family homes to be built in San Antonio (Table 9). Net present value is $12.6 million discounted at 3% over 30 years. The benefit cost ratio is 1.02, which can be interpreted as generating $1.02 in benefits to the community, for every $1 spent in costs associated with the policy. This ratio indicates that even as the NPV is positive, the program's cost is only just offset by the social, financial, and environmental benefits. Cumulative grid emission reductions are estimated to be 30,300 tons of carbon by 2030; 78,000 tons by 2040; and 317,800 tons by 2050 (Figure 12). Residual value of the roof readiness and the induced user installed PV systems contribute significantly to the benefits, at $278 million and $56.5 million, respectively. This residual value is present as the largest number of homes are built in later years, and the depreciated value invested in the home is returned for the remainder of the home's lifespan. The readiness benefit has a PV system user financial component, and an electricity rate savings component. Carbon emissions reduction amounts to $12.7 million in environmental benefits over 30 years.

TABLE 9. TBL-NPV PV SYSTEM ROOF READINESS NEW CONSTRUCTION POLICY RESULTS

Photovoltaic System Roof Readiness Policy		
Discount Rate		*3%*
Time Period		*30 Years*
Social Cost of Carbon		*Central*
CPS Energy Emissions Forecast		*Flexible Path*
Total Costs	**-$**	**675,194,000**
Readiness Capital Expenditure	-$	549,344,000
Induced PV System Capital Expenditure	-$	110,643,000
Induced PV System Operation & Maintenance	-$	15,207,000
Total Benefits	**$**	**687,815,000**
Roof Readiness Residual Value	$	278,087,000
Induced PV System Residual Value	$	56,542,000
Induced User Readiness Cost Savings	$	58,665,000
Non-Induced User Readiness Cost Savings	$	146,283,000
Induced Energy Rate Savings	$	134,263,000
Carbon Emissions	$	12,661,000
Air Pollutants	$	1,314,000
Triple Bottom Line - Net Present Value	**$**	**12,621,000**
Triple Bottom Line - Benefit-Cost Ratio		**1.02**

FIGURE 12. CUMULATIVE EMISSIONS REDUCTIONS FROM PV ROOF READINESS POLICY



4.5 ZERO NET ENERGY (ZNE) MUNICIPAL BUILDINGS

4.5.1 OVERVIEW

As part of the SA Climate Ready Plan, the City of San Antonio continues to address energy waste in municipal buildings by measuring and managing its energy use because it saves taxpayer money, increases the quality of its buildings, reduced greenhouse gas emissions, and demonstrates effective solutions that can be replicated locally in many other buildings.

In order to better understand and manage the energy performance of this large and diverse portfolio, the City began tracking energy usage in 2010 of more than 299 of its largest facilities using the U.S. EPA's ENERGY STAR® Portfolio Manager® tool. A 2019 San Antonio Municipal Building Energy Benchmarking Report provides transparency through the public disclosure of the Energy Use Intensity (EUI) of municipal properties larger than 10,000 square feet and serves as an example of the benefit of benchmarking to move the City, and motivate the private sector, towards a cleaner, smarter, and more efficient building-stock. The data in this report shows that while San Antonio has been a pioneer in building benchmarking in Texas, there is still much work to be done to achieve the climate targets identified in the City's Climate Action and Adaptation Plan. As such, municipal buildings with high EUIs are further investigated within the context of the Zero Net Energy Municipal buildings proposal. This analysis serves an opportunity to identify improvements that will ultimately result in cost savings, energy savings, and a more comfortable and safer and healthier environment for building occupants and visitors.

Working towards the common goal of decarbonization of the building sector, the SA Climate Ready Plan identifies a goal to achieve zero net energy usage across the municipal building portfolio.

By continuing to implement and expand cost effective retrofit measures, the City is poised to set the standard in terms of building performance by demonstrating the financial feasibility, along with the vast direct and indirect community co-benefits, associated with investments in energy reduction strategies.

To demonstrate the significant social economic and environmental benefits attributed to efficient building investments, the analysis investigates the impacts of implementing two different retrofit approaches for achieving zero net energy across municipal properties. These are the Standard and Deep Retrofit solutions. The first option investigated under the analysis is the Standard Retrofit package, identified as operational based interventions geared towards low-cost optimization and calibration of internal building controls. The installation of on-site solar photovoltaic (PV) panels are required to offset the remaining energy usage that is not reduced through the Standard Retrofit investment bundle. The second type of retrofit option recommended by the DOE’s retrofit guide is defined as a Deep Retrofit solution, which is more capital intensive and results in greater energy savings as compared to the simpler measures proposed in the Standard Retrofit design. Design considerations have also been made to ensure all proposed retrofit intervention measures are phased in on an annual basis to minimize operational disturbances incurred by building occupants and prevent temporary displacement during the retrofit construction. The main differentiation between the two retrofit designs stems from the extensiveness of capital investments and greater upfront expenditures. However, it is expected to be more costly to offset a greater proportion of energy consumption via solar generation compared to addressing building inefficiencies through retrofit investments.

Solar photovoltaic systems are assumed to offset the remaining energy usage of the buildings to meet the municipality goal of achieving zero net energy demand. Rooftop area availability across the 6 building portfolio is estimated at approximately 14,550 square meters (sq m) of suitable roof area for PV array installation. The required size of the solar array is dictated by the amount of energy to be offset after implementation of the retrofit design measures. The difference between available rooftop solar area and the array area requirement (approximately 6,500 sq m under the Deep Retrofit design) is assumed to be installed on site of the building property and/or expected to canopy over existing parking lot spaces.

Alternatively, if a site is unsuitable for alternate PV installations the building may be able to instead invest more in extensive retrofit measures (such as adding computer power management capabilities as listed in the DOE advanced retrofit guide). This would reduce the energy consumption required to be offset by PV and in turn reduce the area required for on-site solar energy generation.

Requiring municipal buildings to reach zero net energy compliance is expected to drive notable triple bottom line benefits to the community of San Antonio. By setting the standard in building performance, the policy is expected to eliminate all energy expenditures from the grid and shift to on-site generation of renewable energy. This transition not only provides benefits from having greater energy independence, but is also expected to result in significant financial savings accrued to the City in the form of avoided utility costs. In conjunction, reducing the energy consumption from municipal buildings has the potential to offer CPS Energy better Demand-Response capacity to meet future grid loads. Eliminating energy demand from the grid also drives reductions in air pollutants following the projections outlined by CPS Energy's Flexible Path grid emission factors. Flexible Path emissions are CPS Energy's forecast for future grid emissions which takes into consideration planned action and climate change, such as the reduction in polluting generating methods and shifts to more sustainable sources of solar, wind, and natural gas power. Emission factors (per kWh) are monetized by their respective social costs, with carbon emissions monetized by values of carbon developed from the Interagency Working Group (2016), forecasted from 2020 to 2050. NOx and SO2 social costs are developed by Heo et al. (2016) and the USDOT (2015).

4.5.2 RESULTS

Requiring municipal buildings across the City to achieve ZNE is expected to drive major benefits to the municipality, building occupants, and the broader community. Presented below in Tables 10 to 13 are the expected costs and benefits associated with achieving ZNE across the municipal building portfolio. Results are segmented by small and large properties to account for variations in building typologies and occupancy schedules. Since efficiency investments will likely vary across building vintages, the analysis presents two versions of retrofit to capture differences in existing infrastructure: Standard (minimalist) and Deep (intensive) scenarios. In addition, the results are also presented on an incremental basis ($ / sq ft) for easier comparison across retrofit design scenarios.

Capital expenditures reflect the upfront costs incurred by the city for investing in energy efficient interventions. Operations & maintenance estimates reflect the costs incurred over the study period required for preventative maintenance and servicing intervals of the retrofit components. Measurement and verification costs are representative of the financial costs associated with ensuring the building investments are performing to the prescribed efficiency standards. Retrofit investments are assumed to have a useful life of 20 years, where after they require replacement to continue adequate operation of the building and are accounted under replacement costs. At the end of the project period, any remaining useful value of the retrofit investment is discounted back to today's dollars representing the residual value of the asset. Direct benefits from achieving ZNE come in the form of energy rate savings to the City. Additionally, by reducing the energy consumption of municipal buildings, emissions from electricity generation decrease and thus produce environmental benefits from reduced carbon and other air pollutants. All results presented are discounted using a real rate of 3% and assume a 30 year study duration.

Standard ZNE Retrofit – Small Municipal Buildings

Schaefer Library, Fire Station #30, and the Northwest Police Substation denote the 'small' municipal buildings (< 50,000 sq ft), and are used to segment the first portion of the results. The Standard Retrofit design is estimated to generate $818,000 dollars in total TBL-NPV benefits to all small buildings (Table 12). The bulk of the benefits are derived from energy rate savings to the City estimated at roughly $1.3 million, along with a residual value of the retrofit investments expected at $42,000. Decreased usage of electricity translates to lower grid emissions and offers environmental benefits expected at approximately $190,000. Cumulative grid emission reductions are estimated to be 1,649 tons of carbon by 2030; 2640 tons by 2,040; and 3,350 tons by 2050 (Figure 13). All-in costs to the small Standard Retrofit packages are estimated to be $702,000. Overall, the small Standard Retrofits are estimated to produce a TBL-BCR of 2.17, which can be interpreted as generating $2.17 of benefits for every $1 spent in costs for the retrofit design.

TABLE 10. STANDARD ZNE RETROFIT - SMALL FINANCIAL COST BREAKDOWN

ZNE Municipal Building Policy		
Discount Rate		*3%*
Time Period		*30 Years*
Building Size		*Small*
Retrofit Type		*Standard*
Total Capital Costs	**-$**	**532,000**
Retrofit Investments	-$	53,000
PV Investments	-$	479,000
Total Operations & Maintenance Costs	**-$**	**98,000**
Retrofit Investments	-$	15,000
PV Investments	-$	83,000

Deep ZNE Retrofit – Small Municipal Buildings

The small building Deep Retrofit is expected to accrue a TBL-NPV of $823,000, with the majority of benefits derived from utility rate savings to the City estimated at approximately $1.2 million (Table 13). Total costs of the small Deep Retrofit scenario are expected to total $702,000. The environmental benefit from reduced electricity usage from municipal buildings is expected to amount to over $180,000. Cumulative grid emission reductions are estimated to be 1,500 tons of carbon by 2030; 2,495 tons by 2040; and 3,200 tons by 2050 (Figure 14).

TABLE 11. DEEP ZNE RETROFIT - SMALL FINANCIAL COST BREAKDOWN

ZNE Municipal Building Policy		
Discount Rate		*3%*
Time Period		*30 Years*
Building Size		*Small*
Retrofit Type		*Deep*
Total Capital Costs	**-$**	**505,000**
Retrofit Investments	-$	127,000
PV Investments	-$	378,000
Total Operations & Maintenance Costs	**-$**	**58,000**
Retrofit Investments	$	6,000
PV Investments	-$	64,000

The $10,000 difference in environmental impacts between the standard and Deep Retrofits stems from the construction scheduling that allocates Deep Retrofits an additional year to achieve ZNE. Whereas Standard Retrofit packages complete their upgrades faster, and in turn install their PV arrays a year sooner. Although the Standard Retrofit option does achieve NZE quicker, it comes at a higher cost to the Municipality, mainly through greater solar installations requirements (Table 10). Compared to the Deep Retrofit Option which benefits from operations and maintenance savings from more dependable building infrastructure, as well as achieving greater EUI reductions through retrofit investments requiring less PV expenditures (Table 11). The TBL-BCR estimated for the small Deep Retrofit package is 2.24 - reflecting a marginal improvement compared to the Standard Retrofit design.

TABLE 12. TBL-NPV ZNE SMALL BUILDING STANDARD RETROFIT RESULTS

ZNE Municipal Building Policy		
Discount Rate		*3%*
Time Period		*30 Years*
Building Size		*Small*
Retrofit Type		*Standard*
Social Cost of Carbon		*Central*
Emissions		*Flexible Path*
Total Costs	**-$**	**702,000**
Capital Expenditures	-$	532,000
Operations & Maintenance	-$	98,000
Measurement & Verification	-$	44,000
Replacement Cost	-$	28,000
Total Benefits	**$**	**1,520,000**
Energy Rate Savings	$	1,286,000
Residual Value	$	42,000
Carbon Emissions	$	166,000
Air Pollutants	$	26,000
Triple Bottom Line - Net Present Value	**$**	**818,000**
Triple Bottom Line - Benefit-Cost Ratio		**2.17**

TABLE 13. TBL-NPV ZNE SMALL BUILDING DEEP RETROFIT RESULTS

ZNE Municipal Building Policy		
Discount Rate		*3%*
Time Period		*30 Years*
Building Size		*Small*
Retrofit Type		*Deep*
Social Cost of Carbon		*Central*
Emissions		*Flexible Path*
Total Costs	**-$**	**665,000**
Capital Expenditures	-$	505,000
Operations & Maintenance	-$	58,000
Measurement & Verification	-$	58,000
Replacement Cost	-$	44,000
Total Benefits	**$**	**1,488,000**
Energy Rate Savings	$	1,255,000
Residual Value	$	52,000
Carbon Emissions	$	157,000
Air Pollutants	$	24,000
Triple Bottom Line - Net Present Value	**$**	**823,000**
Triple Bottom Line - Benefit-Cost Ratio		**2.24**

FIGURE 13. CUMULATIVE EMISSIONS REDUCTIONS FROM ZNE - SMALL STANDARD RETROFIT

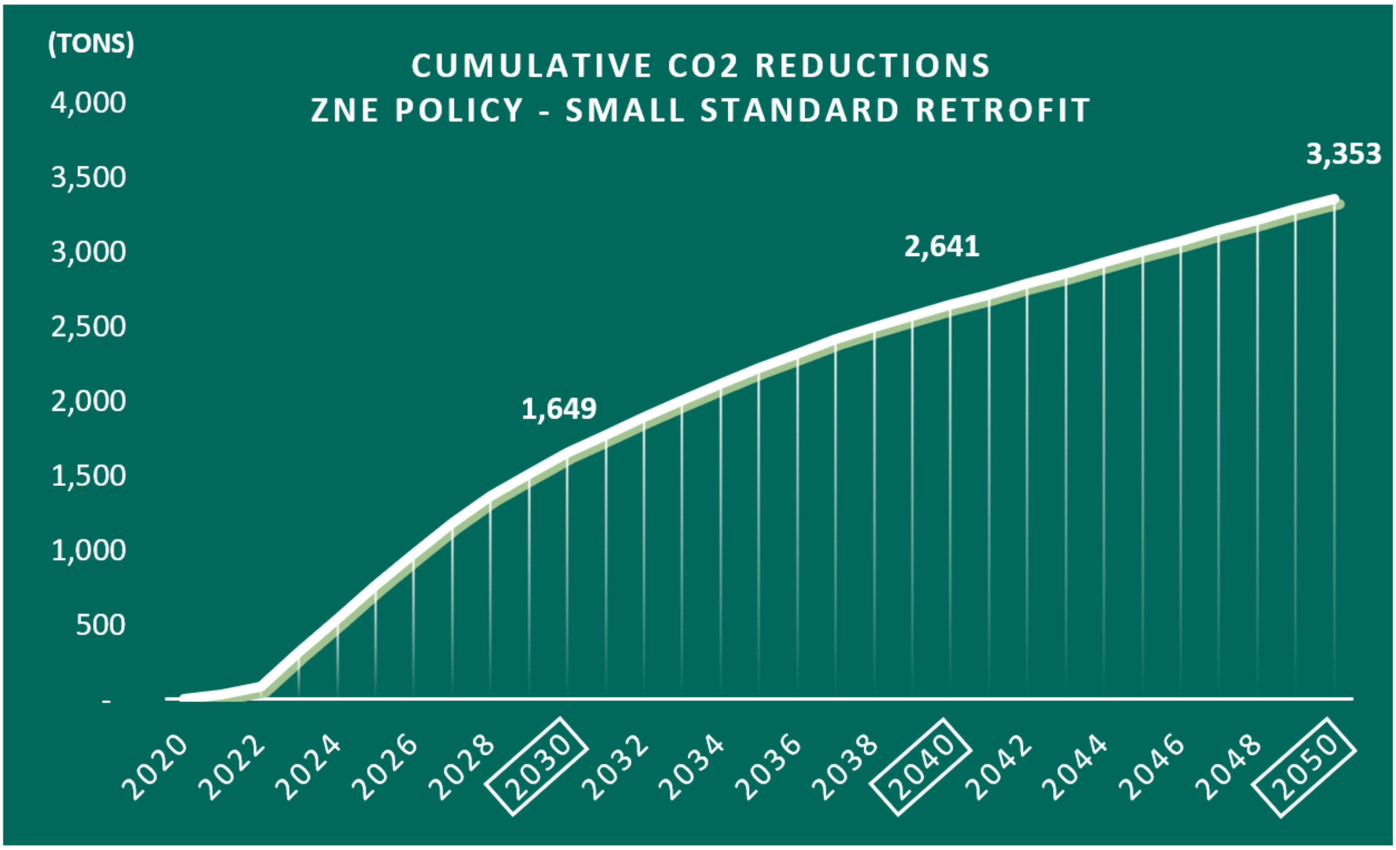
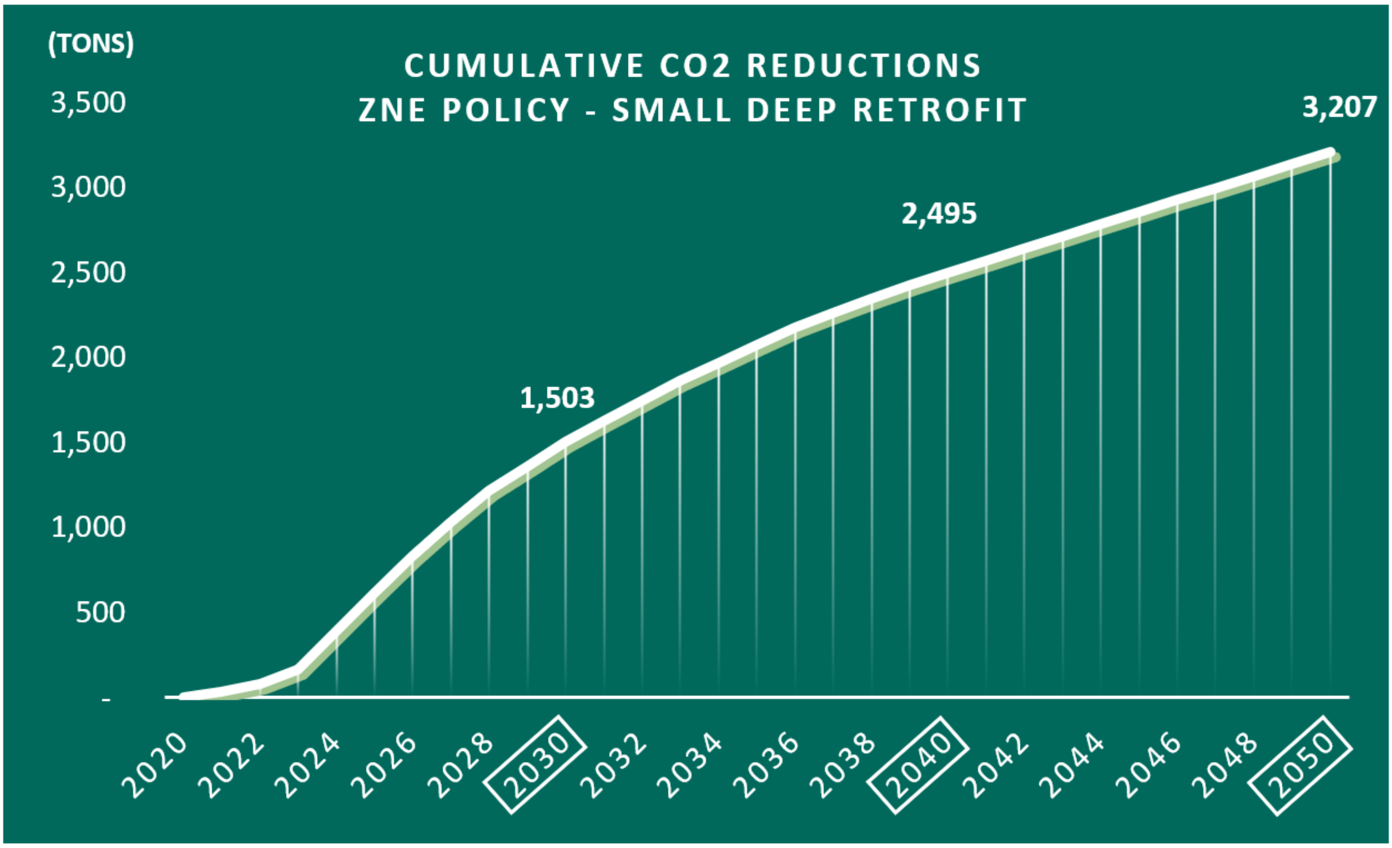


FIGURE 14. CUMULATIVE EMISSIONS REDUCTIONS FROM ZNE - SMALL DEEP RETROFIT



Standard ZNE Retrofit – Large Municipal Buildings

Municipal Records, Frank Wing, and the Public Safety Headquarter represent the 'large' municipal buildings (> 50,000 sq ft) and are used to segment the second portion of the results. The standard retrofit design is estimated to generate close to $11 million dollars in total TBL-NPV benefits to all large buildings (Table 16). Utility rate savings to the City constitute the largest benefit category estimated at over $17.7 million. Environmental impacts are induced by reductions in emissions derived from electricity generation, which amount to over $2.6 million of benefits to the community. Cumulative grid emission reductions are estimated to be 22,700 tons of carbon by 2030; 36,400 tons by 2040; and 46,200 tons by 2050 (Figure 15). Total costs to the large building standard retrofit design are expected to be approximately $9.9 million incurred to the Municipality. Overall, the Standard Retrofit for large building types has a TBL-BCR of 2.1.

TABLE 14. STANDARD ZNE RETROFIT - LARGE FINANCIAL COST BREAKDOWN

ZNE Municipal Building Policy		
Discount Rate		*3%*
Time Period		*30 Years*
Building Size		*Large*
Retrofit Type		*Standard*
Total Capital Costs	**-$**	**7,649,000**
Retrofit Investments	-$	1,046,000
PV Investments	-$	6,603,000
Total Operations & Maintenance Costs	**-$**	**1,348,000**
Retrofit Investments	-$	206,000
PV Investments	-$	1,142,000

Deep ZNE Retrofit – Large Municipal Buildings

The Deep Retrofit scenario is expected to deliver $11.4 million in total TBL-NPV benefits across the 30 year analysis (Table 17). Energy rate savings are estimated to be over $17 million accrued to the City. Avoided emissions from the utility grid represent an environmental benefit of over $2.5 million. Cumulative grid emission reductions are estimated to be 20,700 tons of carbon by 2030; 34,400 tons by 2040; and 44,200 tons by 2050 (Figure 16). Total costs of the Deep Retrofit package across all large buildings is expected to be approximately $9.1 million. In aggregate, the large Deep Retrofit design scenario is expected to drive a TBL-BCR of 2.25 - again reflecting a marginal improvement relative to the standard retrofit option. However, the Deep Retrofit design offers the largest TBL-NPV benefits for both small and large building sizes.

TABLE 15. DEEP ZNE RETROFIT - LARGE FINANCIAL COST BREAKDOWN

ZNE Municipal Building Policy		
Discount Rate		*3%*
Time Period		*30 Years*
Building Size		*Large*
Retrofit Type		*Deep*
Total Capital Costs	**-$**	**6,914,000**
Retrofit Investments	-$	1,704,000
PV Investments	-$	5,210,000
Total Operations & Maintenance Costs	**-$**	**801,000**
Retrofit Investments	$	75,000
PV Investments	-$	876,000

Similar to small building results, although the standard retrofit option does achieve ZNE quicker, it comes at a higher cost to the City. Increased cost expenditures are induced through greater solar installations requirements. However, this path achieves ZNE compliance faster and inevitably leads to higher carbon emissions avoided. Although the Standard Retrofit option does achieve ZNE quicker, it comes at a higher cost to the Municipality, mainly through greater solar installations requirements (Table 14). Compared to the Deep Retrofit Option which benefits from operations and maintenance savings from more dependable building infrastructure, as well as achieving greater EUI reductions through retrofit investments requiring less PV expenditures (Table 15).

TABLE 16. TBL-NPV ZNE LARGE BUILDING STANDARD RETROFIT RESULTS

ZNE Municipal Building Policy		
Discount Rate		*3%*
Time Period		*30 Years*
Building Size		*Large*
Retrofit Type		*Standard*
Social Cost of Carbon		*Central*
Emissions		*Flexible Path*
Total Costs	**-$**	**9,967,000**
Capital Expenditures	-$	7,648,000
Operations & Maintenance	-$	1,348,000
Measurement & Verification	-$	601,000
Replacement Cost	-$	370,000
Total Benefits	**$**	**20,951,000**
Energy Rate Savings	$	17,728,000
Residual Value	$	579,000
Carbon Emissions	$	2,283,000
Air Pollutants	$	361,000
Triple Bottom Line - Net Present Value	**$**	**10,984,000**
Triple Bottom Line - Benefit-Cost Ratio		**2.10**

TABLE 17. TBL-NPV ZNE LARGE BUILDING DEEP RETROFIT RESULTS

ZNE Municipal Building Policy		
Discount Rate		*3%*
Time Period		*30 Years*
Building Size		*Large*
Retrofit Type		*Deep*
Social Cost of Carbon		*Central*
Emissions		*Flexible Path*
Total Costs	**-$**	**9,112,000**
Capital Expenditures	-$	6,914,000
Operations & Maintenance	-$	801,000
Measurement & Verification	-$	806,000
Replacement Cost	-$	591,000
Total Benefits	**$**	**20,518,000**
Energy Rate Savings	$	17,302,000
Residual Value	$	711,000
Carbon Emissions	$	2,171,000
Air Pollutants	$	334,000
Triple Bottom Line - Net Present Value	**$**	**11,406,000**
Triple Bottom Line - Benefit-Cost Ratio		**2.25**

FIGURE 15. CUMULATIVE EMISSIONS REDUCTIONS FROM ZNE - LARGE STANDARD RETROFIT

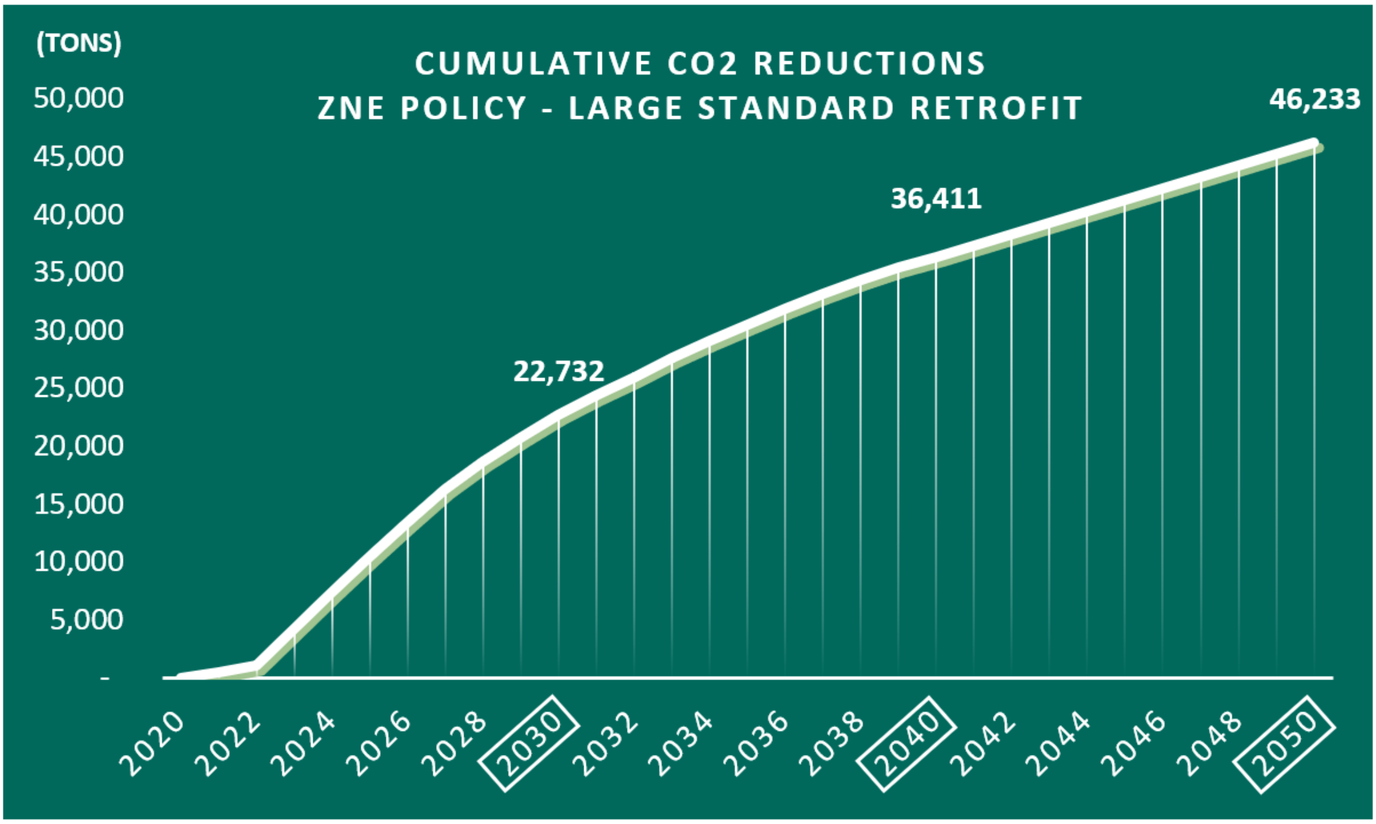
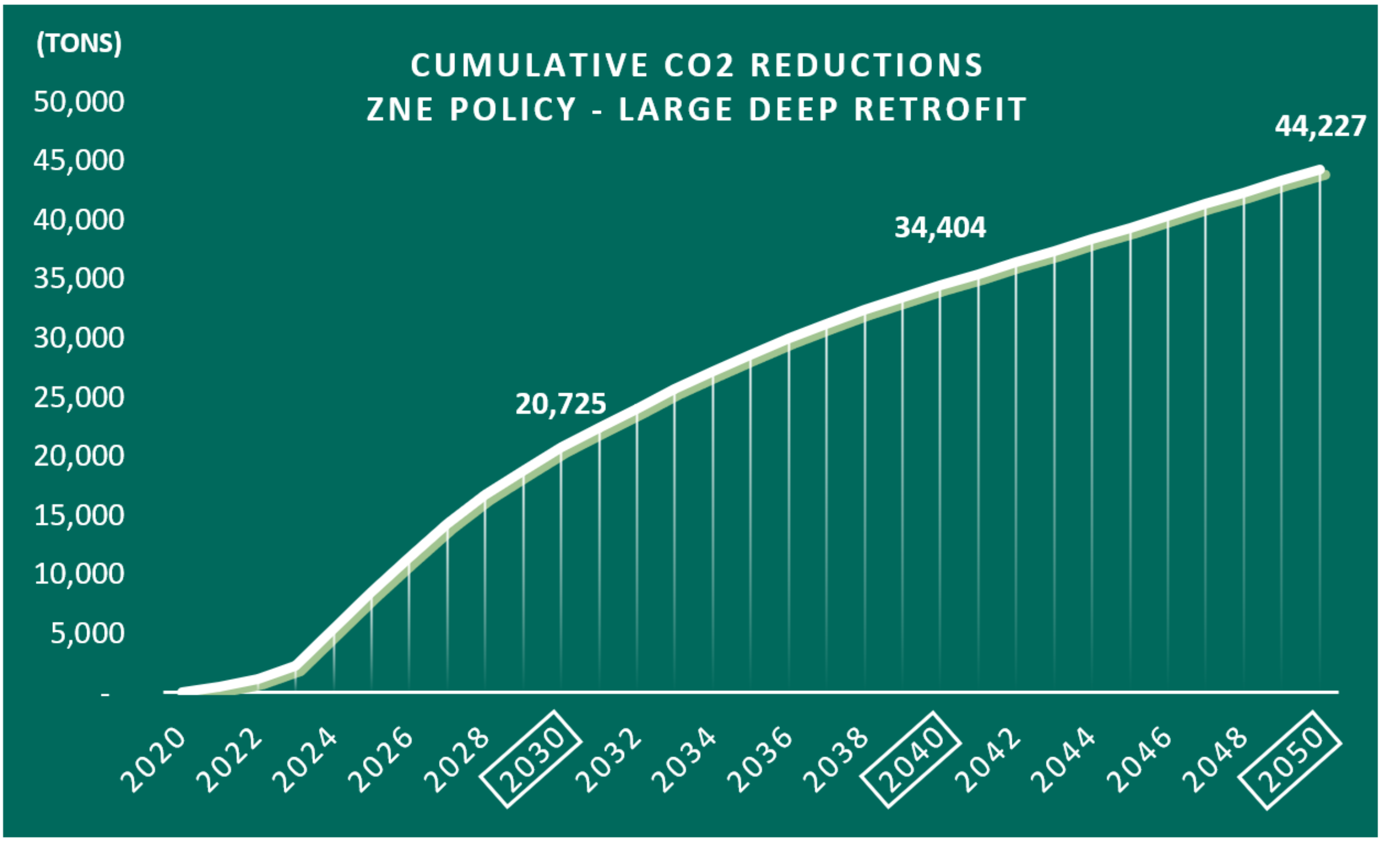


FIGURE 16. CUMULATIVE EMISSIONS REDUCTIONS FROM ZNE - LARGE DEEP RETROFIT



4.6 URBAN AGRICULTURE

4.6.1 OVERVIEW

This analysis showcases a prototypical urban farm in San Antonio, with the intent to showcase a policy option of replicating the half acre example across the city. There are 1,740 empty lots owned by the City which are over half an acre, and 408 between 0.5 and 1 acres (City of San Antonio Vacant Land, 2020). If a fraction of these unused or unmanaged spaces are converted to a similar urban agriculture project, results as in the prototypical farm site are expected from each. The specifications of the farm allow for two different scenarios in the initial City owned site: 1) The initial site is an already existing green space, such as an unmanaged turf space; 2) The initial site is a paved over area of asphalt or concrete. The first scenario provides lower net benefits with respect to carbon sequestration, pollination, stormwater infiltration, and urban heat island. The second scenario generates higher net benefits for carbon sequestration, urban heat island, pollination, and stormwater infiltration benefits. These higher benefits are partially offset by greater initial capital costs in removing the pavement and applying top soil amendments for healthy plant growth.

San Antonio is a city with a rich history of farming, providing produce for its population and the region year-round. Because of its unique growing season, San Antonio was known as the winter breadbasket of the United States. However, it is situated in a dry environment, which leads to higher water requirements. The soil types in San Antonio vary, with the north having limited top soil and high amounts of limestone, the south being sandy soil, the urban center being clay and the east being black gumbo soil, a nutrient rich clay.

The urban agriculture site can be multifunctional, designed to function also as urban recreation for the surrounding homes and an education space for university and grade school children. This will provide its local neighborhood with social benefits in the form of a recreation area for visiting and volunteering. Local schools and colleges with agricultural educational opportunities will also benefit from this program. Education as it aims to showcase urban agriculture as a viable profession is an important factor in the prototypical site, and the cost of hiring a part time educator to support this benefit is incorporated in the CBA.

Managing and developing the urban agriculture project would be in the form of a private enterprise seeking to receive a return on investment. The production schedule for the prototypical farm assumes two harvest seasons, in the spring/summer and in the fall/winter. In each season three crops are grown on the half acre plot, in equal distribution. For the spring/summer crop, zucchini, cucumber, and tomatoes are grown, and carrots, broccoli, and lettuce will be grown in the fall/winter. It is assumed that besides the labor hours implicit in planting, maintaining, and harvesting this crop, the farm will be owned and operated by a full-time manager. The manager may be overseeing other similar half-acre urban farm sites.

4.6.2 RESULTS

Urban Agriculture analysis results show that the TBL-NPV is positive in both scenarios for the half acre prototypical site. The first scenario is an unmanaged turf site converted to urban farming (Table 18), and the second scenario of a previously impervious site of concrete/asphalt gives the greatest benefit (Table 19). In the first scenario the TBL-NPV is $446,000 at a 3% discount over 30 years. The TBL-BCR is 1.98, meaning that $1.98 is generated for every $1 spent. The financial net present value is -$156,300 and the BCR ratio is 0.66. If an unmanaged turf site is replaced, there are very low benefits from UHI reductions, higher carbon emissions of -$38,000, and no benefits from flood risk reduction and pollination, since the site is already vegetated, providing similar environmental benefits.

In the second scenario where an asphalt and concrete impervious cover is replaced, the triple bottom line net present value is $678,000 at a 3% discount over 30 years. The TBL-BCR is 2.24, meaning that $2.24 is generated for every $1 spent. Cumulative carbon sequestration and truck emissions reduction are estimated to be 1,100 tons of carbon by 2030; 2,200 tons by 2040; and 3,300 tons by 2050 (Figure 17).

The financial net present value is -$245,600 and the TBL-BCR ratio is 0.55. If an impervious paved site is replaced by the urban farm, social benefits from UHI mitigation, carbon emissions reduction, flood risk reduction, and pollination are present and positive. These benefits are offset by the higher capital costs of converting the site to a fertile farm.

Benefits which do not differ among scenarios are crop revenue, water scarcity value, property value, trucking food miles, recreation, education for grade school and university students, volunteering, and health improvements. A substantial source of benefits is the contribution to educational opportunities, valued at $427,000 per half acre for grade school students. This large benefit is offset, however, by the cost of a part time educator for the weekly visits of students.

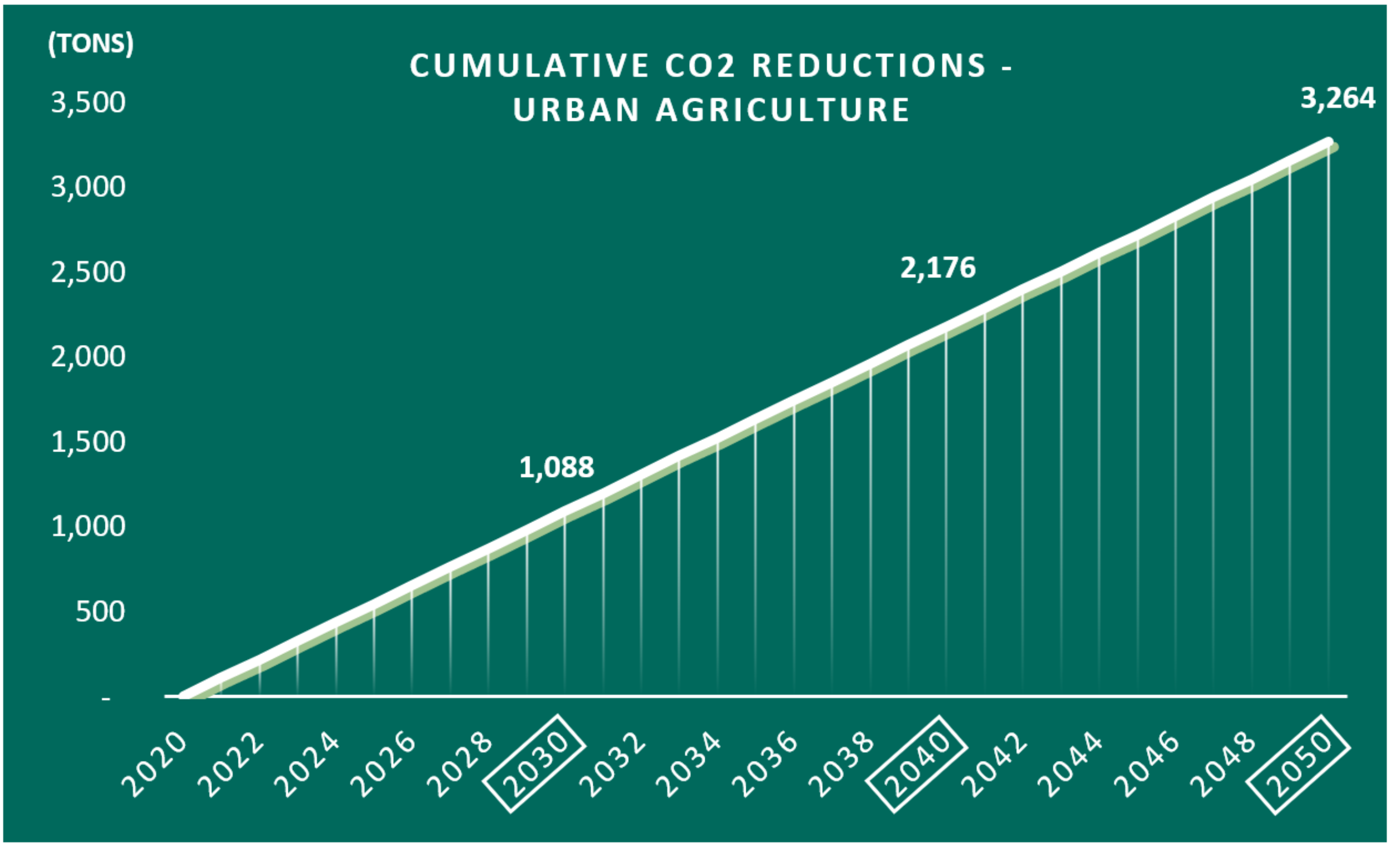
TABLE 18. TBL-NPV URBAN AGRICULTURE UNMANAGED TURF BASE CASE RESULTS

Urban Agriculture		
Discount Rate		*3%*
Time Period		*30 Years*
Crop Price		*Retail*
Social Cost of Carbon		*Central*
Original Site		*Unmanaged Turf*
Acres		*0.5*
Total Costs	**-$**	**455,800**
Capital Expenditure	-$	7,300
Land Rent	-$	100,000
Water Utility Cost	-$	33,100
Maintenance and Insurance	-$	9,400
Machinery Rental Cost	-$	13,400
Labor Cost	-$	278,800
Seeding	-$	7,200
Chemicals	-$	6,600
Total Benefits	**$**	**901,600**
Crop Revenue	$	299,500
Urban Heat Island - Mortality Reduction	$	6,300
Urban Heat Island - Morbidity Reduction	$	100
Water Scarcity Value	-$	31,600
Carbon Sequestration	-$	38,300
Stormwater Infiltration and Flood Risk	$	-
Pollination	$	-
Property Value	$	99,500
Trucking Food Miles	$	23,100
Recreation	$	37,600
Education K-12	$	426,900
Education University	$	18,100
Volunteering	$	25,600
Health	$	34,800
Financial - Net Present Value	**-$**	**156,300**
Financial - Benefit-Cost Ratio		**0.66**
Triple Bottom Line - Net Present Value	**$**	**446,000**
Triple Bottom Line - Benefit-Cost Ratio		**1.98**

TABLE 19. TBL-NPV URBAN AGRICULTURE ASPHALT/CONCRETE BASE CASE RESULTS

Urban Agriculture		
Discount Rate		*3%*
Time Period		*30 Years*
Crop Price		*Retail*
Social Cost of Carbon		*Central*
Original Site		*Concrete/Asphalt*
Acres		*0.5*
Total Costs	**-$**	**545,100**
Capital	-$	96,600
Land Rent	-$	100,000
Utility	-$	33,100
Maintenance and Insurance	-$	9,400
Machinery Rental Cost	-$	13,400
Labor	-$	278,800
Seeding	-$	7,200
Chemicals	-$	6,600
Total Benefits	**$**	**1,222,900**
Crop Revenue	$	299,500
Urban Heat Island: Mortality Reduction	$	141,800
Urban Heat Island: Morbidity Reduction	$	1,200
Water Scarcity Value	-$	31,600
Carbon Sequestration	$	142,400
Flood Risk Reduction	$	900
Pollination	$	3,100
Property Value	$	99,500
Trucking Food Miles	$	23,100
Recreation	$	37,600
Education K-12	$	426,900
Education University	$	18,100
Volunteering	$	25,600
Health	$	34,800
Financial - Net Present Value	**-$**	**245,600**
Financial - Benefit-Cost Ratio		**0.55**
Triple Bottom Line - Net Present Value	**$**	**678,000**
Triple Bottom Line - Benefit-Cost Ratio		**2.24**

FIGURE 17. CUMULATIVE EMISSIONS REDUCTIONS FROM URBAN AGRICULTURE FOR PAVEMENT REPLACEMENT



APPENDIX - A

TABLE A1. CITY OF SAN ANTONIO BUILDING GROWTH PROJECTIONS

Building Growth Projections			
Data	**Value**	**Units**	**Source**
Yearly Single Family Homes - 2020	9,838	homes/year	Economic & Planning Systems (2015)
Yearly Single Family Homes - 2021-2030	12,084	homes/year	Economic & Planning Systems (2015)
Yearly Single Family Homes - 2031-2050	14,843	homes/year	Economic & Planning Systems (2015)
Yearly Multi Family Homes - 2020	5,297	homes/year	Economic & Planning Systems (2015)
Yearly Multi Family Homes - 2021-2030	6,507	homes/year	Economic & Planning Systems (2015)
Yearly Multi Family Homes - 2031-2050	7,993	homes/year	Economic & Planning Systems (2015)
Total Commercial Buildings > 50K - 2020	2,780	Commercial Buildings	NRDC (2020)
Total Commercial Buildings > 50K - 2030	3,524	Commercial Buildings	Autocase Calculation
Total Commercial Buildings > 50K - 2040	4,467	Commercial Buildings	Autocase Calculation
Total Commercial Buildings > 50K - 2050	5,663	Commercial Buildings	Autocase Calculation

APPENDIX - B

SA CLIMATE READY MITIGATION STRATEGIES

The full SA Climate Ready Plan may be accessed at
www.sanantonio.gov/sustainability

COMMUNITY MITIGATION STRATEGIES

		STRATEGIES
INCREASE CARBON-FREE ENERGY	1	REDUCE THE CARBON INTENSITY OF SAN ANTONIO'S ENERGY SUPPLY Work with CPS Energy on the implementation of their "Flexible Path" to drive towards carbon neutrality by 2050.
	2	SUPPORT AND INCENTIVIZE DISTRICT-SCALE CLEAN ENERGY PROJECTS Support and incentivize district-scale clean energy projects that harness renewable and waste energy at large scales.
	3	FUEL SWITCHING As evolving technologies becomes increasingly economical and efficient, promote and incentivize the use of cleaner fuel sources for existing buildings, including industrial process applications.
REDUCE BUILDING ENERGY CONSUMPTION	4	COMMERCIAL AND MULTIFAMILY BENCHMARKING AND DISCLOSURE ORDINANCE Through a diverse stakeholder process, consider a benchmarking and disclosure ordinance for large commercial, industrial, and multifamily buildings (above 50,000 sq. ft.). The initial phase should include a voluntary pilot or accelerator program for leading property owners.
	5	COMMERCIAL AND RESIDENTIAL ENERGY AND WATER RATING SYSTEM Thorough a diverse stakeholder process that includes owners, builders, renters, and potential buyers and to inform consumer decision-making, develop and pilot an energy and water rating system for commercial and residential properties.
	6	ZERO NET ENERGY BUILDING CODE Continue San Antonio's leadership in building codes by continually adopting the most recent update to the IECC code, with the goal of adopting a Zero Net Energy (ZNE) code for all new buildings and substantial rehabilitations, taking into consideration technical and economic feasibility.
	7	ENERGY EFFICIENCY PROGRAMS Continue to support and expand the energy efficiency and green building programs functioning within the City, such as the CPS Energy STEP program.
	8	REDUCE WATER CONSUMPTION Work with residents, businesses, developers, utilities, and institutions on efforts to continue reduction of San Antonio's total per capita water consumption in alignment with the SAWS Water Management Plan.[39]
REDUCE TRANSPORTATION ENERGY CONSUMPTION	9	CLEANER AND MORE EFFICIENT VEHICLE TECHNOLOGIES Encourage the accelerated adoption of and transition to clean and more efficient vehicle technologies for personal vehicles, trucks, transit, and freight.
	10	VEHICLE MILES TRAVELED (VMT) Reduce vehicle miles traveled per person throughout the City, prioritizing the reduction of VMT in single-occupancy vehicles by diversifying transportation choices.
	11	CONNECTIVITY / WALKABILITY Accelerate connectivity and walkability by prioritizing the funding and construction of infrastructure for micro-mobility modes such as walking, biking, and other human-powered transportation with an emphasis on the protection of vulnerable road users.
	12	SUSTAINABLE LAND PLANNING AND DEVELOPMENT Support and incentivize the development and redevelopment of more compact, connected, cost-effective, and resilient neighborhoods and districts.
	13	MOBILITY AS A SERVICE Utilize smart city and big data solutions to promote mobility as a service to reduce the GHG impact of transportation solutions.

LEGEND

Initiation Phase
- **NT** Near-term (Initiated by 2021)
- **LT** Long-term

Constraints
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- **P** Policy
- **T** Technology

In Current City Plan*
- **Y** Yes

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Co-Benefits
- **AQ** Air Quality
- **NC** Natural Capital/ Ecosystem Services
- **QJ** Quality Jobs
- **H** Health Outcomes
- **A** Affordability

LEAD / PARTNER AGENCY	PHASE	GHG	CONSTRAINTS	IN PLAN	AQ	NC	QJ	H	A
CPS ENERGY Office of Sustainability, Finance Department	NT	H	I, P, T	Y	✓		✓	✓	✓
CPS ENERGY Office of Sustainability, Economic Development Department, Development Services Department	LT	L-M	I	Y	✓	✓	✓	✓	✓
CPS ENERGY	LT	L-M	I, BC		✓	✓	✓	✓	
OFFICE OF SUSTAINABILITY Development Services Department, CPS Energy, San Antonio 2030 District	NT	L-M	I, P	Y	✓		✓		✓
OFFICE OF SUSTAINABILITY SAWS, CPS Energy	LT	L	I, P		✓			✓	✓
DEVELOPMENT SERVICES DEPARTMENT Office of Sustainability, Office of Historic Preservation	LT	H	I, P	Y	✓		✓		✓
CPS ENERGY Office of Historic Preservation, Office of Sustainability, Build San Antonio Green, San Antonio 2030 District, SAWS	NT	M	A, BC, I, P	Y	✓		✓	✓	✓
SAWS SARA, CPS Energy	LT	L	A, BC, I	Y	✓	✓			✓
OFFICE OF SUSTAINABILITY Building & Equipment Services, Office of Management & Budget, Purchasing, CPS Energy	NT	H	BC, I, T	Y	✓			✓	
TRANSPORTATION & CAPITAL IMPROVEMENTS Office of Sustainability, VIA	NT	H	I, P, BC	Y	✓			✓	
TRANSPORTATION & CAPITAL IMPROVEMENTS Office of Sustainability, Center City Development & Operations, Office of Innovation	LT	L-M	I, P, BC	Y	✓	✓		✓	✓
PLANNING DEPARTMENT Transportation & Capital Improvements, Neighborhood & Housing Services, Office of Sustainability, Development Services Department	LT	L-M	I, P	Y	✓	✓		✓	✓
TRANSPORTATION & CAPITAL IMPROVEMENTS Office of Innovation, VIA	LT	L	A, T, P	Y	✓		✓		✓

LEAD & PARTNER OFFICES

LEAD Agency leading the initiative

Partner Agency(ies) supporting the initiative

GHG = GHG Reduction Potential (Total to 2030)
- **H** High Reduction Potential: More than 1,000,000 tCO_2e by 2030
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COMMUNITY MITIGATION STRATEGIES
CONTINUED

		STRATEGIES
ADVANCE THE CIRCULAR ECONOMY	14	COMMERCIAL WASTE REDUCTION Building on the City of San Antonio Solid Waste Management Department's ReWorksSA Program,[40] continue to reduce landfilled commercial waste.
	15	RESIDENTIAL WASTE REDUCTION Continue to reduce landfilled residential waste with the goal of becoming a zero-waste community.
	16	ORGANICS DIVERSION Accelerate the diversion of organics from landfills to the highest and best use opportunities and ensure low-carbon composting solutions.
	17	MATERIAL REUSE AND CIRCULARITY Support the development of a local circular economy to extend product lifespan through improved design and servicing and relocating waste from the end of the supply chain to the beginning.
	18	REDUCED-LANDFILL CONSTRUCTION Building on CoSA's Deconstruction Pilot Program,[41] accelerate the acceptance of low-waste construction projects through education, incentives and partnerships, and continue to pursue zero-landfill waste practices for all construction projects.
PROMOTE BIODIVERSITY AND HEALTHY ECOSYSTEMS	19	CARBON CAPTURE AND STORAGE Develop and implement a plan for carbon capture and storage that takes advantage of all available solutions including increasing plant material, restoring the soil landscape, increasing the use of Green Infrastructure, including increasing the tree canopy, enhancing wetlands, and implementing technological solutions that also support biodiversity and the regeneration of native species and ecosystems.
	20	URBAN HEAT ISLAND Analyze and quantify the urban heat island (UHI) in San Antonio and develop an implementable and impactful UHI mitigation and adaptation plan with a focus on vulnerable populations and ecosystems.
	21	ECOLOGICAL PLANNING AND CLIMATE-SENSITIVE DESIGN Integrate climate mitigation and adaptation into existing land development review and permitting processes with a goal of maximizing the benefits of natural geographic and watershed features.
EDUCATE AND EMPOWER	22	GHG EDUCATION AND TRAINING Work with partner organizations to develop and implement comprehensive sustainability and GHG education and workforce training programs.
	23	SA TOMORROW PLANS Fund, track, and achieve the goals of the SA Tomorrow Sustainability, Comprehensive, and Multi-Modal Transportation Plans,[42] specifically the portions of those plans offering significant mitigation and adaptation opportunities.
	24	BUSINESS INCENTIVES Incentivize business that operate within the City of San Antonio to set GHG reduction targets for their own operataions that match or exceed the City targets.
	25	ELECTRIC AND WATER RATE STRUCTURES Evaluate the potential to update electricity and water rate structures to support GHG reductions.
	26	GHG REDUCTION QUANTIFICATION Complete a comprehensive scope 3 or consumption-based assessment for San Antonio's community sector.
	27	DEVELOP AND IMPLEMENT A FRAMEWORK FOR REGIONAL COLLABORATION Work with Bexar County, suburban cities, and regional partner organizations to expand CAAP efforts through a Regional Climate Council.
	28	FINANCING ENERGY EFFICIENCY Explore financing mechanisms to accelerate adoption of energy efficiency, demand response, distributed renewable generation, and energy storage.

LEGEND

Initiation Phase
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LEAD / PARTNER AGENCY	PHASE	GHG	CONSTRAINTS	IN PLAN	AQ	NC	QJ	H	A
SOLID WASTE MANAGEMENT DEPARTMENT Office of Sustainability	LT	L-M	I, BC	Y	✓	✓	✓	✓	✓
SOLID WASTE MANAGEMENT DEPARTMENT Office of Sustainability	NT	L-M	BC, I, T	Y	✓	✓	✓	✓	✓
SOLID WASTE MANAGEMENT DEPARTMENT Office of Sustainability	NT	M	BC, I, T	Y		✓	✓	✓	
OFFICE OF SUSTAINABILITY Solid Waste Management Department, Office of Innovation, Economic Development Department, Office of Historic Preservation	LT	L	BC, I, T				✓		✓
OFFICE OF SUSTAINABILITY Solid Waste Management Department, Office of Historic Preservation	LT	L	I, P	Y			✓		✓
OFFICE OF SUSTAINABILITY SARA, Green Spaces Alliance of South Texas, UTSA, Edwards Aquifer Authority	LT	M	I, P, T	Y	✓	✓		✓	
OFFICE OF SUSTAINABILITY Office of Emergency Management, San Antonio Metropolitan Health District, Planning, Development Services Department, Neighborhood & Housing Services, Parks & Recreation, SARA	NT	M	I, P	Y	✓	✓		✓	✓
DEVELOPMENT SERVICES DEPARTMENT Office of Sustainability, Office of Historic Preservation	NT	L-M	P	Y		✓	✓	✓	
OFFICE OF SUSTAINABILITY	LT	L	I, BC	Y	✓	✓	✓	✓	✓
PLANNING, TRANSPORTATION & CAPITAL IMPROVEMENTS, OFFICE OF SUSTAINABILITY, CITY MANAGER'S OFFICE, OFFICE OF MANAGEMENT & BUDGET, VIA	NT	M	I, P	Y	✓	✓	✓	✓	✓
ECONOMIC DEVELOPMENT DEPARTMENT Office of Sustainability, San Antonio Economic Development Foundation, Office of Historic Preservation	NT	M	I, P	Y	✓	✓	✓	✓	
CPS ENERGY, SAWS Office of Sustainability, Finance Department	LT	L	P	Y	✓			✓	✓
OFFICE OF SUSTAINABILITY	NT		I		✓	✓	✓	✓	
MAYOR'S OFFICE Government & Public Affairs, Office of Sustainability	LT		I	Y	✓	✓		✓	
OFFICE OF SUSTAINABILITY CPS ENERGY	LT	L	P	Y	✓		✓	✓	✓

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MUNICIPAL MITIGATION STRATEGIES

San Antonio's municipal government will take the lead on GHG mitigation efforts within the City. While municipal government operations only account for 3% of the city's total GHG emissions, the municipal mitigation strategies set a significant reduction goal that will allow the City to pilot approaches before implementing them in the broader community. The City of San Antonio commits to a greener and more efficient government to benefit all San Antonians and will continue to strive for excellence through implementation of City plans, including the SA Tomorrow Sustainability, Comprehensive and Multi-Modal Transportation Plans.

		STRATEGIES
REDUCE BUILDING ENERGY CONSUMPTION	M1	BENCHMARKING AND PUBLIC DISCLOSURE OF BUILDING ENERGY CONSUMPTION Benchmark and publicly disclose building energy and water use for municipal buildings.
	M2	MUNICIPAL ENERGY POLICY To reduce energy consumption, adopt an Energy Policy Ordinance for City-owned buildings and facilities.
	M3	ZERO NET ENERGY (ZNE) BUILDINGS Achieve ZNE for all municipal buildings by 2040.
	M4	COOL/GREEN ROOFS Install cool or green roofs on municipal government buildings, as appropriate.
REDUCE TRANSPORTATION ENERGY CONSUMPTION	M5	STREETLIGHT CONVERSION Convert all streetlights to LEDs with daylight sensors by 2021 and implement the recommendations of the Urban Lighting Master Plan.
	M6	CLEANER AND MORE EFFICIENT VEHICLE TECHNOLOGIES Convert all fleet passenger vehicles and small trucks to more efficient options by 2025, with a priority on electrification based on recommendations of the Electric Fleet Conversion and Infrastructure Study (currently in development). Additionally, research and pilot the electrification of heavy trucks.
	M7	TRANSPORTATION DEMAND MANAGEMENT Reduce the GHG impact of employee commuting.
	M8	AIRPORT ACCREDITATION Consider pursuing and achieving Airport Carbon Accreditation.
ADVANCE THE CIRCULAR ECONOMY	M9	PRIORITIZATION IN DECISION-MAKING To encourage ongoing education and decision-making around GHG reduction, include a carbon impact analysis in City projects and budgeting processes as well as consideration of City investments.
	M10	ENVIRONMENTALLY-PREFERABLE PURCHASING Update the City's green purchasing policy to consider the lifecycle impacts when choosing products.
	M11	GREEN SPECIFICATIONS Reduce the GHG impact of materials specified in public works and roadway projects.
	M12	ZERO WASTE Strive to achieve zero waste for all municipal government operations by 2030 with a focus on overall reduction, product reuse, and circularity.
EDUCATE & ENABLE	M13	GHG EDUCATION Develop and implement a comprehensive sustainability and GHG education program for municipal employees.

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- **A** Affordability

LEAD DEPARTMENTS	PHASE	GHG	CONSTRAINTS	IN PLAN	AQ	NC	QJ	H	A
Office of Sustainability, Finance Department	NT	L	P	Y	✓			✓	
Office of Sustainability, Building and Equipment Services	NT	L	P	Y	✓			✓	✓
Transportation & Capital Improvements, Office of Sustainability	LT	H	I, P	Y	✓		✓	✓	✓
Transportation & Capital Improvements	LT	L	I, P	Y	✓	✓	✓	✓	✓
Finance Department, Transportation & Capital Improvements, Center City Development & Operations Department, CPS Energy	NT	L	I	Y			✓		✓
Office of Sustainability, Building and Equipment Services, Solid Waste Management Department, Transportation & Capital Improvement	NT	H	I	Y	✓			✓	
SA Metro Health District, Transportation & Capital Improvements, Human Services	NT	L-H	I, P, BC	Y	✓		✓	✓	✓
Aviation	LT	H	I		✓			✓	
City Manager's Office, Mayor and City Council, Office of Management & Budget, Office of Sustainability	NT	L	P, BC	Y	✓	✓	✓	✓	✓
Finance Department	LT	L	P	Y			✓	✓	
Transportation & Capital Improvements, Finance Department	NT	L	P	Y	✓		✓		
Solid Waste Management Department, Office of Sustainability	LT	L	BC	Y	✓	✓		✓	✓
Office of Sustainability	NT	L	BC	Y	✓	✓	✓		

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DISCLAIMER

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