Addressing Future Economic Effects of Climate Change In The American West

An Applied Policy Project

Prepared for Protect Our Winters

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POW PROTECT OUR WINTERS

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Disclaimer

The author conducted this study as part of the program of professional education at the Frank Batten School of Leadership and Public Policy, University of Virginia. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgments and conclusions are solely those of the author, and are not necessarily endorsed by the Batten School, by the University of Virginia, or by any other agency.

Honor Pledge

On my honor as a student, I have neither given nor received unauthorized aid on this assignment.

Douglas Sean Weimer

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Arizona and Nevada face significant risk of catastrophic economic damage from the looming threat of climate change. Currently, the two states are gradually shifting their energy sectors towards clean, renewable energy, but not at a fast enough pace. The potential economic damages to the two states warrant a review of their current policies regarding emissions as a whole, with a particular focus on the energy production sector, as it represents the largest category of emissions in both states. This analysis will review the background of the problem, review the energy sector emissions portfolios of both states, the potential damages present, the governance structure of both states, and finally, review evidence for potential solutions.

This report will then establish criteria and analyze three separate potentially viable alternatives to address the policy problem through those criteria. The potential alternatives to be reviewed are:

- Current Policy: Status-Quo Baseline
- Alternative 1: Public-Private Cooperation
- Alternative 2: Implementation of Taxes, Penalties, or other Punishment to Reach Socially Optimal Emissions
- Alternative 3: Regional Partnerships

This report will review these alternatives through the criteria of cost-effectiveness, equity, political feasibility, and implementation ability.

The analysis in this report concludes that Alternative 3: Creation of a regional partnership is the most viable opportunity for reducing the future potential economic harm associated with climate change as it offers the states the ability to accomplish their set out goal of reducing CO_2 emissions while being moderately cost efficient, highly equitable, and politically feasible, though it will be difficult to implement. The creation of a regional partnership to trade carbon emission allowances makes the largest overall impact on emissions of all of the alternatives, reducing emissions a projected 33% over the ten-year period. This reduction in emissions, along with the additional revenues brought in from allowance auction proceeds, represents a nearly $13.3 billion reduction in total costs across the ten-year projection compared to the status-quo projection. This alternative will help shift production towards cleaner sources of energy, reduce emissions, spur development, and reduce the future potential economic harm from climate change.

This report will then outline a final implementation strategy and timeline to review.

INTRODUCTION

In this analysis, we will demonstrate the causes of climate change, the projected extent of climatic changes, how these changes will affect the United States, more specifically, Arizona and Nevada, and review some existing literature that can be useful research in providing unique potential solutions to mitigate and adapt to the adverse effects of climate change. Broadly, it is well accepted that we have reached a point of the inevitability of climate change. It is not, however, a “worst-case” scenario at this point, however. Climate models have been adjusted to project different future scenarios based on the amount of greenhouse gas emission reductions over the next eighty years. These projections indicate the discrepancy in the potential reductions, and the devastating effects of climate inaction.

This is not only a humanitarian concern, but also, an economic concern. The United States is projected to have losses up to 1.5 to 5.6% GDP at 4°C of warming, and at 8°C warming potential losses of 6.4 to 15.7% GDP annually, ending in a linear form of approximate damages of ~1.2% GDP per 1°C on average (Hsiang et al., 2017). This would mean the United States is at risk of experiencing a direct loss of between 2.78 billion USD to 3.45 trillion USD (in 2021 dollars) per year in the worst case scenario (Hsiang et al., 2017). These losses will not be evenly distributed across the United States, as some areas will experience worse climatic effects than other areas, and certain industries are more climate sensitive than others, including many tourism industries. This poses a great risk to both Nevada and Arizona, who heavily rely on the tourism sector as a source of both tax revenue and as job provider.

PROBLEM STATEMENT

The level of CO_2 emissions in Arizona and Nevada is too high. This is leading to rapidly increasing, irreversible climactic effects. The American West is being affected more by a changed climate than any other part of the United States outside of Alaska.(Saunders et al., 2008) The cost of climate inaction emissions will cause economic devastation for the region, particularly for states that rely on yearly tourism revenue.

Climate change future impacts and costs, as a direct result of these varied symptoms, will directly impact and diminish outdoor recreation activities, and in turn, economically damage tourism reliant economies. Research on the United States has found a possibility of losses up to 1.5 to 5.6% GDP at 4°C of warming, and at 8°C warming potential losses of 6.4 to 15.7% GDP annually, ending in a linear form of approximate damages of ~1.2% GDP per 1°C on average in their sample of scenarios (Hsiang et al., 2017). For comparison, a loss of 1.2% GDP in current dollars would be a loss of over 278 billion USD (*Gross Domestic Product, Third Quarter 2021 (Advance Estimate) | U.S. Bureau of Economic Analysis (BEA)*, 2021), estimated to occur under a “emissions as usual” scenario. When reducing the scope to the state and local level, the effects of climate change are equally staggering. Existing research estimates that 13 of Arizona’s 15 counties will experience net total direct damages to county level GDP, with Gila County and Mojave County experiencing the worst estimated net total direct damage, at over 15% loss of GDP. Similarly, 10 of Nevada’s 17 counties will experience net total direct damages to county level GDP, with Clark County and Esmeralda County experiencing over 5% loss of GDP

(Hsiang et al., 2017). Both of these estimates are found using a model estimating effects between 2080-2099, relative to the 30-year span between 1980-2010.

Client Overview

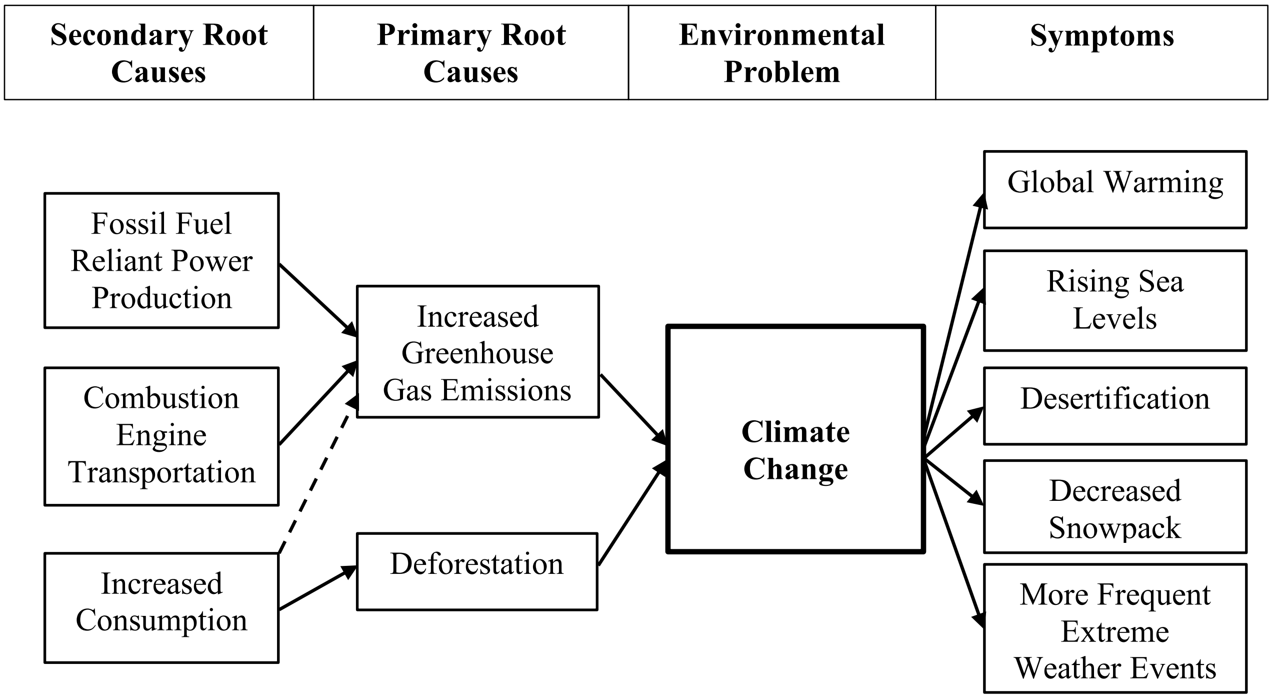
Protect Our Winters' (POW) mission is "… to turn passionate outdoor people into effective climate advocates. We bring together a community of athletes, creative pioneers, and forward-thinking business leaders to affect systemic solutions to climate change." This specific problem is important to the organization as it is a part of their new strategic plan: a focus on state level policy change in the Rocky Mountain West. POW as an organization focuses on lobbying efforts to combat climate change, specifically, focusing on legislation regarding carbon pricing, renewable energy, electrifying transit options, and protection of public lands. The problem analyzed in this paper specifically targets policy makers in Rocky Mountain states and enables POW to effectively lobby these policy makers by having a framework that adequately summarizes the effects of climate inaction in their specific states.

While this problem, and POW's work, is widespread across the United States, this applied policy project will be narrowed to focus on two states: Arizona and Nevada. This is a result of consulting with the point of contact at POW and his notification of POW's specific needs, as their current strategic focus is on Arizona, Colorado, Montana, Nevada, and Utah, with particular interest is Arizona and Nevada. Due to the broad nature of the problem, focusing on these two specific states will provide a useful framework in designing future policy analyses for other Rocky Mountain states.

BACKGROUND

Causes

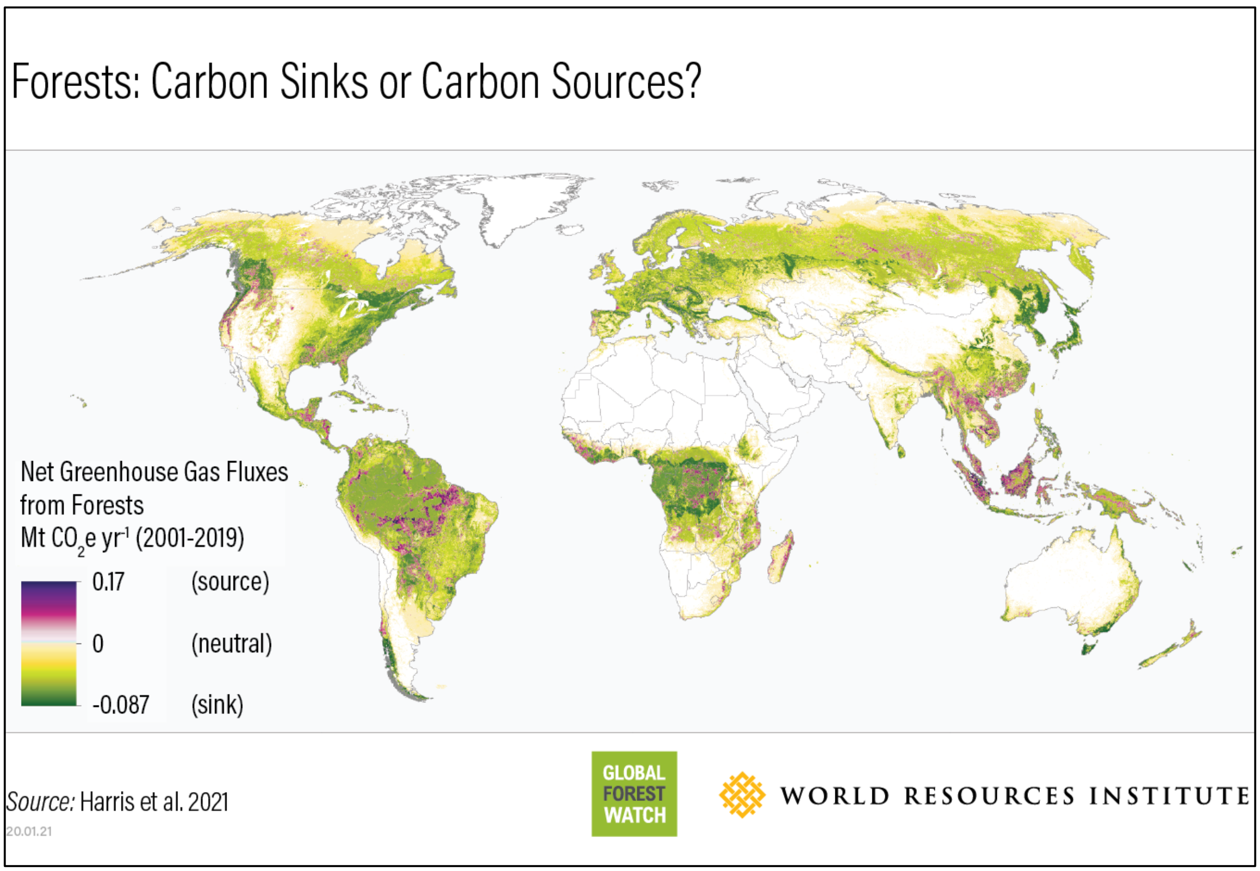
Figure 1. Root Cause Analysis



In considering causes for the policy problem under analysis, this report will focus on emissions and deforestation as the primary root causes for climate change at large. This report will use these causes as a primary focus for generating and evaluating policy alternatives for Arizona and Nevada policy makers to mitigate emissions to curb the future effects of climate change, demonstrated visually above in Figure 1. Focusing on these two primary root causes allows the report to sufficiently accomplish the client's goals of reduction of overall greenhouse gas (GHG) emissions for their strategic Rocky Mountain strategic focus area as well as carbon offsetting with combating deforestation. This aligns with Protect Our Winters' (POW) policy mission as well, as they seek to advocate for reducing emissions (specifically in power generation and electrifying transit) and protection of public lands (including national and state forests). Using Wagner's model of root cause analysis (RCA), these fit into the secondary root causes, as they contribute to both increased GHG emissions and broader deforestation (Wagner, 2014).

Climate change is the broad environmental issue being considered in this applied policy project. While climate change is a global problem being both caused and exacerbated by an plethora of factors, the two largest human activity factors causing climate change that are recognized by the US Environmental Protection Agency (EPA) are GHG emissions and the reflectivity or absorption of the Sun's energy, with a large part of that being contributed to widespread deforestation (US EPA, 2021b). GHG emissions absorb and store significant energy, and slow or prevent heat loss from the atmosphere. "They act like a blanket, making the earth warmer than it would otherwise be. This process, commonly known as the "greenhouse effect," is natural and necessary to support life. However, the recent buildup of greenhouse gasses in the atmosphere from human activities has changed the earth's climate and resulted in dangerous effects to human health and welfare and to ecosystems," (US EPA, 2021a). Curbing the emission of GHGs is paramount to combating the future potential effects of climate change. Similarly, the reflectivity or absorptivity of the Sun's energy is a large focus of combatting climate change. While deforestation provides variable local effects, generally, it provides a small cooling effect, due to broader land use patterns such as replacing darker, more absorptive greenery with lighter crop coverage (US EPA, 2021b). However, this effect is sequestered in comparison to the carbon offset that forests generally provide. Forests absorb nearly twice the amount of carbon dioxide, a GHG, that they naturally produce. In a 2021 study by the Nature Climate Change, it was found that forests worldwide emitted an average of 8.1 billion metric tons of carbon dioxide into the atmosphere each year from 2001 to 2019 due to deforestation and other disturbances but absorbed an average of 16 billion metric tons of CO_2 per year (N. L. Harris et al., 2021). This means that global forests provide a "carbon sink" that "absorbs a net 7.6 billion metric [tons] of CO_2 per year, 1.5 times more carbon than the United States emits annually," (N. Harris & Gibbs, 2021). The geographic breakdown of this absorption is spread across both temperate and tropical zones, as demonstrated in Figure 2 below.

Figure 2. Carbon Capture and emissions from forests by location.



Source: World Resources Institute, 2021.

This analysis will be utilizing CO_2 emissions as a proxy for GHG emissions in general. CO_2 is generally credited with being the most important anthropogenic GHG, being responsible for the greatest portion of climate change currently. Often, direct emissions of CO_2 are in tandem with other emissions, such as the emission of methane and nitrous oxide along with CO_2 in the process of combustion of fossil fuels for power (US EPA, 2017b). As such, for applicability and ease of understanding, this analysis will consider CO_2 as the primary emission of focus.

The symptoms of climate change are as broad as the problem itself. The ones that will be focused on in this applied policy project are global warming, rising sea levels, desertification, decreased snowpack, and more frequent extreme weather events. Each of these symptoms provide local and unique challenges to towns, cities, states, and countries. While some benefits may be accrued from climate change's future effects, broadly, it will be a net loss to society. Several of these symptoms relate directly to POW's mission in connecting "passionate outdoor people" to effective, systemic climate change solutions. Climate change future impacts and costs, as a direct result of these varied symptoms, will directly impact and diminish outdoor recreation activities, and in turn, economically damage tourism reliant economies.

State Emissions & Energy Overview

Arizona

In 2018, Arizona produced 93.9 million metric tons of CO_2 from all sources, the 22nd highest in the United States (*Arizona - Rankings - U.S. Energy Information Administration (EIA)*, 2021). The highest emitting sector was that of the electric power generation, which 46.8 million metric tons of CO_2, or about half of the total share of emissions. The second highest emission source was transportation, representing about 37.2 million metric tons of CO_2, or about 39.7% of the total share of emissions (*State Carbon Dioxide Emissions Data - U.S. Energy Information Administration (EIA)*, 2021).

In 2018, petroleum produced the highest total emissions by fuel at 41 million metric tons of CO_2, or 43.6% of the total share of emissions. This is likely due to the shared emissions across sectors, as petroleum includes much of the total transportation emissions share, as well as household, industrial, and at a smaller scale, energy production level. Coal came in at second, with 31.7 million metric tons of CO_2, or 33.7% of the total share of emissions. Natural gas sources produced 21.3 million metric tons of CO_2, or 22.6% of the total share of emissions (*State Carbon Dioxide Emissions Data - U.S. Energy Information Administration (EIA)*, 2021).

As of November 2021, Arizona generates 7,422 thousand megawatt-hours (MWh) of energy. The highest share of this total generation is from natural gas combustion facilities, which generate 2,720 thousand MWh, or 36.6% of total generation. Nuclear sources generate 2,474 thousand MWh, or 33.3% of total generation. Renewable sources, including hydroelectric, generate 993 thousand MWh, or 13.4% of total generation (*Arizona - Rankings - U.S. Energy Information Administration (EIA)*, 2021).

Nevada

In 2018, Nevada produced 41 million metric tons of CO_2 from all sources, the 38th highest in the United States (*Nevada - State Energy Profile Overview - U.S. Energy Information*

Administration (EIA), 2021). Unlike Arizona, the second largest emission generator in Nevada in 2018 was transportation, producing 18.7 million metric tons of CO_2 or 45.5% of the total share of emissions. Electric power generation was the second largest emitting sector, producing 13.7 million metric tons of CO_2 or 33.4% of the total share of emissions (*State Carbon Dioxide Emissions Data - U.S. Energy Information Administration (EIA)*, 2021).

Like Arizona, in 2018, petroleum produced the highest total emissions by fuel at 21.2 million metric tons of CO_2, or 51.7% of the total share of emissions. As mentioned above, petroleum is likely the highest source due to the shared emissions across sectors, as petroleum includes much of the total transportation emissions share, as well as household, industrial. Additionally, Nevada's tourism industry draws more transportation on average. For example, Nevada experienced around 1.2 million more enplanements in 2019 than Arizona, which likely contributes to the higher share of petroleum sourced emissions (Federal Aviation Authority, 2020). This is backed up by U.S. Energy Information Administration, which acknowledges Nevada's transportation sector accounts for almost one-third of the state's end-use energy consumption (*Nevada - State Energy Profile Analysis - U.S. Energy Information Administration (EIA)*, 2021). Natural gas was the second largest source of emissions by fuel, at 16.5 million metric tons of CO_2, or 40.2% of the total share of emission (*State Carbon Dioxide Emissions Data - U.S. Energy Information Administration (EIA)*, 2021).

As of November 2021, Nevada generates 2,977 thousand megawatt-hours (MWh) of energy. The highest share of this total generation is from natural gas combustion facilities, which generate 1,775 thousand MWh, or 59.6% of total generation. Coal sources generate 324 thousand MWh, or 10.9% of total generation. Renewable sources, including hydroelectric, generate 878 thousand MWh, or 29.5% of total generation. Notably, in 2019, about 85% of the energy Nevada consumed came from outside the state (*Nevada - State Energy Profile Overview - U.S. Energy Information Administration (EIA)*, 2021).

THE COSTS TO SOCIETY

Direct Costs

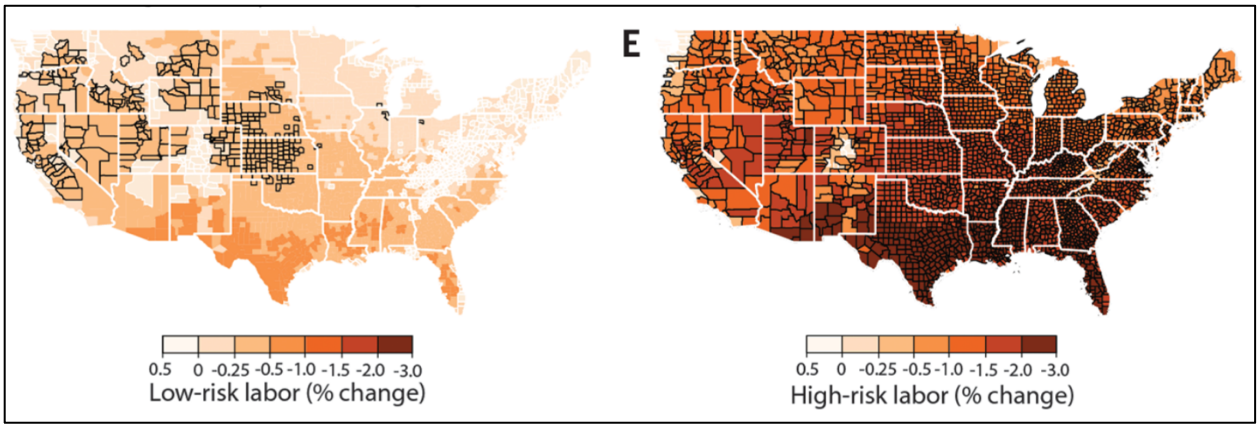
The first and most significant costs are the direct observable health care costs. With a rise in average temperatures associated with climate change, society can expect to bear significant costs due to rising heat-related illnesses (HRI), as individuals get sick and have to visit a physician and may have to be hospitalized. From 1979 to 2011, incidences of heat waves per year have generally increased in the United States, with the largest increase in incidences occurring in the Southeast and Great Plains regions (T. T. Smith et al., 2013). This trend is expected to continue, and likely worsen, with global temperature rises, according to the UN Intergovernmental Panel on Climate Change's 2007 report (Intergovernmental Panel on Climate Change & Intergovernmental Panel on Climate Change, 2007). This will lead to increased healthcare costs associated with HRI, which have been found to have an average cost of $12,480 between 2001-2010 (Schmeltz et al., 2016). Few studies have been done as far as aggregate future costs associated with this increase across the United States, but in one localized projection conducted in 2012, costs are expected to increase between $26–$76 million in 2080-2099 in New York alone (Lin et al., 2012).

The direct costs associated with climate change are grounded in general economic well-being for society. Much of this can be summarized in damage to gross domestic product for communities or states. When linking global mean surface temperature (GMST) to market and nonmarket costs in the United States, and then aggregating county level impacts within each state, Hsiang et al. found that expected annual losses increase between "~0.6% GDP per 1°C at +1°C of GMST warming (relative to 1981 to 2010) to 1.7% GDP per 1°C at +5°C GMST," (Hsiang et al., 2017).

Opportunity Costs

Other sizable but smaller contributions to damages come from changes in labor supply, energy demand, and agricultural production (Hsiang et al., 2017). The bulk of this estimation of GDP loss is a result of lost wages when individuals are sick or in the hospital, and further, increased mortality rates of individuals who consequently die before reaching age 65. The trend in projections generally represents reduced mortality in cold northern counties and elevated it in hot southern counties, with few exceptions. This cost is derived from the 2010 US EPA value of a statistical life update analysis, with a central estimate of $7.4 million ($2006) (US EPA, 2017a).

Figure 3. Change in labor supply with global temperature supply. Darker shaded counties represent higher losses, while lighter shaded counties represent smaller losses or gains (in the lightest shade).

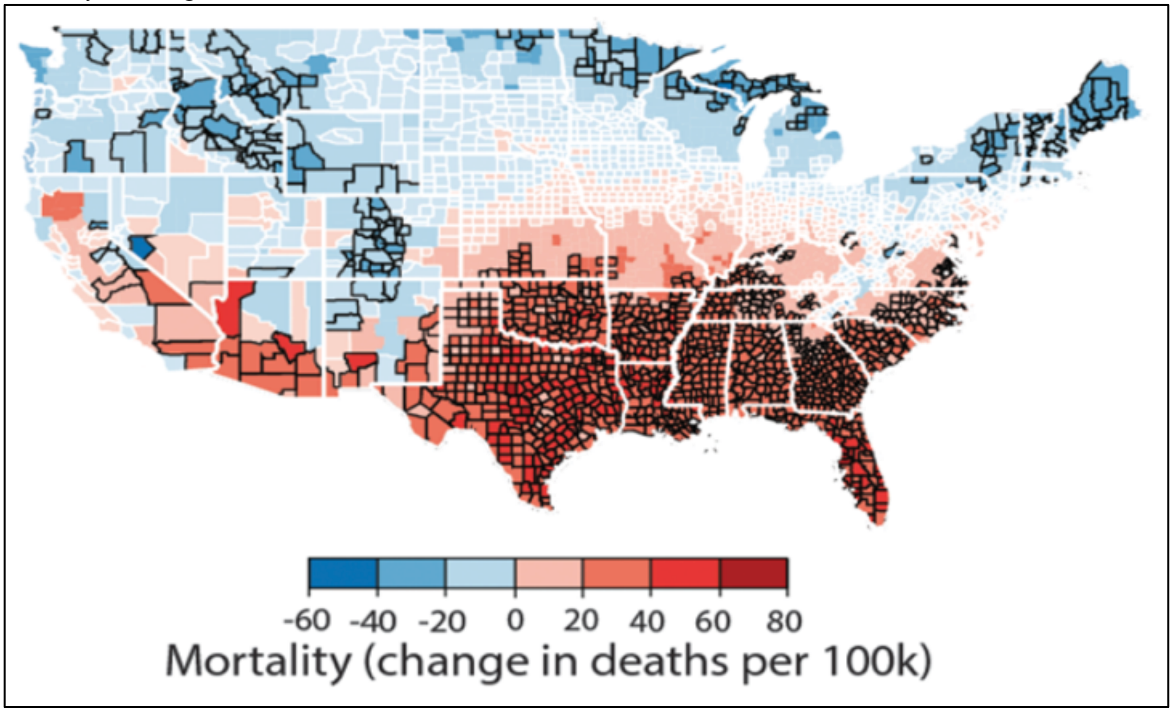


Source: Science, 2017.

Increases in mortality rates represent losses to other sectors, with decreased labor supply in both low-risk and high-risk jobs, as demonstrated at the county level change in Figure 3 above.[1] Specifically, Total hours of labor supplied declines ~0.11% per °C in GMST for low-risk workers, 0.53% per °C for high-risk workers, with high risk representing ~23% of all employed workers in the United States in 2017, in sectors such as construction, mining, agriculture, and manufacturing (Hsiang et al., 2017).

[1] Hsiang et al. define low-risk as jobs where workers are minimally exposed to outdoor temperature and high-risk as jobs where workers are heavily exposed to outdoor temperatures.

Figure 4. Mortality rate – change in deaths per one-hundred thousand. Blue shades indicate a reduction in mortality rate, while red shades indicate and increase in mortality rate, with darker shades indicating higher intensity in change.



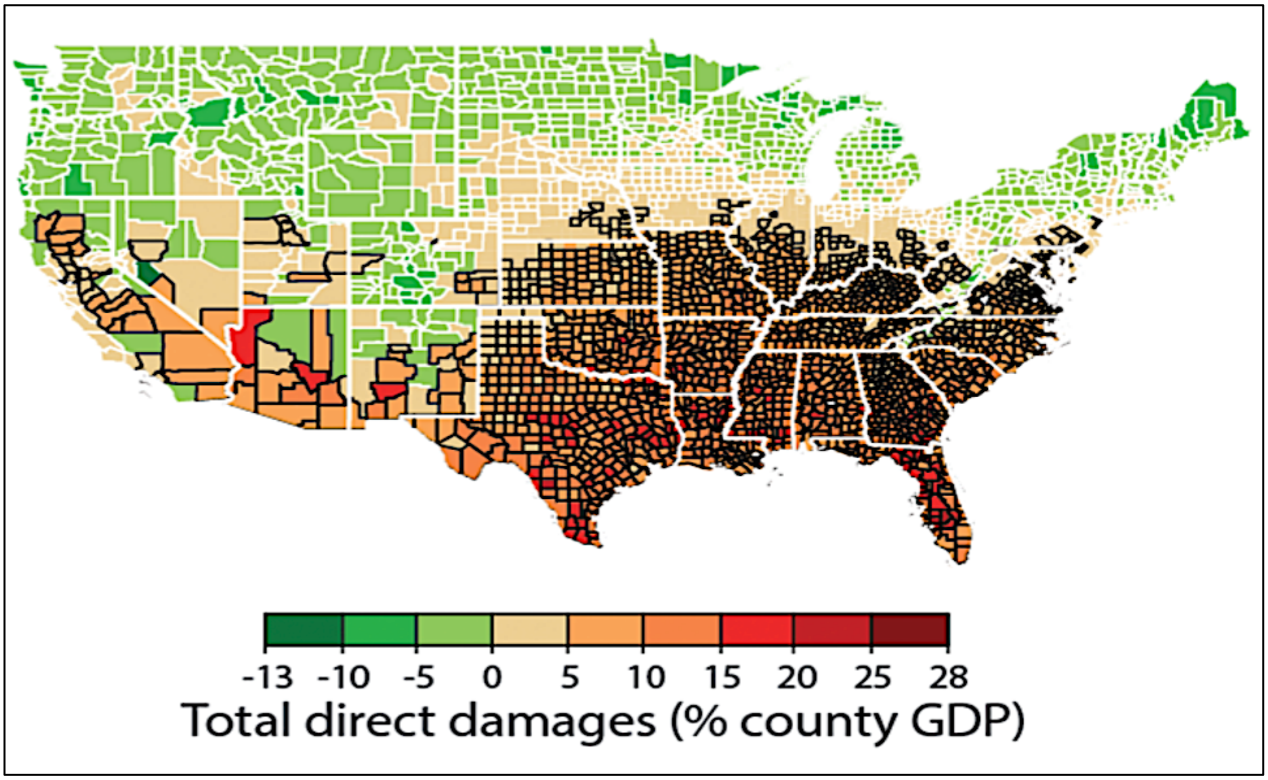
Source: Science, 2017.

The opportunity costs associated with increased mortality has a strong ripple effect, beyond just decreased labor supply. Increased mortality leads to lost wages due to an early death, to lost tax revenue and spending potential, and to increased burden on associated persons (such as dependents), which leads to overall higher potential future costs due to the opportunity cost. The actual numbers associated with opportunity costs are much harder to measure and predict, but conceptually, higher mortality rates carry a high burden on society. The change in overall mortality rate projected change at the county level can be viewed above in Figure 4.

Externalities

Generally, climate change externalities are measured with the EPA's estimated "Social Cost of Carbon" (SC-CO_2). The 2025 estimate for SC-CO_2 with a recognized 3% discount rate is $46 (in 2007 dollars per metric ton CO_2), or currently adjusted with inflation to ~$61 per metric ton CO_2 (US EPA, 2013b). Other GHG are included in the social cost measurement, such as methane (SC-CH_4), at an adjusted ~$1,868 per metric ton CH_4, and the social cost of nitrous oxide (SC-N_2O), at an adjusted ~$22,678 per metric ton N_2O (US EPA, 2013b). The SC-CO_2 is "…meant to be a comprehensive estimate of climate change damages and includes changes in net agricultural productivity, human health, property damages from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning," (US EPA, 2013b). The measurement is used in cost benefit analyses of policy alternatives for rulemaking measures. For the purpose of this APP, the focus will be on CO_2 specifically, as it is the emission most closely tied to the tourism industry (based on emissions and effects).

Figure 5. Direct damages in percentage point change in current county gross domestic product.



Source: Science. 2017.

Other externalities are measured through more specific predicted effects of climate change, such as those indicated in the “symptoms” column within the above RCA, such as decreased snowpack or the increased frequency of extreme weather events. These externalities are extremely varied and heavily localized in their impacts, with hotspots appearing in different localities more susceptible to specific effects. These shifts in projected total direct damages to GDP, broken down to a localized level are exhibited above in Figure 5. Instances of increased temperature have direct impacts towards mortality rates and crop yields, as referenced above in the Hsiang et al. study, and indirect impacts, such as loss of recreation opportunities and subsequent tourism revenue. Broadly, US temperatures have generally been increasing for a century (“What Climate Change Means for Nevada,” 2016). For example, the State of Nevada Climate Initiative projects average temperatures to be 4 to 6ºF warmer by midcentury across the State, increasing to 6 to more than 10ºF warmer by the end of this century, depending on which emissions scenario is followed in coming decades (B. Smith, 2021). Due to the increased temperatures, the State of Nevada Climate Initiative predicts a decrease in time available to be safely outside, and being a “deterrent to attracting visitors,” (B. Smith, 2021).

Connection Between Climate Change and Tourism

Climate forms the basis for any tourism sector. Whether it be from branding and public perception, such as that of Southern California (known for having consistent warm weather), availability and provision of recreation opportunities, such as ski areas (who need consistent snowpack for business success), or for the demand of tourism services, such as watercraft rentals (who need water levels to be high enough to attract visitors to demand rental services), climate is a critical piece of any tourism based or adjacent business' model. "Weather and climate impact the demand for tourism at destinations and have direct and indirect impacts on industry costs, revenues, and profitability," (Day et al., 2013). Thus, it is important to recognize this connection between climate change and the tourism sector. Furthermore, it is imperative to connect that to policy solutions to mitigate the future effects of climate change to reduce the overall amount of damage associated to the industry, and economies that rely on the industry.

Consensus in tourism sector research indicates that climate is a large motivator in travel considerations. Specifically, it is recognized as a "pull" factor when viewing motivations through a cognitive push or pull lens (Crompton, 1979; Turnbull & Uysal, 1995). Some research goes as far as to say that "Climate is perhaps the most common marketing theme used as the basis for selling a tourism region once it has suitable visitor attractions," (Mill & Morrison, 2009). Of important note, this draws a distinction between "climate" and "weather." Weather refers to an area's short term atmospheric conditions while climate is the weather of area averaged over an extended period of time (USGS, 2015). Both weather and climate influence consumers' preferences and decisions, and poor weather can be a restrictive motivator in the same manner that good weather can be a "pull" factor in motivation. Much of this is grounded in visitors' expectations of the weather, rather than the weather itself, which has led researchers to believe that climate itself can be a larger driver in tourism sector attraction than specific weather events (Thapa, 2012), though this does not account for weather related disaster events' impact on public perception, nor does it account for seasonable variability, which can have profound effects on weather sensitive industries, such as the ski industry (Cook et al., 2010). Both weather and climate have lasting impacts for destinations, as bad weather experiences can more negatively impact visitor satisfaction than good weather experiences positively impact such satisfaction(Coghlan & Prideaux, 2009), and climate has long-term implications on public perception rather than specific experiences (Ritchie & Crouch, 2003).

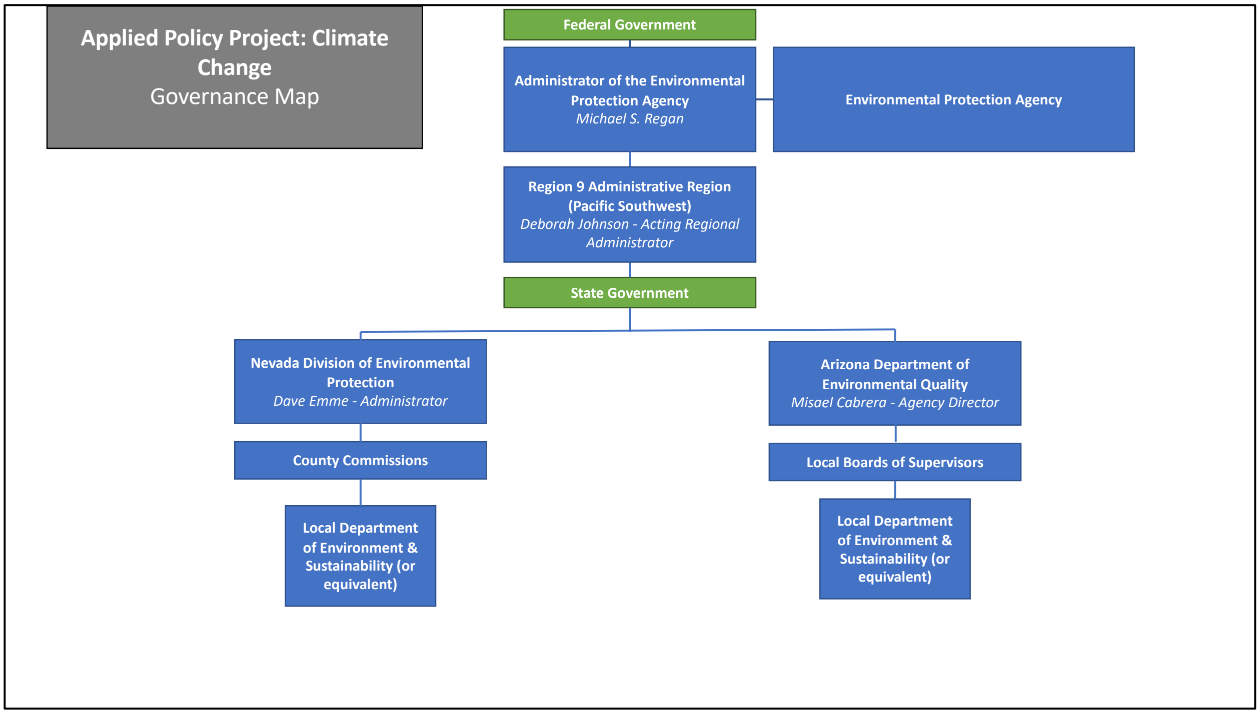
A localized example the effect of climate change on tourism is the increased temperature and drought at Lake Powell in Arizona, where in July of this year, the lake's water level fell to a historic low of 3,554 feet as a result of an ongoing extreme drought, a level that has not been seen since 1969, when the reservoir was first filled (McGivney, 2021). The reservoir is currently three-quarters empty and will continue dropping at least through spring 2022 due to the record low snowpack levels in the Colorado River basin, potentially preventing tourists from visiting the park. 4.4 million visitors came to Glen Canyon National Recreation Area (who manages the lake) in 2019. "The visitors spent $427m in Page and the surrounding area and supported 5,243 jobs, including providing a vital source of employment for the nearby Navajo Nation," (McGivney, 2021).

It is estimated from a statistical analysis of tourism at Lake Powell conducted at the University of Arizona that for every 1 percent drop in reservoir levels, visits fall by 5 percent (Ponnaluru, 2005). Drought also effects other critical tourist attractions in the Southwest, such as golf resorts and national parks. Limited water resources necessitate water usage restrictions, which heavily effects the golf industry, which uses large amounts of water to maintain their course appearance and functionality. Local Las Vegas golf courses were found to be used by three of every 10 tourists and others who spend $1.1 billion annually on the sport in a report from the National Conference of State Legislatures. Quality decreases in the golf industry could decrease tourists' desire to choose Nevada as a vacation destination. Nearly $200 million and more than 1,100 jobs could be lost if climate change resulted in such impacts, resulting in a total $222,766,768 economic loss (*CIER - Center for Integrative Environmental Research*, 2008).

Another symptomatic effect of climate change that specifically effects tourism economies is decreased snowpack. Snowpack influences general water availability, as snowpack acts as a natural reservoir, and during its melt runoff collects in river basins and flows to reservoirs to be utilized, but also heavily impacts winter and water-based recreation opportunities. For example, in Nevada, it is projected that in the near term, "…some 5–10% more of total precipitation is anticipated to fall as rain rather than snow, with basins around Tahoe and northwestern Nevada projected to experience 10–15% more rain rather than snow," (B. Smith, 2021). With less precipitation falling as snow, and with snowpacks also more inclined to melt earlier due to the warming winters, the amount of water in April snowpacks is projected to decline between 30 to 50% by the end of century in most basins in Nevada. This follows the general trend experienced across the West, where April snowpacks have been declining for the past 60 years (Mote et al., 2018).

Governance

Figure 7. Governance Map of Arizona and Nevada.



Federal Government

Much of the onus of mitigating CO_2 emissions and limiting the effects of climate change lies with the federal government, as most of the regulatory power when it comes to controlling industry lies within federal agencies (which are authorized by Congress itself). This can take on many different forms, such as expanding current EPA regulatory power to restrict emissions, such as expansions of a federal law like the Clean Air Act. Another potential lever is through levying taxes (via the Internal Revenue Service and partnering agencies) on carbon emissions from industrial sources, or through setting up a cap-and-trade system to establish a market for carbon emission allowances.

Below the EPA is their regional enforcement subsidiary, EPA Region 9, also known as the Pacific Southwest Region, which oversees implementing and enforcing federal environmental laws in Arizona, California, Hawaii, Nevada, the Pacific Islands[2], and 148 Tribal Nations (US EPA, 2013a). Any federal policy lever involving the EPA that is implemented would need to be passed down through region 9 officials to ensure effective and efficient operation of the lever to create meaningful change. Additionally, any policy initiatives at lower levels of government

[2] The EPA refers to the U.S. Pacific Territories of American Samoa, the Commonwealth of the Northern Mariana Islands (CNMI), and Guam; U.S. Minor Outlying Islands in the Pacific; and the Freely Associated States of the Federated States of Micronesia, the Republic of the Marshall Islands, and the Republic of Palau as "The Pacific Islands."

would need to ensure that they have proper jurisdiction and are compliant with federal minimum guidelines enforced by region 9.

At the local level, environmental protection rules are established by county commissions or local boards of supervisors, and implementation is carried out by departments of environment & sustainability. At this level, policy intervention potential is limited due to both lack of authority and lack of sufficient funding for enforcement. This is especially true in Nevada, which is considered a "Dillon's Rule" state to a large degree, meaning that, in a general sense, Nevada municipalities and counties are only permitted authority through official state designation, severely limiting the likelihood of solely local provisioning of environmental protection regulation.[3]

Arizona

Current regulation from the Arizona Corporation Commission (ACC) set standards for electric generation through the Renewable Energy Standard and Tariff (REST). The REST was first established by the ACC in 2006, and provisions that regulated electric utilities must generate 15 percent of their energy from renewable resources by 2025 (*Renewable Energy Standard and Tariff | Arizona Corporation Commission*, n.d.). Arizona also permits net billing for customers, "…which credits customer-generators with the avoided costs for energy delivered to the grid and facilitates small-scale, customer-sited renewable generation," (*Arizona - State Energy Profile Analysis - U.S. Energy Information Administration (EIA)*, 2021). Net billing compensation varies based on utility avoided costs, all on an ACC approved rate, with current export compensation rates at 10.45 cents/kWh (APS), 8.68 cents/kWh (TEP), and 10.35 cents/kWh (UNS) (*DSIRE*, 2021b).

Nevada

The regulatory authority overseeing Nevada's utility standards is the Public Utility Commission Nevada (PUCN). The PUCN's largest regulation in place governing electricity production is the Renewable Portfolio Standard (RPS). First adopted by the Nevada Legislature in 1997, it has been modified countless times, nearly every session. The RPS sets the overall percentage of electricity sold each year by providers of electric service to Nevada customers that must come from renewable energy, with the ultimate goal of 50% of all production coming from renewable sources by 2030. Each year, electric utility providers must submit a report to the PUCN providing evidence of their compliance with the RPS. If the PUCN determines a provider failed to meet the RPS, the PUCN has the authority impose a fine, provide an exemption or take other administrative action (*Renewable Portfolio Standard*, n.d.). The 2030 measure was cemented in the state constitution via referendum in 2020, as Nevada voters gave final approval of a ballot

[3] Nevada has relaxed some parts of its Dillon's Rule standing through AB493 of the 2015 legislative session, allowing governing bodies of incorporated cities to exercise powers "necessary or proper to address matters of local concern for the effective operation of city government, whether or not the powers are expressly granted to the governing body," but excludes any matters that have a "… state interest that requires statewide uniformity or regulation, the regulation of business activities that are subject to substantial regulation by a federal or state agency…" which would likely preclude any, if not all, environmental protection regulations at the local level. (*AB493 Overview*, 2015)

initiative that amends the state constitution and requires electric utilities to acquire at least 50% of their electricity from renewable sources by 2030 (*Nevada Question 6, Renewable Energy Standards Initiative (2020)*, n.d.). Nevada has permitted net metering for customers since 1997. The regulation allows systems up to 25 kW to be eligible, with monthly net excess generation credited at a rate equal to 75% of retail rate while systems larger than 25 kW and up to 1 MW are eligible for monthly netting at the retail rate. Any credits that exceed the customer's monthly bill will be carried over to the next billing period indefinitely (*DSIRE*, 2021a).

EVIDENCE ON POTENTIAL SOLUTIONS

Now that that this review has established the causes of climate change, the projected extent of climatic changes, how these changes will affect the United States, and more specifically, Arizona and Nevada, utilizing research in mitigation and adaptation strategies to address the looming problem will provide useful context for eventual policy recommendations. This report will focus on three areas of potential solutions, those being public-private cooperation, implementation of taxes or penalties to reach socially optimal emissions and building a market for financial risk mitigation to aid adaptation efforts, which will help guide the APP in a direction towards final recommendations. As a note, these are only a few areas to base our future direction in recommending solutions to address the effects of climate change on tourism industry reliant economies. Climate change is a broad topic, with numerous heavily researched and recommended solution options. These specific topics, however, represent unique opportunities to connect the tourism industries to state and local governments to preserve the industries that make up a large portion of their economies.

Public-Private Cooperation

Scott and Becken note that the most prominent associations between the private tourism sector and national and international government organizations is in the aviation sector, such as the International Air Transport Association (IATA), a trade association, or the International Civil Aviation Organization (ICAO), a specialized and funding agency of the United Nations. For example, the IATA has public stated goals of an average annual aviation fuel efficiency improvement of 1.5%, carbon-neutral growth from 2020 and the aspirational goal of reducing net emissions from aviation by 50% by 2050 compared with 2005 levels (Scott & Becken, 2010).

While industry-government partnerships may be one viable method to continue to curb emissions and reduce the future effects of climate change, destination level impacts may not match up. Turton et al. used a case study of four Australian destinations to gauge tourism stakeholders' knowledge of climate change and its potential impact in the destination, existing approaches to climate change adaptation, and the potential for building a self-assessment toolkit that can be utilized by other tourism destinations to examine their own vulnerability (Scott & Becken, 2010). In their findings, the researchers found several concerning indicators. The first finding was that industry level leaders felt that the burden and responsibility of addressing climate change rested within the public sector, specifically, localities (for adaptation). Second, the researchers found that the tourism sector is not yet ready to invest in climate change adaptation because of the "… perceived uncertainties in the magnitude of climate change and related environmental impacts," (Turton et al., 2010). The researchers found common themes in responses that perceived adaptations to climate change were actually adaptations to climate policy (reducing GHG emissions or marketing the destination as "green") and that these are better described as being sustainable development practices rather than being specific practices to climate change adaptation (Turton et al., 2010). In their conclusion and recommendations, the researchers concluded that while they accomplished their goal of raising awareness of climate change risks and identifying and evaluating specific vulnerabilities for the sector, a further development of a toolkit would be useful, and connections between the industry and local governments for the distribution of this toolkit are needed to ensure sustainability within the sector.

Implementation of Taxes, Penalties, or other economic policies to Reach Socially Optimal Emissions

The tourism industry is becoming increasingly involved with mitigation efforts to curb the future potential effects of climate change. The World Travel and Tourism Council, a forum for the travel and tourism sector, "…issued its first position paper on climate change in 2009 ("Leading the Challenge"), specifying 10 elements that should be part of an international agreement to be reached in Copenhagen, including the need for "deep and rapid cuts" in GHG emissions and the recognition that 'delaying action will increase the costs of stabilizing the climate,'" and the emissions reduction targets in the order of 25–30% by 2020 and 50% by 2035 (both from 2005 levels) were the first specified sector-wide targets made by anyone in the sector (Scott & Becken, 2010). In the more recent 2016 Paris agreement, the tourism sector has likewise pledged to reduce its GHG emissions by 70% by 2050 (Gössling & Scott, 2018). Scott and Becker note this as an ever-increasing target across the sector, as, regardless of causation arguments, the industry recognizes the existential threat that climate change poses. The response varies from carbon neutrality goals set by national governments for the tourism sector, such as the Seychelles, to movements by the Group of Least Developed Countries within the Bali Action Plan in 2008, recommending the implementation of an International Air Passenger Adaptation Levy that was estimated to be capable of generating approximately $8 billion per year for climate change adaptation in developing nations (Scott & Becken, 2010).

This commitment is justified for multiple reasons. As discussed above, the tourism industry is one of the most sensitive and at-risk economic sectors to the adverse effects of climate change. Additionally, tourism is a large contributor to global CO_2 emissions as a global economic sector interconnected with many other sectors such as aviation, accommodation and retail, and thus, should make a contribution to global efforts to reduce GHG emissions and address climate change (Scott et al., 2010). However, there is an impasse in reaching these goals solely within the private sector, as Gössling and Scott find in their 2018 study analyzing responses from tourism sector business leaders on their pledge from the 2016 Paris agreement. While the researchers found general consensus in respondents' views that the climate change is underway and that limiting further climate change is vital to the future development of tourism, the respondents articulated diverging views regarding "… the urgency of change ([decarbonization] timelines); continued growth in tourism as opposed to mitigation needs; and the role and potential of technology vís-a-vís climate governance in reducing emissions," (Gössling & Scott, 2018).

Implementation of market control mechanisms, such as the International Air Passenger Adaptation Levy, can help bridge this gap and encourage more aggressive reductions in emissions within the tourism industry. This is not exclusive to the international community, as similar taxes have been proposed within the United States, such as CS/CS/HB 1429 (2021) - "Tourist and Convention Development Taxes" proposed in Florida this year, which would authorize counties to impose tourist development & district convention development taxes to finance flood mitigation projects or improvements (*CS/CS/HB 1429 (2021) - Tourist and Convention Development Taxes | Florida House of Representatives*, 2021).

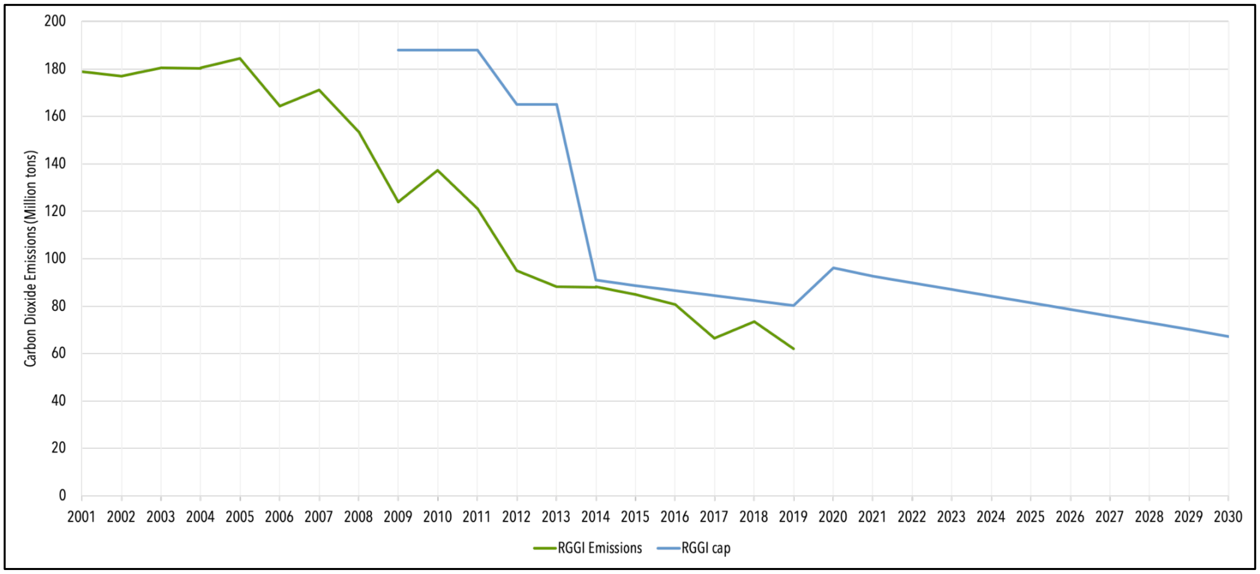
Another example of a market mechanism that could be expanded in Arizona and Nevada is net metering or net billing. Net metering is the practice of metering the relative energy consumption of electricity consumers who also generates electricity from their own energy producing facilities, such as solar panels (Zhang & Wang, 2017).There is an important distinction to be made, however, between the two policies. While Nevada has traditional net metering, where excess generation is netted one-to-one against consumption over a billing period, Arizona has net billing, where customer-generators are to be credited at an avoided cost rate for energy exported to the grid in an instantaneous manner (*DSIRE*, 2021b). The primary difference lies in the rate credited by the utility provider, as net billing credits are equal to or less than the wholesale price which the utility pays for purchasing energy from other energy power plants, thus the "avoided cost" language (*Utility Net Metering vs. Utility Net Billing*, 2021).

As the US strives to meet lofty climate goals, any low-carbon alternative, no matter its immediate impact, must be considered. This is what drives many policymakers towards net metering or net billing. The rise of solar photovoltaic energy has been directly correlated to reductions in cost of home solar. Since 1998, the reported prices for installing a residential solar PV system have fallen by 50 cents per watt per year on average ("Net Energy Metering," 2016). Even so, upfront costs deter many consumers from investing in home solar and need an incentive to help justify -or even cover- initial costs. These benefits have returns for utilities as well, as, "An increased reliance on solar power will reduce local pollution and carbon emissions from fossil fuel power plants while also enhancing grid reliability and power quality. These benefits help utilities avoid the cost of building new power plants; emission control technologies for fossil fuel plants; or other reliability and power quality equipment," ("Net Energy Metering," 2016).

Regional Partnerships

Regional partnerships instituting environmental regulations have proven to be effective policy tools to curb emissions. One example of a collaborative regional program is the Regional Greenhouse Gas Initiative (RGGI), which limits CO_2 emissions from the power sector. Established in 2002, eleven states currently participate in RGGI: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont, and Virginia, with Pennsylvania expected to join in 2022, making the total 12 states ("Regional Greenhouse Gas Initiative (RGGI)," 2021). RGGI establishes a regional cap on CO_2 emissions, which sets an overall limit on emissions from power plants within RGGI participating states. The program is designed so that, over time, the regional cap declines incrementally, and has reduced emissions from power plants by more than 50% since its inception, over twice as fast as the nationwide average. In the process, the program has raised over $4 billion, as it is a market-based cap-and-invest initiative (*RGGI 101 Fact Sheet*, 2021).

Figure 8. RGGI emissions and allowance cap per year, 2001-2030 (proj.).



Source: Center for Climate and Energy Solutions, 2017.

RGGI is generally accepted as effective in reducing overall CO_2 emissions, with emissions falling below the cap permit limit each year since its inception. The RGGI emission allocation auction proceeds have been credited with part of this success, as RGGI rules provision that at least 25% of proceeds generated from auctions must be used for consumer benefit or strategic energy purposes, and between 2008-2013 (the early stage of the program's implementation), 67% of proceeds were used for "efficiency, GHG abatement, renewable energy, or electricity bill assistance," (Ceres, n.d.).

Other examples of regional partnerships include the West Coast Governors' Global Warming Initiative, a 2003 collaboration between the executives of California, Oregon, and Washington, with a number of provisions focused on electrification, emission reductions, and renewable electricity development (duVair et al., 2007), The Western Climate Initiative (WCI), which functions as a nonprofit corporation that provides assistance to support the "… implementation of state and provincial greenhouse gas emission trading programs," ("Multi-State Initiatives," 2020), with California and the Province of Quebec as current participating jurisdictions, and the Pacific Coast Collaborative (PCC), a "… cooperative agreement among the leaders of Alaska, British Columbia, California, Oregon, and Washington to leverage clean energy innovation and low-carbon development to reduce the effects of climate change on the regional economy. Participating jurisdictions coordinate, propose, and adopt policy aimed at generating investments in renewable energy, climate resilience, low-carbon transportation infrastructure, and environmental conservation," ("Multi-State Initiatives," 2020).

There is currently untapped potential for states within the Rocky Mountain Region and American Southwest to form a cooperative partnership in collaborative climate policy interventions, including Arizona and Nevada. Such a plan could be formulated at a small, incremental level, such as agreed upon taxes on carbon emissions, or as large as forming a market for emission allowances, similar to RGGI. Such a partnership would reduce the chances for spill-over effects or the "hotspot" effect within the region and has been proven effective as a model to reduce emissions.

Building a Market for Financial Risk Mitigation to Aid Adaptation Efforts

Another critical component of industry adaptation is hedging or diversifying to offset risks associated with investment. Tang and Jang explore this strategy by researching the use of "weather derivatives," which are financial instruments whose value depends on the index of weather variables such as temperature, rainfall, and snowfall. Examples of hedging within the winter sports tourism sector includes expansion of snowmaking, investment into different geographic areas in a collective, or financial risk management (insurance or derivatives). Weather derivatives are already utilized by a number of industries in managing volatility, as utility industry, insurance, banking, and agriculture are major users of weather derivatives (Tang & Jang, 2012). The researchers found that by using "snowfall forwards," or in other words, short positions (to receive a payoff when snowfall drops) based on local snowfall indexes, alleging that doing so will help to hedge the risks associated with weather volatility. Of course, any short position requires a counterparty. The researchers suggest that for ski resorts, the ideal counterparty would be "…local municipalities since they have negative exposure to snowfalls because of the extra costs of paying for materials and employee overtime for cleaning streets and maintaining infrastructure," (Tang & Jang, 2012). This represents an opportunity for policy creation, as this could result in a mitigation strategy through economic investment that has potential to mitigate risk for both the public and private sectors. Using a ski resort as an example, the researchers Monte Carlo simulations reveal that snowfall forwards could reduce ski resorts' cash flow volatility up to 25.8%, providing a large incentive to increase financial security, and eventually, grow the value of the company, which will spill over into the broader local and state economies (through tax revenue, new capital investments, and job creation). The researchers hypothesize that this hedging strategy or similar ones are also applicable for other nature-based businesses, such as beach resorts and golf courses (Tang & Jang, 2012).

The research is limited, however, in that their primary focus was on that of weather volatility rather than long-term climatic change. However, it is reasonable to assume that due to the general increase in weather volatility that accompanies climate change (in frequency/strength of extreme weather events, shifting precipitation patterns, etc.), the practice will continue to increase in prevalence and in usage. Additionally, research in this specific area is sparse, and using weather derivatives for strategic planning is still in its infancy in practice within the tourism industry, so further research is needed on how this concept can apply more specifically to climate change. Considering this, future research is needed to determine the viability of applying this in mutual partnership agreements between municipalities and tourism sites at high risk of adverse effects from climate change, such as ski resorts and golf courses. This represents a unique opportunity to minimize risk and provide mutual protection for both the industry and the locality that relies on it for its tax base and employment opportunities.

While this report will not analyze this as a legitimate alternative to addressing the economic effects of climate change, it is important to recognize the market mechanisms available to help mitigate damages. The lack of substantial research and lack of implementation case study opportunities does not allow this to be reviewed in this context but does open up future opportunities for research and further consideration of nontraditional market mechanisms being used in similar manners.

CRITERIA

1. Cost-Effectiveness (35%)

Cost-effectiveness will be measured by taking the net present value of the future 10-year costs for each individual alternative and dividing that by the sum of total metric tons of carbon emissions over the next ten years; to be measured in terms projected future emissions relative to 2018 emissions. This shall be representative as a proxy for all GHG emissions, as they are often associated with carbon emissions, and carbon emissions are considered the most important by climate scientists.[4]

2. Equity (35%)

Equity will be measured by a coefficient representing the geographic spread of carbon emission reductions from each individual alternative. This will be measured at the county level, as utilized prior in the analysis through the UN Intergovernmental Panel on Climate Change's 2007 report (Intergovernmental Panel on Climate Change & Intergovernmental Panel on Climate Change, 2007). An additional consideration will be on the magnitude of the effect, as it serves as a proxy for reduction in economic damages for most county level GDP measures. Weight will be given to the effect on high-income areas compared to the effect on low-income areas. Additionally, overall total impact will be considered, as the reduction of emissions, and subsequent reduction of economic harm, will impact impoverished communities as a net positive, generally. Specifically, this analysis will be done by comparing the projected GDP change per 1°C warming found in "Estimating the Economic Effects of Climate Change," (Hsiang et al., 2017) and comparing these projections to 2019 poverty rates (*Maps & Data*, n.d.).

3. Political Feasibility (20%)

Political feasibility will be measured on a value scoring system, ranging from "1" to "4," with "1" representing the lowest political feasibility, and "4" representing the highest political feasibility. While this measure is more abstract, it will be measured qualitatively based on political tendencies of policy makers, such as the governor or state legislators, prior ballot provisions or legislative voting measures, press releases, and based on current political trends at respective levels of governance, as well as the feasibility among stakeholder groups.

4. Ability to Implement (10%)

Implementation is critical to any policy's intended impact, as it is a necessary step to ensure that desired effects are accomplished. Some alternatives face external challenges, through multi-government cooperation, capital restrictions, or through regulatory incapacity. A successful alternative will be able to navigate these challenges and be properly implemented in a timely manner, and will be measured on a value scoring system, ranging from "1" to "4," with "1" representing the lowest ability to implement, and "4" representing the highest ability to

[4] For a more detailed explanation on the cost-effectiveness criteria, please refer to the "Methodology" section on page 25, as well as the appendix demonstrating all projections on the outcome and cost estimates.

implement. This likely will stem directly from existing programs and their ability to expand or shift resources to a new directive, technology, and staff availability. Additionally, this will factor in agency staff "buy-in" and the number of organizations that will be required to cooperate with one another to successfully implement a given alternative.

Methodology

For the *baseline cost estimates*, this report will use the Environmental Protection Agency's (EPA) Social Cost of Carbon (SC-CO_2) from 2020 at $42 per metric ton (2007$; 3% discount rate) (US EPA, 2016). This baseline figure, found using $42 x 135,300,000 tons CO_2 (the amount of projected emissions for our base year of 2020 for Arizona & Nevada), equals $5,682,600,000, or around 5.7 billion USD (in 2007 dollars). Additionally, the costs of program operations for ADEQ & PUCN are included at $56,565,800, or about 57 million USD. For future projections, these numbers will be updated using inflation projections for each year within our analysis timeline (*US Inflation Forecast*, n.d.). The estimated total cost for our base year is $5,874,465,800 USD, or around 5.8 billion. Of note, due to the nature of this analysis in its attempt to reduce the overall economic damages incurred for Arizona & Nevada, the cost-effectiveness measure will be a negative value, and should be viewed through the lens of reduction rather than effectiveness through value gain. The outcome projection tables & cost projection tables can be found in the attached appendix.

For *Alternative 1*, this report utilizes a CO_2 offset of 50 grams per kilowatt-hour of power produced from solar panels. The average solar equipped home has roughly a 5-kilowatt-hour system (*The Environmental Offset of Solar Power*, 2020). In 2021, small-scale solar photovoltaic generation within the residential sector in Arizona produced 165 thousand MWh and 59 thousand MWh in Nevada (*State Energy Profile Data*, 2022) which would offset 180,600 metric tons of CO_2 per year. Between 2010 to 2020, solar photovoltaic residential generation across the United States increased nearly 2,700%, or 270% per year (*SOLAR ELECTRICITY NET GENERATION - U.S. Energy Information Administration (EIA) - Data*, n.d.). This analysis will be assuming a slightly more conservative 200% increase per year increase (from the base year).

In utilizing the same calculation assumption of 200% increase in solar photovoltaic residential generation per year, the costs will increase accordingly. The total resource cost captures the total direct monetary impact of net metering, using the PUCN study as a general baseline. Under this test, the costs include net metering system capital costs as well as et metering program and integration costs. Of note, this cost identifies the projected effect of net metering increases discouraging the development of utility scale renewable energy projection from energy providers. The PUCN found a total resource cost at a $0.02/kWh rate, which is multiplied by total projected solar photovoltaic residential generation year-by-year (ICF International, 2018) (Energy + Environmental Economics, 2014).

For *Alternative 2*, this analysis utilized existing projections from researchers at Columbia for the establishment and implementation of a "low" carbon tax $30 per ton in 2021, rising at 5 percent plus inflation per year, which found emissions would be at 3,998 million metric tons of CO_2 in 2030, a 23.42% reduction (Larsen et al., 2020). Using the nationwide model at a micro scale, this report will split that reduction across ten years at 2.34% reduction per year. In estimating the cost versus gained revenues, this report will utilize existing evidence suggesting that carbon taxes may have a small positive effect instead of restricting growth and creating net losses (Pomerleau & Asen, 2019) (Metcalf & Stock, 2020).

For *Alternative 3*, using RGGI as a model, this report used reductions in the annual average CO_2 emissions from RGGI electric generation sources from 2016 to 2018, which decreased by 66.8 million short tons of CO2, or 48.3 percent, compared to the base period of 2006 to 2008. In addition, RGGI has a goal of a 30% reduction in CO2 emissions by 2030, compared to 2020 levels. Using the average between their 48.3% actual and 30% goal over the span of ten years, this analysis assumed a similar reduction schedule at 39.15% reduction by 2032 in the model, distributed equally across 10 years at a 3.92% reduction per year.

In estimating costs, this report will assume a similar structure for a regional carbon capture and trade organization to that of the Regional Greenhouse Gas Initiative's structure, and thus, can assume similar administrative operation costs (Regional Greenhouse Gas Initiative, Inc., 2022). Additionally, the analysis will consider the average lost revenues within the electric market to owners of generating assets from the third observation period of the program (2015-2017) as it is the closest data period to that of our base year. The total lost revenues was ~$350,000,000 for all generating asset owners, averaging $116,666,667 per year (Hibbard et al., 2018). This report will adjust both figures for inflation over the projection, with the same schedule as used in the baseline cost projections. In addition, this report will add on projected CO_2 allowance auction proceeds to reflect the revenue generated from the program, calculated using the projected emissions per year multiplied by the allowance price (per short ton of CO_2 emissions) (*Allowance Prices and Volumes | RGGI, Inc.*, n.d.). While the allowance price varies and is determined for each individual auction period, for feasibility's sake this report will continue to use the inflation projections used prior.

ALTERNATIVES AND FINDINGS

Alternative 1: Public-Private Cooperation

Given the geographic scope of this analysis, public-private partnerships are much more limited in availability and scope compared to examples offered previously, such as International Air Transport Association (IATA) or the International Civil Aviation Organization (ICAO). This is due to limited jurisdiction, lack of control, and finite capital resources at the regional, state, and local levels of governance in the United States. Public-Private cooperation at a state or regional level is much more likely to form as a broader strategic plan initiative through commitments to things such as green energy commitments, subsidization of transition processes, and economic development initiatives to attract clean industry.

One available opportunity for such a partnership is within the energy sector itself. Energy production remains as one of the highest regulated industries in the United States, varying from state to state, as it is recognized as a critically necessary for a functioning economy and society. As such, there is precedent for high public involvement within the energy sector. One example is in Virginia's 2018 energy plan, where the Virginia General Assembly passed Senate Bill 966 "Electric utility regulation; grid modernization, energy efficiency," (*SB 966 Electric Utility Regulation; Grid Modernization, Energy Efficiency.*, 2018), provisioning that Dominion Energy, Inc. and Appalachian Power Company (APCO), invest in clean energy development, to be subsidized by the commonwealth through "… increasing utility-funded energy efficiency programs to $100 million per year for Dominion Energy and $15 million per year for Appalachian Power Company," (Office of the Secretary of Commerce and Trade & Department of Mines, Minerals and Energy, 2018). A similar program can go into effect in both Arizona and Nevada, partnering with their largest private electric providers, like Arizona Public Service (APS), or with local electric co-ops. More specifically, expansion of the existing net metering program in Nevada, and the net billing program in Arizona, in conjunction with such a fund could greatly reduce the carbon load currently on the energy sector. This is an incredibly feasible option, as legal jurisdiction and program infrastructure currently exists in both states. By expanding the program to include more users, specifically through provisioning increased rates in metering and increasing the financial incentive to install solar photovoltaic energy, the demand-side intervention capabilities could make significant impact on future emissions. This will create returns for utilities as well, as increased take up in the net metering programs will reduce local pollution and carbon emissions from fossil fuel power plants, as well as enhance overall grid reliability and power quality. These benefits will help utilities reduce the cost of building new power plants, emission control technologies for fossil fuel plants, or other efficiency or reliability equipment ("Net Energy Metering," 2016). The onus of expanding these programs would lie in the hands of state legislators, who would work in conjunction to agencies such as the Arizona Corporation Committee and the Public Utility Commission Nevada to ensure enforcement capability.

On average, solar panels offset 50 grams of CO_2 per kilowatt-hour of power produced. The average solar equipped home has roughly a 5-kilowatt-hour system (*The Environmental Offset of Solar Power*, 2020). In 2021, small-scale solar photovoltaic generation within the residential sector in Arizona produced 165 thousand MWh and 59 thousand MWh in Nevada (*State Energy*

Profile Data, 2022) which would offset 180,600 metric tons of CO_2 per year. Between 2010 to 2020, solar photovoltaic residential generation across the United States increased nearly 2,700%, or 270% per year (*SOLAR ELECTRICITY NET GENERATION - U.S. Energy Information Administration (EIA) - Data*, n.d.). For this alternative, this report will assume a slightly more conservative 200% increase per year increase (from the base year). In utilizing the same calculation assumption of 200% increase in solar photovoltaic residential generation per year, the costs will increase accordingly. The total resource cost captures the total direct monetary impact of net metering, using the PUCN study as a general baseline. Under this test, the costs include net metering system capital costs as well as the metering program and integration costs. Of note, this cost identifies the projected effect of net metering increases discouraging the development of utility scale renewable energy projection from energy providers. The PUCN found a total resource cost at a $0.02/kWh rate, which is multiplied by total projected solar photovoltaic residential generation year-by-year (ICF International, 2018) (Energy + Environmental Economics, 2014).

- *Cost-Effectiveness*: Alternative one scores “Low” on the overall cost-effectiveness criteria. With a cost-effectiveness value of -1,376,509, alternative one represents greater harm compared to the baseline current policy continuation, which had a cost-effectiveness score of -1,325,887. This is due to the cost of program expansion compared to overall projected CO_2 emission reductions. Over the course of the projection analysis, alternative one is projected to reduce average annual emissions within the energy sectors of Arizona and Nevada by about 8.7% and represents a total projected cost of about $89.9 billion dollars.

- *Equity*: Alternative one scores “Low” in terms of the equity criteria evaluation. While net metering can relieve economic burden from consumers by reducing their average monthly energy utility bills, the upfront capital required to purchase and install solar photovoltaic energy panels or other eligible renewable energy sources makes this alternative prohibitively expensive. Additionally, this alternative has the lowest overall impact on emissions over the projection analysis, and thus, will have the smallest impact on vulnerable communities.

- *Political Feasibility*: Alternative one scores “4” in terms of political feasibility criteria evaluation. In both Arizona and Nevada, there are already existing net metering incentive programs in place that have experienced expansions over the past twenty years. Additionally, stakeholders, specifically, energy producers, are likely to support net metering expansion to some degree, as it reduces their overall energy burden and allows them to more gradually meet existing clean energy standards set in place by the ADEQ and PUCN, without placing strain on their existing provider systems.

- *Ability to Implement*: Alternative one scores “4” in terms of ability to implement criteria evaluation. As the current programs already exist, an expansion would only require shifting internal resources and potentially a slight increase in staff if the program has a high take-up rate, to ensure enforcement.

Alternative 2: Implementation of Taxes, Penalties, or other Punishment to Reach Socially Optimal Emissions

Another alternative feasibly implemented at the state level is that of taxes, penalties, or punishments on energy producers to reduce overall carbon emissions. This alternative has some existing precedent in other states, such as Colorado, with the Boulder Climate Action Plan Tax (as a part of their broader Climate Action Plan) (Newsletters, 2009), which established the first municipal carbon tax in the United States, or in California, with The San Francisco Bay Area Air Quality Management District's tax chagrining local emitters (Nastu, 2008). However, there is no precedent at the state level for passing an outright carbon tax in the United States.

At the state level, the state legislature would be responsible for enacting a policy provisioning a carbon tax on emissions for any given sector. A tax on emissions would need to establish what industries/businesses are subject to the penalty, what specific emissions (if more than CO_2 emissions) are subject to restriction, the exact penalty amount and threshold for the penalty (if one would exist), and how the funds accrued from the penalty should be distributed and used. This policy would be implemented in tandem between state regulatory agencies, such as the Arizona Department of Environmental Quality or Nevada Division of Environmental Protection, which would oversee monitoring emissions, and revenue collection agencies, such as the Arizona Department of Revenue or the Nevada Department of Taxation, to collect penalties from violating parties.

Setting the price of carbon to reach the socially optimum level of emissions would help pressure producers to reduce their emission totals. The exact price should be set incrementally to avoid any economic shock effects, with reducing totals over time to gradually hit loftier emission reduction goals. Existing taxes passed by other countries range from less than $1 to $121 per ton. In the U.S., models seem to converge at $40 to $47 (Metcalf, 2020). The establishment and implementation of a "low" carbon tax $30 per ton in 2021, rising at 5 percent plus inflation per year, researchers at Columbia found that emissions would be at 3,998 million metric tons of CO_2 in 2030, a 23.42% reduction (LARSEN et al., 2020). Using a price of $30/ton of CO_2 emissions, and utilizing the nationwide model at a micro scale, this analysis will be splitting that reduction across ten years at 2.34% reduction per year. In isolation, a carbon tax negatively impacts GDP growth & employment. However, recent research has revealed that when funds are instituted & redistributed correctly, carbon taxes may have a small positive effect instead (Pomerleau & Asen, 2019) (Metcalf & Stock, 2020). This, in-turn, negates program costs of implementation and enforcement, which are assumed to be relatively marginal considering the enforcement agencies' (ADEQ & PUCN) as well as financial reporting agencies' existing scope of operations.

- *Cost-Effectiveness*: Alternative two scores "High" on the overall cost-effectiveness criteria. With a cost-effectiveness value of -494,839, this alternative has the highest cost-effectiveness score in the analysis. Over the course of the projection analysis, alternative one is projected to reduce average annual emissions within the energy sectors of Arizona and Nevada by about 21.1% and represents a total projected cost of $22 billion dollars. This notable difference in total cost projection compared to other alternatives is partially due to the projected incurred revenues gained from penalties accrued from emitters within the energy sector.

- *Equity*: Alternative two scores "Moderate" on equity, as it represents the second most impact on emissions in the alternative projection analysis and is significantly higher than alternative one. While a carbon tax does not impose any direct costs on consumers, energy producers would likely push some, if not all, of any potential increased costs onto consumers. This can be mitigated through proper management of the revenues accrued from tax penalties by the state governments, and can be utilized in tax rebates, bill relief payments, or energy efficiency improvements for communities. This alternative does not, however, specifically target at-risk communities, and information availability and time costs may be present, severely diminishing the overall equity evaluation score for this alternative.

- *Political Feasibility*: Alternative two scores "1" in terms of political feasibility. No fully encompassing statewide (or nationwide) carbon tax has been implemented in the United States, though many have been proposed. Of note, former Arizona US Senator proposed placing a price on carbon emissions in 2018 (Green, 2018), but the bill did not pass. Additionally, current Nevada governor Steve Sisolak signed an executive order calling for new climate strategy, notably including "market-based mechanisms," such as a carbon tax (Noa Dalzell, 2019) (Steve Sisolak, 2019). No legislation since has included an explicit carbon tax, however.

- *Ability to Implement*: Alternative two scores "2" in terms of ability to implement criteria evaluation. While ADEQ & PUCN already ensure compliance with existing emission portfolio standards, this alternative would expand their regulatory responsibility, and would also require expansion within the Arizona Department of Revenue and the Nevada Department of Taxation, to collect penalties from violating parties. This is a large shift in resources, and standards and procedures would require significant time to design and implement if this alternative was selected.

Alternative 3: Regional Partnerships

Regional partnerships have a degree of constitutionality under the "Compacts Clause,"[5] as "… the [Supreme] Court has used a functional test that permits interstate agreements without congressional consent so long as the agreements do not undermine the supremacy of the federal government," (Harvard Law Review, 2007). This interpretation has been utilized in environmental compacts across the United States for many years, most notably, the Regional Greenhouse Gas Initiative (RGGI), which limits CO_2 emissions from the power sector. Established in 2002, eleven states currently participate in RGGI: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont, and Virginia, with Pennsylvania expected to join in 2022, making the total 12 states ("Regional Greenhouse Gas Initiative (RGGI)," 2021). RGGI establishes a regional cap on CO_2 emissions, which sets an overall limit on emissions from power plants within RGGI participating states.

[5] For more information on the "Compacts Clause" and Interstate Commerce Provisions in the US Constitution, see https://constitution.congress.gov/browse/essay/artI_S10_C3_3/

A similar program would likely see success in a region such as the Rocky Mountain West. The multistate cooperation is critical to the success of such a program, however, as electric providers can avoid cap restrictions through importing power from bordering states not a part of a regional cooperative, which is diminished as more states join into a partnership or can be reduced through border adjustments that penalize this action to discourage it. A partnership would need to be established in tandem between state legislatures and through executive approval in participating states. The partnership would need to agree to a cap on carbon emissions for energy producers, such as the 116,112,784 CO_2 allowances for RGGI in 2022 (*Elements of RGGI | RGGI, Inc.*, 2022). A potential model exists through a different multi-state compact NGO, in the Southwest Energy Efficiency Project (SWEEP), which focuses on energy efficiency measures in Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming (Southwest Energy Efficiency Project, n.d.). A compact among these states would offer significant protection from border effects and would be of enough magnitude to see substantial changes in emissions over time. In using RGGI as a model, the annual average CO2 emissions from RGGI electric generation sources from 2016 to 2018 decreased by 66.8 million short tons of CO2, or 48.3 percent, compared to the base period of 2006 to 2008. In addition, RGGI has a goal of a 30% reduction in CO2 emissions by 2030, compared to 2020 levels. Using the average between their 48.3% actual and 30% goal over the span of ten years, we will assume a similar reduction schedule at 39.15% reduction by 2032 in our model, distributed equally across 10 years at a 3.92% reduction per year.

In estimating costs, this report will assume a similar structure for a regional carbon capture and trade organization to that of the Regional Greenhouse Gas Initiative's structure, across the prior mentioned six states, and thus, can assume similar administrative operation costs (Regional Greenhouse Gas Initiative, Inc., 2022). Additionally, we will consider the average lost revenues within the electric market to owners of generating assets from the third observation period of the program (2015-2017) as it is the closest data period to that of our base year. The total lost revenues was ~$350,000,000 for all generating asset owners, averaging $116,666,667 per year (Hibbard et al., 2018). We will adjust both figures for inflation over our projection, with the same schedule as used in the baseline cost projections. In addition, we will add on projected CO_2 allowance auction proceeds to reflect the revenue generated from the program, calculated using the projected emissions per year multiplied by the allowance price (per short ton of CO_2 emissions) (*Allowance Prices and Volumes | RGGI, Inc.*, n.d.). While the allowance price varies and is determined for each individual auction period, for feasibility's sake we will continue to use the inflation projections used prior.

- *Cost-Effectiveness*: Alternative three scores "Moderate" in cost effectiveness, with a score of -1,279,906. Over the course of the projection analysis, alternative one is projected to reduce average annual emissions within the energy sectors of Arizona and Nevada by about 33% and represents a total projected cost of $58.3 billion dollars.

- *Equity*: Alternative three scores "High" on equity, as it represents the highest impact on emissions in the alternative projection analysis and is significantly higher than alternative one. Similar to alternative two, the cost of allowance purchases may be partially passed on to consumers from energy providers, but this can once again be mitigated through allowance revenues being reinvested through rebates, efficiency upgrades, and bill relief.

Additionally, the overall reduction in emissions is significant enough to mitigate the cost transfer, as the net benefit of harm reduction far exceeds it.

- *Political Feasibility*: Alternative three scores “2” in terms of political feasibility. Currently, there exists no program to the scale and scope comparable to RGGI in the American West, but there does exist precedent for multi-state, regional partnerships, such as SWEEP and the Western Climate Initiative (WCI), which houses Washington & California as participating jurisdictions subject to emission auction provisions. Participation in similar programs to that of this alternative, such as SWEEP, indicates that there is a reasonable opportunity for either the creation of a new program, or joining/adapting an existing program (such as SWEEP or WCI) (*Greenhouse Gas Emissions Trading*, n.d.).

- *Ability to Implement*: Alternative three scores “1” in terms of ability to implement criteria evaluation. The creation of a regional allowance market would require a large shift in resource, creation of state commissions to determine procedures and policies, and cooperation between different state governments. Thus, the application for this alternative is incredibly taxing and time consuming, and will require a great deal of organizing, strategizing, and implementation.

Outcomes Matrix

Figure 9. Outcomes Matrix.

	Public-Private Cooperation	Carbon Tax	Regional Partnership
Cost-Effectiveness	Low -1,376,509	High -494,839	Moderate -1,279,906
Equity	Low	Moderate	High
Political Feasibility	4	1	2
Ability to Implement	4	2	1

Recommendation

To lessen the future negative effects of climate change, Arizona and Nevada must unequivocally commit to reducing greenhouse gas emissions. This analysis has found that the best manner in which to accomplish this goal is through focusing on the energy sector, as it is the largest carbon dioxide emission source for both states. This analysis recommends Alternative 3: Developing a Regional Partnership to best accomplish emission reductions.

Alternative three allows the states to accomplish their set out goal of reducing CO_2 emissions while being moderately cost efficient, highly equitable, and politically feasible. While this alternative will be difficult to implement, it has a high longevity, as the time spent to create the program will allow it to cement itself as a continuously operated and updated program, constantly reevaluating its emissions cap-and-trade market.

While the cost effectiveness score is the second best in terms of the ten-year projection, this alternative provides the most flexibility to determine both the cap amount, and the yearly CO2 allowance cost, as it is continuously updated. This alternative also makes the largest overall impact on emissions, reducing them a projected 33% over the ten-year period. This reduction in emissions, along with the additional revenues brought in from allowance auction proceeds, represents a nearly $13.3 billion reduction in total costs across the ten-year projection compared to the current policy, status-quo projection. This alternative will help shift production towards cleaner sources of energy, reduce emissions, spur development, and reduce the future potential economic harm from climate change.

IMPLEMENTATION

To implement alternative three, the states must form broad, consensus support for the creation of a regional partnership that creates an emissions market. This is likely best accomplished through multiple organizations coordinating efforts in state legislatures, specifically, nongovernmental organizations, such as Protect Our Winters, lobbying for a proposal that authorizes each state as a participating jurisdiction. Such a proposal would be best suited to have broad outlines that allow for individual states to set procedures and policies distinct from one another to allow for different timelines and priorities when joining the compact.

The multistate cooperation is critical to the success of such a program, however, as electric providers can avoid cap restrictions through importing power from bordering states not a part of a regional cooperative. This is crucial considering the border effects that can result and render the program effectively useless. To combat this, the agreement must span multiple states, ideally as many as possible. This is reasonable over the program's timespan, however, as if the program experiences success, more states can be expected to join, such as what has happened in the case of RGGI. A good target would be the states already participating in SWEEP, being Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming, as these states share common regional boundaries and similar sector features, along with participating in the same electric markets currently.

Following the authorization of such a compact agreement, commissions that represent the individual states' interests will need to be formed to write out an amicable partnership agreement. This will determine the power each state has separate from the commission, will outline what powers it is effectively surrendering to the partnership, what enforcement mechanisms the partnership will have, and how it will delineate enforcement responsibilities to state commissions or associated agencies.

Once the agreement has been finalized, the current market provisions will be outlined by the partnership organization. These will likely include the initial cap, the allowance cost and schedule, and future adjustment schedules. Once this has been provisioned, the program will enter operation following the initial auction period. While the projection analysis period is over a ten-year period, the organization may decide to have shorter observation periods to ensure that the program is functioning as intended and effectively, such as how RGGI operates on three-year observation periods.

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APPENDIX

Output Projections

Current Policy Projection

Arizona	
Year	CO_2 (in million metric tons)
2008	102.6
2009	93.8
2010	99.0
2011	97.2
2012	95.0
2013	99.0
2014	97.1
2015	94.7
2016	90.7
2017	90.3
2018	93.9
10-Year Average: 95.8	
2022	95.8
2023	95.8
2024	95.8
2025	95.8
2026	95.8
2027	95.8
2028	95.8
2029	95.8
2030	95.8
2031	95.8
2032	95.8
TOTAL	1053.8

Nevada	
Year	CO_2 (in million metric tons)
2008	40.9
2009	39.5
2010	40.9
2011	37.5
2012	37.5
2013	39.4
2014	40.1
2015	38.1
2016	39.6
2017	39.7
2018	41.0
10-Year Average: 39.5	
2022	39.5
2023	39.5
2024	39.5
2025	39.5
2026	39.5
2027	39.5
2028	39.5
2029	39.5
2030	39.5
2031	39.5
2032	39.5
TOTAL	434.5

Arizona + Nevada Average/Year: 135.3
AZ + NV TOTAL: 1488.3

Alternative 1: Public-Private Cooperation – Net Metering Program

Year	Net Metering CO_2 Offset/Year (in million metric tons)	CO_2 (in million metric tons)
2022 (data from Dec. 2021)	0.14 (AZ) + 0.04 (NV) = 0.18	135.12
2023	0.36	134.76
2024	0.54	134.22
2025	0.72	133.5
2026	0.90	132.6
2027	1.08	131.52
2028	1.26	130.26
2029	1.44	128.82
2030	1.62	127.20
2031	1.80	125.40
2032	1.98	123.42
TOTAL		1436.82

Alternative 2: Implementation of Taxes, Penalties, or other Punishment to Reach Socially Optimal Emissions – Carbon Tax

Year	CO_2 (in million metric tons)
2022	132.13
2023	129.04
2024	126.02
2025	123.07
2026	120.19
2027	117.38
2028	114.63
2029	111.95
2030	109.33
2031	106.77
2032	104.27
TOTAL	1294.78

Alternative 3: Regional Partnerships – Regional Carbon Capture & Trade Market

Year	CO_2 (in million metric tons)
2022	130.00
2023	124.90
2024	120.00
2025	115.30
2026	110.78
2027	106.44
2028	102.27
2029	98.26
2030	94.40
2031	90.70
2032	87.15
TOTAL	1180.2

Cost Projections

Current policy projection

Year	CO_2 (in million metric tons)	SC-CO_2/mT CO_2 ($USD 2007)	SC-CO_2 Total ($USD 2007)	Projected ADEQ Emissions Inspection Budget ($)	Projected PUCN Budget ($)	Inflation Projections (%)	ADEQ-EI + PUCN with Inflation ($)	TOTAL ($)
2022	135.3	43	5,817,900,000	26,665,800	29,900,000	--	56,565,800	5,874,465,800
2023	135.3	44	5,953,200,000	27,225,782	30,527,900	2.1	57,753,682	6,010,953,682
2024	135.3	45	6,088,500,000	27,797,523	31,168,986	2.1	58,966,509	6,147,466,509
2025	135.3	46	6,223,800,000	28,381,271	31,823,535	2.1	60,204,806	6,284,004,806
2026	135.3	47	6,359,100,000	28,977,278	32,491,829	2.1	61,469,107	6,420,569,107
2027	135.3	48	6,494,400,000	29,614,778	33,206,649	2.2	62,821,427	6,557,221,427
2028	135.3	49	6,629,700,000	30,325,533	34,003,609	2.4	64,329,142	6,694,029,142
2029	135.3	49	6,629,700,000	31,053,346	34,819,695	2.4	65,873,041	6,695,573,041
2030	135.3	50	6,765,000,000	31,798,626	35,655,368	2.4	67,453,994	6,832,453,994
2031	135.3	51	6,900,300,000	32,561,793	36,511,097	2.4	69,072,890	6,969,372,890
2032	135.3	52	7,035,600,000	33,343,276	37,387,363	2.4	70,730,639	7,106,330,639
TOTAL	1488.3	--	70,897,200,000	327,745,006	367,496,031	--	695,241,037	71,592,441,037

Alternative 1: Public-Private Cooperation – Net Metering Program

Year	Total Projected Solar PV Residential Generation (kWh)	Levelized Total Resource Cost (-$)	Status-Quo Costs (-$)	TOTAL (-$)
2022	448,000,000	8,960,000	5,874,465,800	5,883,425,800
2023	896,000,000	17,920,000	6,010,953,682	6,028,873,682
2024	1,792,000,000	35,840,000	6,147,466,509	6,183,306,509
2025	3,584,000,000	71,680,000	6,284,004,806	6,355,684,806
2026	7,168,000,000	143,360,000	6,420,569,107	6,563,929,107
2027	14,336,000,000	286,720,000	6,557,221,427	6,843,941,427
2028	28,672,000,000	573,440,000	6,694,029,142	7,267,469,142
2029	57,344,000,000	1,146,880,000	6,695,573,041	7,842,453,041
2030	114,688,000,000	2,293,760,000	6,832,453,994	9,126,213,994
2031	229,376,000,000	4,587,520,000	6,969,372,890	11,556,892,890
2032	458,752,000,000	9,175,040,000	7,106,330,639	16,281,370,639
TOTAL	917,056,000,000	18,341,120,000	71,592,441,037	89,933,561,037

Alternative 2: Implementation of Taxes, Penalties, or other Punishment to Reach Socially Optimal Emissions – Carbon Tax

Year	CO_2 (in million metric tons)	Carbon Tax ($30 + 5% annual increase) ($)	Additional Revenue (+$)	Status-Quo Costs (-$)	TOTAL COSTS (Costs – Additional Revenue) ($)
2022	132.13	30	3,963,900,000	5,874,465,800	1,910,565,800
2023	129.04	31.5	4,064,760,000	6,010,953,682	1,946,193,682
2024	126.02	33.08	4,168,741,600	6,147,466,509	1,978,724,909
2025	123.07	34.73	4,274,221,100	6,284,004,806	2,009,783,706
2026	120.19	36.47	4,383,329,300	6,420,569,107	2,037,239,807
2027	117.38	38.29	4,494,480,200	6,557,221,427	2,062,741,227
2028	114.63	40.20	4,608,126,000	6,694,029,142	2,085,903,142
2029	111.95	42.21	4,725,409,500	6,695,573,041	1,970,163,541
2030	109.33	44.32	4,845,505,600	6,832,453,994	1,986,948,394
2031	106.77	46.54	4,969,075,800	6,969,372,890	2,000,297,090
2032	104.27	48.87	5,095,674,900	7,106,330,639	2,010,655,739
TOTAL	1294.78	--	49,593,224,000	71,592,441,037	21,999,217,037

Alternative 3: Regional Partnerships – Regional Carbon Capture & Trade Market

Year	Projected Program Operation Costs (-$)	Projected Lost Revenues (-$)	Inflation Projections (%)	CO_2 (in million metric tons)	Allowance Cost ($)	Allowance Auction Revenues (+$)	Status-Quo Costs (-$)	TOTAL (Additional Revenue – Costs) (-$)
2022	3,118,019	350,000,000	--	130.00	13.50	1,755,000,000	5,874,465,800	4,472,583,819
2023	3,183,497	357,350,000	2.1	124.90	13.78	1,721,559,150	6,010,953,682	4,649,928,029
2024	3,250,351	364,854,350	2.1	120.00	14.07	1,688,754,420	6,147,466,509	4,826,816,790
2025	3,318,608	372,516,291	2.1	115.30	14.37	1,656,686,381	6,284,004,806	5,003,153,324
2026	3,388,299	380,339,133	2.1	110.78	14.67	1,625,167,384	6,420,569,107	5,179,129,156
2027	3,462,842	388,706,594	2.2	106.44	14.99	1,595,851,582	6,557,221,427	5,353,539,281
2028	3,545,950	398,035,552	2.4	102.27	15.35	1,570,130,845	6,694,029,142	5,525,479,800
2029	3,631,053	407,588,405	2.4	98.26	15.72	1,544,771,704	6,695,573,041	5,562,020,796
2030	3,718,198	417,370,527	2.4	94.40	16.10	1,519,705,716	6,832,453,994	5,733,837,004
2031	3,807,435	427,387,420	2.4	90.70	16.48	1,495,184,362	6,969,372,890	5,905,383,383
2032	3,898,813	437,644,718	2.4	87.15	16.88	1,471,142,721	7,106,330,639	6,076,731,449
TOTAL	38,323,065	4,301,792,994	--	1180.2	--	17,643,954,264.20	71,592,441,037	58,288,602,832

Net Present Values

Net present value for the baseline

($1,973,318,226)

Net present value for Alternative 1

($1,977,796,039)

Net present value for Alternative 2

($640,707,283)

Net present value for Alternative 3

($1,510,544,868)

Cost Effectiveness Measures

Estimates for the base case

-1,973,318,226 / 1488.3 = -1,325,887

Alternative 1

-1,977,796,039 / 1436.82 = -1,376,509

Alternative 2

-640,707,283 / 1294.78 = -494,839

Alternative 3

-1,510,544,868 / 1180.2 = -1,279,906