

# Climate Change and Texas

Impacts, Sources of Pollution, and the Path  
Towards Keeping Our Climate Livable



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# | Executive Summary

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Texas is both the largest emitter of global warming pollution<sup>1</sup> in the United States and home to some of the most dramatic consequences of that pollution.<sup>2</sup>

If we don't act quickly to cut global warming pollution and get on a path to net zero emissions by mid-century, the consequences could prove catastrophic for the Lone Star State. Texas already has more billion dollar weather disasters than any other state.<sup>3</sup> But there is still hope, and broad public support<sup>4</sup> and technological advances,<sup>5</sup> for cutting emissions and protecting a livable climate in Texas.

This primer summarizes the latest science on how global warming is impacting Texas, the largest sources of pollution, solutions for cutting emissions to avoid the worst impacts of climate change, and steps for adapting to those climate changes which are now inevitable.

## **Global warming is making Texas hotter, drier and deadlier**

Extreme weather is on the rise, with record heat, wildfires, flooding and hurricanes causing significant loss of human life and damage to property and infrastructure.<sup>6</sup> Extreme temperatures disrupt electricity service and keep people from spending time outside, drought threatens drinking water supplies and reduces opportunities for swimming and boating, and allergy<sup>7</sup> and mosquito seasons grow in length. Entire species may disappear from Texas altogether, as many already have.<sup>8</sup>

## **Texas is getting dangerously hot**

From 1895 to 2020, the average daily minimum and maximum temperatures rose by 2.2 degrees in Texas.<sup>9</sup> The average annual surface temperature in 2036 is predicted to be another 1.8 degrees warmer than the 1991-2000 average.<sup>10</sup> By 2050, Texas is projected to see 115 dangerous or extremely dangerous heat days

(greater than 103 degrees) a year – an increase of more than 40 days.<sup>11</sup>

Heat-related health issues and deaths are on the rise.<sup>12</sup> At least 378 heat-related deaths were documented in Texas between 2018 and 2021, according to the U.S. Centers for Disease Control and Prevention (CDC).<sup>13</sup> A 2015 report found that Texas is likely to see as many as 2,580 additional deaths per year over the next five to 25 years due to extreme heat.<sup>14</sup>

## **Texas' boom and bust water cycle will see more extreme swings**

Higher heat increases evaporation, reducing water levels in rivers and lakes<sup>15</sup> and increasing strain on drinking water supplies.<sup>16</sup>

Evaporation also increases the amount of water that rises into the atmosphere and condenses into rain. When more moisture-laden air moves over land or converges into a storm system, it can produce more intense precipitation and flooding. Texas residents are expected to experience a 50% increase in flood exposure by 2050.<sup>17</sup>

Climate change is also melting ice caps and warming and expanding the oceans. The resulting sea level rise, combined with land sinking due to removal of oil, gas and water from the ground,<sup>18</sup> has caused Texas' coastline to retreat an average of four feet per year since 2000. Sea levels in Galveston could rise as much as 14 feet by 2150.<sup>19</sup>

Drought will decrease agricultural yields and increase health risks for livestock.<sup>20</sup> Texas' cotton output is predicted to drop by as much as 6% by 2020-2039, and an additional 15% by 2040-2059 without climate action.<sup>21</sup> Corn yields may decrease by as much as 39% annually by 2050 without action.<sup>22</sup>

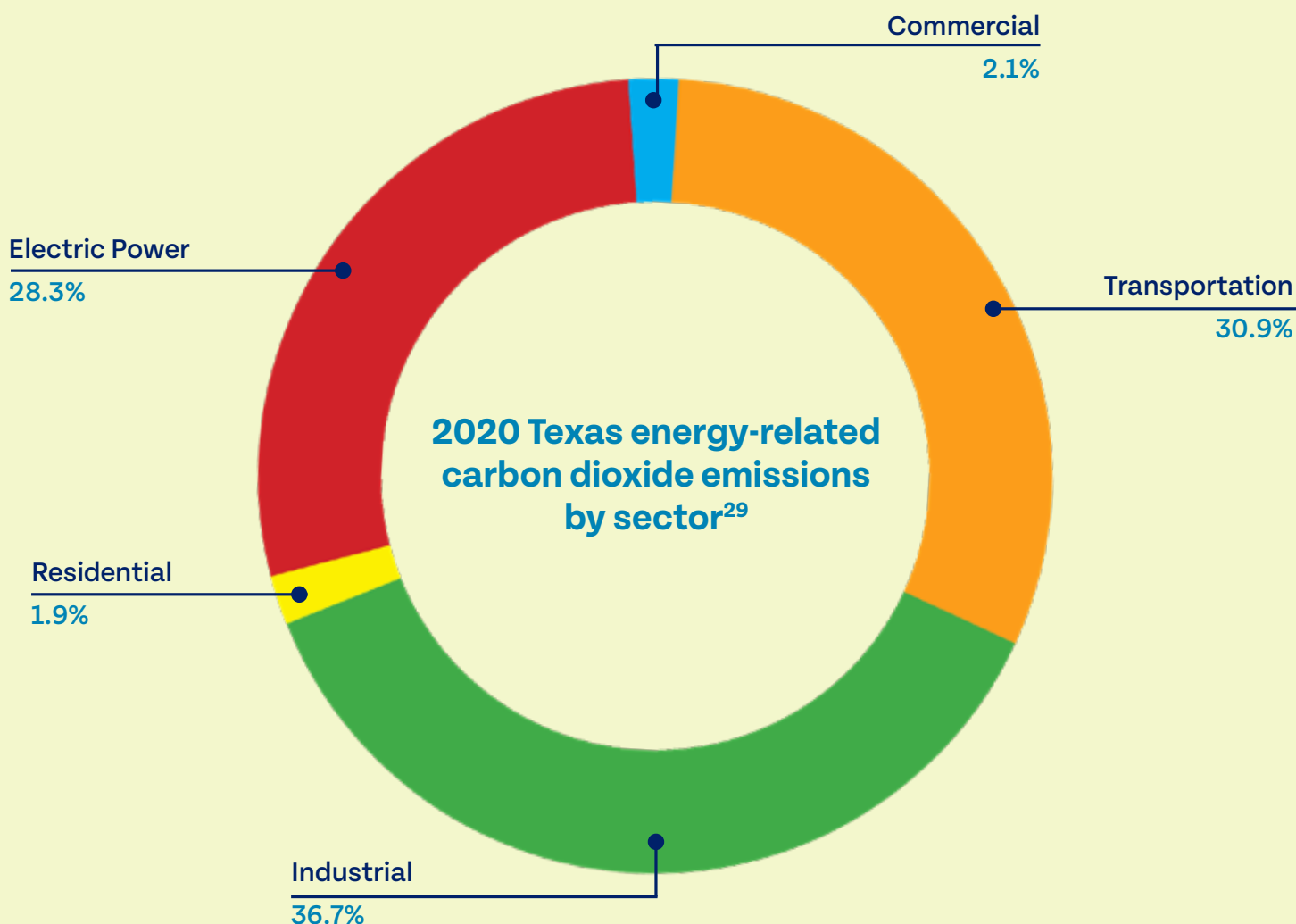
## Texas is getting more dangerous

Warming winters and wetter summers mean Texas is likely to see an expansion of insects moving northward, including mosquitoes that carry West Nile virus, Zika, dengue and yellow fever, as well as beetles that harm native crops.<sup>23</sup> In Lubbock, the number of days in mosquito season has grown from an average of 36 days per year from 1980-1989 to 54 days per year since 2006.<sup>24</sup>

## Global warming is occurring primarily due to the burning of fossil fuels

Texas is the largest annual emitter of carbon dioxide in the United States, emitting 683.2 million metric

tons in 2019 — nearly twice as much as second-place California.<sup>25</sup> If Texas were a nation, it would rank as the eighth-largest emitter in the world.<sup>26</sup> And global warming pollution in Texas is *increasing*. Texas' carbon dioxide emissions from fossil fuel consumption increased 73.9% between 1970 and 2020, reaching 624.0 million metric tonnes in 2020.<sup>27</sup> The majority of Texas' emissions are from three main sources: transportation, industry, and electricity generation.<sup>28</sup>







*Fayette Power Project, a coal power plant near La Grange, Texas*  
Credit: Sam LaRussa on Unsplash, <https://unsplash.com/photos/jqlv433YFI0>

## Industry

The bulk of industrial emissions in Texas come from petrochemical production and oil and gas drilling and refining.<sup>31</sup> Texas extracts, produces and refines more crude oil and natural gas than any other state.<sup>32</sup> We're also home to 70% of the nation's petrochemical production capacity.<sup>33</sup> Dozens of new petrochemical facilities, liquefied natural gas (LNG) export terminals, and other manufacturing facilities threaten to significantly increase Texas' industrial emissions.<sup>34</sup>

## Transportation

Passenger cars, medium- and heavy-duty trucks, and light-duty trucks are the biggest contributors to greenhouse gas emissions from the transportation

sector nationally, accounting for nearly half of these emissions.<sup>35</sup> High transportation emissions result in large part from Texans' commutes – in 2016 alone, Texans drove more than 271 billion miles.<sup>36</sup> Texas drivers are responsible for more carbon dioxide than every train in the world combined.<sup>37</sup>

Factors driving high emissions from light-duty vehicles include inefficient vehicles running on dirty fuels, car-dependent land use patterns, lack of transit access and dangerous conditions for walking and biking.

Commercial aircraft, ships, boats and trains make up the remainder of greenhouse gas emissions from transportation.

## Electricity

While Texas has made significant progress in reducing greenhouse gas emissions from the electricity sector, and is now ranked first and second for wind and solar power production respectively, Texas still remains the largest consumer of coal in the United States<sup>38</sup> and total emissions from the state's power sector alone exceed the pollution from the entire economies of all but six states.

## Agriculture

State-level data on greenhouse gas emissions from agriculture are not available, but farming activities in the United States accounted for 11.2% of U.S. greenhouse gas emissions in 2020.<sup>39</sup> And as a major agricultural producer,<sup>40</sup> Texas farms and ranches are significant contributors to emissions.

### Top emitters of greenhouse gas emissions in Texas, 2021<sup>30</sup>

FACILITY	COUNTY	PARENT COMPANIES	GHG QUANTITY (METRIC TONS CO <sub>2</sub> e)
W A Parish	Fort Bend	NRG Energy Inc (100%)	13,809,928
Martin Lake	Rusk	Vistra Corp (100%)	13,412,908
Oak Grove	Robertson	Vistra Corp (100%)	12,522,718
ExxonMobil Baytown	Harris	ExxonMobil (100%)	11,731,710
Sam Seymour	Fayette	Lower Colorado River Authority (63.4%) Austin Energy Corp (36.6%)	10,901,252
J K Spruce	Bexar	CPS Energy (100%)	7,954,921
Galveston Bay Refinery	Galveston	Marathon Petroleum Corp	6,730,640
ExxonMobil Beaumont Refinery	Jefferson	ExxonMobil (100%)	6,108,591
Limestone	Limestone	NRG Energy Inc (100%)	5,931,804
Sandy Creek Energy Station	McClellan	LS Power Equity Partners Lp (63.87%) Brazos Electric Power Cooperative Inc (25%) Lower Colorado River Authority (11.13%)	5,384,632



# Solutions to Pollution

In order to stabilize the climate and prevent further warming, carbon dioxide emissions need to reach net zero globally by 2050.<sup>41</sup> As one of the planet's top polluters, Texas must do its fair share to decarbonize.

Encouragingly, a recent University of Texas study found “it is possible for the Lone Star State to achieve a net-zero future, and there are multiple ways of getting there.” Despite the state economy's historic dependence on fossil fuel production, Texas could eliminate its carbon pollution in fewer than thirty years while also increasing jobs and the state GDP. The report found that decarbonization of the electric grid, increased electrification of vehicles, reforestation, and other methods will be key to getting Texas to net-zero emissions.<sup>42</sup>

## Switching to 100% renewable energy

Texas has made significant progress in reducing greenhouse gas emissions from the electricity sector. Over the last ten years, Texas accelerated its transition to renewable energy and is now ranked first and second for wind and solar power production respectively.<sup>43</sup> Along with this growth in renewables, Texas is also expecting a reduction in coal power plants. Driven by competition with renewable resources and natural gas, a quarter of US coal plants will close by 2029.<sup>44</sup> Texas and three other states account for 42% of these closures.<sup>45</sup>

With its vast plains and multitude of sunny days, Texas has the best renewable energy potential in the nation.<sup>46</sup> Texas already leads the nation in wind-powered electric generation, producing more than 25% of the total wind-generated electricity in the U.S.<sup>47</sup> Texas also ranks second in solar energy capacity and fourth in battery storage.<sup>48</sup> And we've only just gotten started.

A staggering 209 gigawatts (GWh) of additional solar, wind and battery storage are under development in the ERCOT electric grid in Texas.<sup>49</sup>

New clean energy tax credits in the Inflation Reduction Act will help make sure most of the projects get built. The Bureau of Ocean Energy Management will begin leasing for wind energy development in the Gulf of Mexico next year, creating the potential for even more renewable energy power in Texas.<sup>50</sup>

As state leaders consider the future of the electric grid in the wake of Winter Storm Uri, they should work to support the transition to clean energy by rejecting efforts to make renewable energy more expensive and adopting policies that promote greater energy efficiency and more transmission capacity to bring wind and solar from rural parts of our state to our cities.

## Transforming transportation

Electric vehicles produce lower tailpipe emissions than conventional vehicles, and as Texas increases its renewable energy consumption, the emissions from charging their batteries will decrease as well.<sup>51</sup> Texas ranks fourth in the nation for electric vehicles and ERCOT projects that more than one million EVs will be on the road by 2028.<sup>52</sup>

Thanks to funding from the bipartisan infrastructure law, Texas is building a network of electric chargers throughout the state<sup>53</sup> and more than a dozen school districts are purchasing electric school buses.<sup>54</sup> The state will also receive \$3.3 billion over five years to improve public transportation options<sup>55</sup> and funding to build more sidewalks, trails, and bike lanes.<sup>56</sup>

On the other hand, the Texas Department of Transportation plans to spend \$34.58 billion for highway widening projects alone over the next ten years.<sup>57</sup> A Georgetown Climate Center analysis compared two investment scenarios: one with a larger focus on highway expansion and another emphasizing low-carbon transportation strategies and road maintenance. Their analysis found that the low-

emission scenario could cut emissions by 1.6% below the baseline within five years.<sup>58</sup>

Instead of expanding its highways, the state should instead prioritize repairs to existing roads, transit, and walking and biking infrastructure. We can also further encourage Texans to switch to electric vehicles by expanding funding for the state rebate program,<sup>59</sup> converting state and local vehicle fleets to electric, and modernizing the electric grid to accommodate demands from EVs.

### **Cutting industrial emissions**

The planet can not handle the increased emissions which will come from the current expansion of fossil fuel and petrochemical infrastructure. Much of this infrastructure is to accommodate expected demand for single-use plastics, which pose additional environmental challenges. The state needs to issue a moratorium on the buildout and instead work to cut emissions at existing facilities. Texas should also work to stop methane leaks and end routine flaring of gas.

### **Growing climate solutions through agriculture**

Texas farmers have the opportunity to play a powerful role in solutions to climate change. Climate stewardship practices, including no- and low-till farming, planting cover crops, diversified crop rotations, rotational grazing, and improved nutrient management, sequester carbon in the roots of plants and in soils.<sup>60</sup> The Inflation Reduction Act will invest roughly \$20 billion in agricultural conservation and climate programs, which provides a historic opportunity for Texas agriculture to further grow climate solutions.<sup>61</sup>

## **Conclusion**

As one of the world's largest global warming polluters, Texas has a responsibility to lead and to act. The challenge is massive, but solutions are at hand. By switching from fossil fuels to renewable energy, adopting less resource-intensive ways of living and building a closed-loop economy with zero waste, we can prevent the worst impacts of global warming and improve the health and welfare of people and ecosystems for generations to come. By continuing to support this transition, Texas can continue to lead the nation in ingenuity and help preserve our great state for future generations.

# | Introduction

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*Climate change is moving faster than we are, but we don't give up because we know that climate action is the only path.*

*António Guterres  
Secretary-General of the United Nations*

Texas is experiencing the effects of climate change firsthand: deadly temperatures, more intense hurricanes and droughts, rising sea levels, and more.<sup>62</sup> With a lot to lose from global warming but also a lot to gain from developing our abundant clean energy resources, Texas has the potential — and the responsibility — to be a global leader in solving the crisis.

But progress in Texas is daunting. The fossil fuel industry is firmly entrenched in the state's economy and enjoys significant influence in state government. The state's leaders rarely even say the words climate change,<sup>63</sup> much less take bold action to cut emissions or take steps to prepare the state for the coming impacts.<sup>64</sup>

Governor Abbott ignored offers by the state's leading climate scientists to brief him on the science of climate change<sup>65</sup> but consulted a climate skeptic ahead of record-low temperatures that plunged Texas into a deadly winter storm in February 2021.<sup>66</sup> He signed an executive order to attempt to block President Biden's climate plans, directing "every state agency to use all lawful powers and tools to challenge any federal action that threatens the energy sector in Texas."<sup>67</sup>

Attorney General Ken Paxton joined with other Republican attorneys general in successfully convincing the U.S. Supreme Court to weaken the

authority of the Environmental Protection Agency to restrict global-warming emissions.<sup>68</sup>

The Texas Legislature has passed laws to block cities from regulating fracking<sup>69</sup> or plastic pollution,<sup>70</sup> blocked state agencies from doing business with companies reducing their investments in oil and gas,<sup>71</sup> and moved money intended to reduce air pollution to TxDOT for road projects.<sup>72</sup>

Members of the Railroad Commission of Texas, which oversees most regulation around fossil fuel production in the state, have stated that "the science on climate change is not settled,"<sup>73</sup> we do not have good facts on what is causing climate change,<sup>74</sup> and that regulations are an attack on the oil and gas industry that could cripple small oil producers across the state of Texas that fuel our nation's economy.<sup>75</sup>

But there are signs of hope. Renewable energy and electric vehicle use is booming. The cities of Houston, Dallas, Austin and San Antonio have committed to decarbonize by 2050.<sup>76</sup> General Motors' Arlington factory currently gets 100% of its electricity from a Texas wind farm<sup>77</sup> and Dell has committed to have 100% of its operations powered by renewable energy by 2040.<sup>78</sup> The Inflation Reduction Act invests \$369 billion in clean energy and climate solutions, much of which will flow to Texas.<sup>79</sup> Polls show nearly two-thirds of Texas voters support government action to address climate

change.<sup>80</sup>

While shifting off fossil fuels will be challenging, Texas' increasingly diversified economy<sup>81</sup> could provide for a softer landing. According to an analysis by the Federal Reserve Bank of Dallas, "the relative strength of the Texas economy could persist in coming decades even if the upstream oil and gas sector experiences a long-term decline due to the energy transition."<sup>82</sup> A study from the Cynthia and George Mitchell Foundation estimated "that the reduction in Texas K-12 funding over the next 30 years (related to the ongoing shift toward low-carbon and renewable energy) will only be between 0.5% to 3.0% of the total baseline K-12 funding. This is a relatively modest amount that timely policy changes can offset."<sup>83</sup>

Decarbonizing Texas, and helping the state and planet avoid catastrophic climate impacts, is a mammoth undertaking. Fortunately, global warming solutions are all around us — we just need to use them.

# Impacts

Texas is poised to be disproportionately affected by climate change relative to other states, given the myriad climates and ecosystems housed within its borders. Climate change will impact everything in Texas — from more frequent wildfires and intense floods, to decreased labor productivity and tourism. This section uses four broad categories to discuss the specific impacts of climate change on Texas: human health, the economy, infrastructure and national security, and the natural environment. These impacts are interconnected and impossible to completely compartmentalize, but these sections help illustrate the implications of climate change for Texas.

## Human Health and Safety

Climate change threatens human health in numerous and often unexpected ways. These

impacts are interconnected and potent, as increasing global temperatures lead to increasing heat stress, respiratory issues, mental health stress, and disease spread.

### Heat stress

Texas' heat is the stuff of legends, and its legendary status will only increase as the overall planet warms. From 1895 to 2020, the average daily minimum and maximum temperatures rose by 2.2 degrees in Texas,<sup>84</sup> and the average annual surface temperature in 2036 is predicted to be another 1.8 degrees warmer than the 1991-2000 average.<sup>85</sup> Triple-digit days are no rarity for Texans, and indeed are almost a hallmark of pride in the hardiness of the Texan spirit. Texans can expect to see more triple-digit days with climate change, as the number per year has been steadily increasing over the last century.<sup>86</sup>



*Unabated climate change can pose heat-related health risks, especially to vulnerable populations.*

Credit: Oleksandr Sushko on Unsplash,  
[https://unsplash.com/photos/dDy07Wmz0\\_U](https://unsplash.com/photos/dDy07Wmz0_U)



In 2022, Austin had its hottest May, June, and July ever, and recorded its second-highest temperature reading ever on July 10 at 110 degrees.<sup>87</sup> These days come at the cost of increased health risk as our bodies are overtaxed by the heat. Heat stroke occurs when the body experiences a rapid temperature increase and is unable to cool down, which can lead to permanent disability or death without emergency care.<sup>88</sup> Heat stress also increases the risk for those with underlying conditions such as cardiac disease, diabetes, or kidney problems among others.<sup>89</sup> Furthermore, hotter summer nights reduce our bodies' ability to recover from hot days, exacerbating health impacts.<sup>90</sup> According to the Texas tribune, "at least 214 heat-related deaths were recorded in the first nine months of 2022 alone, the highest annual toll for the state since at least 1999."<sup>91</sup>

Texas is home to nine of the hottest cities in the U.S., and currently averages more than 60 dangerous heat (temperatures greater than 103-degree days a year.<sup>92</sup> In 2021, Texas saw its hottest December on record since 1889,<sup>93</sup> while Houston recorded its hottest July ever in 2022.<sup>94</sup> While Texas is known for its heat, "climate change and global warming [is making] the number of days [in heat waves] greater," according to AccuWeather chief meteorologist Jonathan Porter.<sup>95</sup>

Increasing the implications of these heat waves is the increasingly warm nighttime temperatures, which Andrew Pershing, director of the nonprofit Climate Central, noted "are a particular indicator of a changing climate" as greenhouse gases "accumulate heat during the day in the atmosphere, and then radiate it back to you 24 hours a day."<sup>96</sup>

Under a high-emissions scenario, Houston's climate in 2080 will feel more like today's climate in Ciudad Mante, Mexico, where a typical summer day is 4 degrees warmer and 27.1% wetter. Austin's climate will feel more like Nuevo Laredo, Mexico, where a typical summer day is 6.2 degrees warmer and 34.1% drier. In El Paso, the typical summer day will feel like Maricopa, Arizona, meaning an increase of 9.2 degrees and a 38.1% drier summer.<sup>97</sup>

More than 700 people died from heat-related causes in 2019, and that number is projected to rise to 5,800 per year by 2100 if we allow climate change to continue unabated.<sup>99</sup> From 2010 to 2021 alone, 53 Texas workers died from heatstroke, nearly double the previous decade.<sup>100</sup> Furthermore, extreme heat waves and hotter summers mean an increased burden on our healthcare system, as more people will require medical assistance.<sup>101</sup> According to a 2015 report by Risky Business, extreme heat driven by climate change will likely claim more than 2,570 additional lives each year in Texas by 2020-2039 – the highest total number of heat-related deaths for any state.<sup>102</sup> These are likely to climb by more than 4,500 by 2040-2059.<sup>103</sup>

As extreme heat in Texas climbs, labor productivity will decrease. Workers in high-risk sectors such as agriculture, construction, utilities and manufacturing – all flourishing and economically important sectors in Texas – are among the most vulnerable to higher outdoor temperatures.<sup>104</sup> A 2015 report found that Texas is likely to see the steepest decrease in labor productivity in the nation due to increased temperatures, with a drop of up to 1.1% by 2020-2039, and another 1.7% drop in the subsequent 20 years.<sup>105</sup> These drops in labor productivity will make Texas less competitive nationally while harming local communities. Climate change is predicted to have a negative economic impact mainly throughout the Southwest and Southeast regions of the country.<sup>106</sup> Some areas in Texas are expected to experience economic costs valuing approximately 28% of their income level.<sup>107</sup>

See Figure 1: Estimated costs of climate change by the end of the century<sup>108</sup>





*Pollen levels and the length of allergy season is predicted to worsen as warming continues*  
Source: Lukasz Szmigiel on Unsplash, <https://unsplash.com/photos/Hez3-whPnNA>

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## Respiratory issues

The U.S. Global Change Research Program’s Fourth National Climate Assessment warns that unless the nation acts to improve air quality, “climate change will worsen existing air pollution levels. This worsened air pollution would increase the incidence of adverse respiratory and cardiovascular health effects, including premature death.”

Climate change will worsen air pollution in several ways, including:

- Rising temperatures will speed up the formation of ozone. According to one study, people in the Southwest will experience three to nine more days of ozone pollution at or above the level the U.S. EPA considers “unhealthy for sensitive groups” annually by 2050 compared to 2000 because of higher temperatures.<sup>108</sup>
- Hotter, drier weather will increase the frequency and severity of wildfires, which create particulate pollution, contribute to smog, and can spread air pollution for hundreds of miles.

Already, “many major Texan metropolitan areas violate public health standards for ozone,” and “a hotter Texas will result in more frequent ‘ozone action’ days, more asthma attacks, more hospitalizations, and higher public health costs.”<sup>109</sup> It is a common experience to hear recent transplants and lifelong residents of Texas complain about allergies. In central Texas, the words “cedar season” convey a sense of dread in much of the populace.

According to the Allergy and Asthma Center of Texas, January is the only month out of the year when severe allergens may not be present in the South Central United States (Figure 1)<sup>110</sup>. As climate warms and CO<sub>2</sub> levels rise, pollen levels are expected to get worse. A 2022 study estimates that allergy season will last longer than it currently does, as well as predicting an increase in pollen production.<sup>111</sup> Although normally seen only as a nuisance, allergies are estimated to have a total direct cost of \$3.4 billion nationwide, in large part due to the cost of prescription medications.<sup>112</sup>

See Figure 1: Seasonal Allergens of the South Central US<sup>110</sup>



*Warming water increases prevalence of harmful algal blooms as seen here in Lady Bird Lake in Austin, Texas*  
Image credit: Hatley Post

## Disease spread

Warmer temperatures allow for disease to spread, as many different disease-vectors thrive in warmer, wetter climates that are staying for longer and spreading to new parts of the country. Mosquitos, the arch nemesis of many a spring and summer day spent outside, are thriving in our warming world. In Lubbock, the number of days in mosquito season has grown from an average of 36 days per year from 1980-1989 to 54 days per year since 2006, while nationwide, 76% of major cities have seen an increase in their mosquito season.<sup>113</sup> In 2012, Dallas County experienced one of the largest outbreaks of West Nile Virus in the US, with 19 deaths and 398 confirmed cases.<sup>114</sup> A 2019 study found that “the global risk from mosquito-borne diseases — including

dengue, yellow fever, chikungunya, and Zika — is expanding” due to changes in the spread of two key mosquito species. The authors estimate that these species will invade 19.91-23.45 million km<sup>2</sup>, depending on climate and urbanization scenarios, leading to roughly 49.13% of the world’s population being placed at risk for mosquito-transmitted diseases.<sup>115</sup> Texas is already home to mosquitos, and we are likely to see new species and new diseases move further into the state as warmer temperatures and wetter summers create a more inviting home for our favorite nuisance.<sup>116</sup>

Algal blooms are another consequence of climate change. Lady Bird Lake, a centerpiece of Austin’s outdoor recreation, experienced harmful blooms in 2019 that sickened and killed several dogs, with



the lake experiencing similar blooms in 2020 and 2021. The EPA notes that warmer water favors harmful algae as warmer water mixes less and is easier for small organisms to move through, while blooms absorb sunlight, creating a positive feedback loop in which more blooms occur. Changes in salinity, rainfall, and higher CO<sub>2</sub> levels can all contribute to a more conducive environment for toxic blue-green algae blooms which threaten human health, subsequently impacting recreational and consumption uses associated with Texas' bodies of water.<sup>117</sup> Gabriel Collins, a Baker Botts fellow in Energy and Environmental Affairs at Rice University commented that "[in] situations where more parts of the state are pulling from lower reservoirs," where "rivers...are flowing less and [experiencing] warmer water temperatures, there's a real concern about what pathogens end up in [the water] system."<sup>118</sup> In 2020, a brain-eating amoeba in the Lake Jackson water supply caused the death of a 6-year-old child, and increasingly warm waters "could increase the prevalence of such water-borne amoebas."<sup>119</sup>

## Mental health and stress

Mental health is an equally critical component of the health impacts of climate change. A study by the American Public Health Association and ecoAmerica found that "victims of natural disasters are at increased risk of anxiety, depression, [Post-traumatic stress disorder] PTSD, and suicide," and "up to 54% of adults and 45% of children suffer depression after a natural disaster."<sup>120</sup> Flooding and prolonged droughts, both phenomena that Texas is already experiencing and will continue to experience, have been linked with increased rates of anxiety, depression, and post-traumatic stress disorders.<sup>121</sup> Natural disasters can cause dislocation and bring substantial losses to communities, and groups that are already more disadvantaged are likely to experience increased impacts.<sup>122</sup> Children and teenagers are especially susceptible, with a survey of those aged 16 to 25 in ten countries found that 75% were frightened of the future, with more than half saying they felt humanity was doomed.<sup>123</sup>

Climate anxiety is a major mental health concern, as young people do not feel they have a promising future if we fail to act. A 2020 study on the effects of Hurricane Harvey on residents of the Greater Houston-Area found that increased exposure to the hurricane was linked with increased chance for probable depression, probable anxiety, and probable PTSD after adjusting for other factors associated with mental health, and that these mental health difficulties were still present five months after the storm.<sup>124</sup>

Furthermore, the American Psychiatry Association notes that impacts for communities that have experienced weather disasters can include "PTSD, behavioral problems, cognitive deficits, reduced memory, poorer academic performance, and lower IQ, higher exposure to violence and crime, and higher rates of incarceration."<sup>125</sup> Researchers have found "correlations between exposure to poor air quality and increased risk of psychiatric outcomes," as well as increased suicides as temperatures warm.<sup>126</sup> These health effects can have downstream impacts on "direct medical costs, work loss, increased caregiving, and other limitations on everyday activities," and are likely to increase the burden on hospitals and emergency workers as more people turn to the health care system for help.<sup>127</sup>

## Flooding and hurricanes

Precipitation in Texas is difficult to discuss as a monolith given the vastly different climates within Texas' borders. Average precipitation across the state varies widely, but Texas has seen a 7% increase in intensity in precipitation between 1960-2020.<sup>128</sup> Furthermore, extreme rainfall intensity is predicted to increase by 2-3% by 2036 compared to 2001-2020 levels.<sup>129</sup> With increased precipitation comes flooding: urban flooding is projected to increase 10-15% in 2036 relative to 2001-2020 levels.<sup>130</sup> As of 2022, there are 127,000 people at risk of coastal flooding, a number that will only increase as global sea levels continue to rise due to warmer temperatures.<sup>131</sup>



*Flooding from Hurricane Harvey inundated Port Arthur and Beaumont, Texas*  
Aerial View of Port Arthur and Beaumont Texas after Hurricane Harvey<sup>137</sup>

In the last three years, Houston has seen three “500-year floods”<sup>132</sup> with Hurricane Harvey being the fifth “500-year” flood to hit Texas in the last twelve years.<sup>133</sup> “Tropical cyclones and flooding represent the second and third most frequent [billion-dollar] event types,” as evidenced by the whopping \$125 billion dollars of damage caused to Southeast Texas by Hurricane Harvey.<sup>134</sup> \$21 billion worth of coastal property will be put at risk during high tides by 2030, and critical infrastructure along the coast are at risk for high levels of damage.<sup>135</sup> Furthermore, Austin and Houston led the country in flood fatalities from 2010-2021, with 134 deaths across the two regions.<sup>136</sup>

As the earth warms, tropical cyclones are likely to increase in their intensity, with recent NOAA findings projecting an increase in the number of Category 4 and 5 hurricanes (those with wind

speeds upwards of 130 mph) as the earth warms.<sup>138</sup> Furthermore, warmer temperatures mean the air can hold more moisture, leading to more rainfall when hurricanes come ashore.<sup>139</sup> This is made concerning as hurricanes are moving slower, giving them more time to build and subsequently disperse.<sup>140</sup> Hurricane Harvey spent four days stalled over the Texas Coast, contributing to the unprecedented and catastrophic levels of precipitation that inundated Southeast Texas.<sup>141</sup> A 2017 paper by Dr. Kerry Emanuel found that rapidly intensifying storms, once rarities, are likely to occur every 5-10 years by the end of the 21<sup>st</sup> century.<sup>142</sup> The ability for hurricanes to rapidly intensify close to land increases the unpredictability of forecasting and subsequent danger that there may not be enough time to evacuate.<sup>143</sup> Texas has long experienced hurricanes, but the consequences of hurricanes and tropical storms will mount as climate change brings warmer

weather and stronger storms to the Gulf Coast. Climate change is causing rising sea levels as glaciers in both the Southern and Northern extremes melt and water expands in the warmth, creating more intense tropical storms, and shifting overall precipitation patterns. When these impacts collide with communities and infrastructure, the outcomes can be devastating. Hurricanes bring storm surges with them, and as sea levels rise, so too will storm surge heights.<sup>144</sup> Small changes in sea level rise amount to massive differences in their impact, as “in a third of 55 coastal sites studied throughout the US, 100-year storm surges will be 10-year or more frequent events by 2050.”<sup>145</sup>

Modeling by the Severe Storm Prediction, Education, and Evacuation Disaster (SSPEED) center at Rice University found that a storm 15% larger than Hurricane Ike coming inland on the south end of Galveston Island would produce a storm surge of 20 feet in Galveston, 22-23 feet around the Bayport Industrial complex, and 25 feet in the ship channel itself. Roughly 50% of the storage tanks on the Houston Ship Channel would be flooded to some

degree, and the electrical and piping infrastructure would require replacement after being submerged in salt water.<sup>146</sup> Since Hurricane Ike, Texas has seen increasingly strong hurricanes, the most recent of which was Hurricane Harvey. Roughly 25% of offshore oil and natural gas production in the Gulf of Mexico was shut in as a result of Harvey, and more than 50% of U.S. basic petrochemical production was temporarily disrupted.<sup>147</sup> More than 1 million pounds of dangerous air pollutants were released in the week following Harvey, and a professor of chemical engineering at Texas A&M commented that “every piece of equipment, every tank [is] battered by the flooding,” leaving “a lot of potential for [further] incidents.”<sup>148</sup>

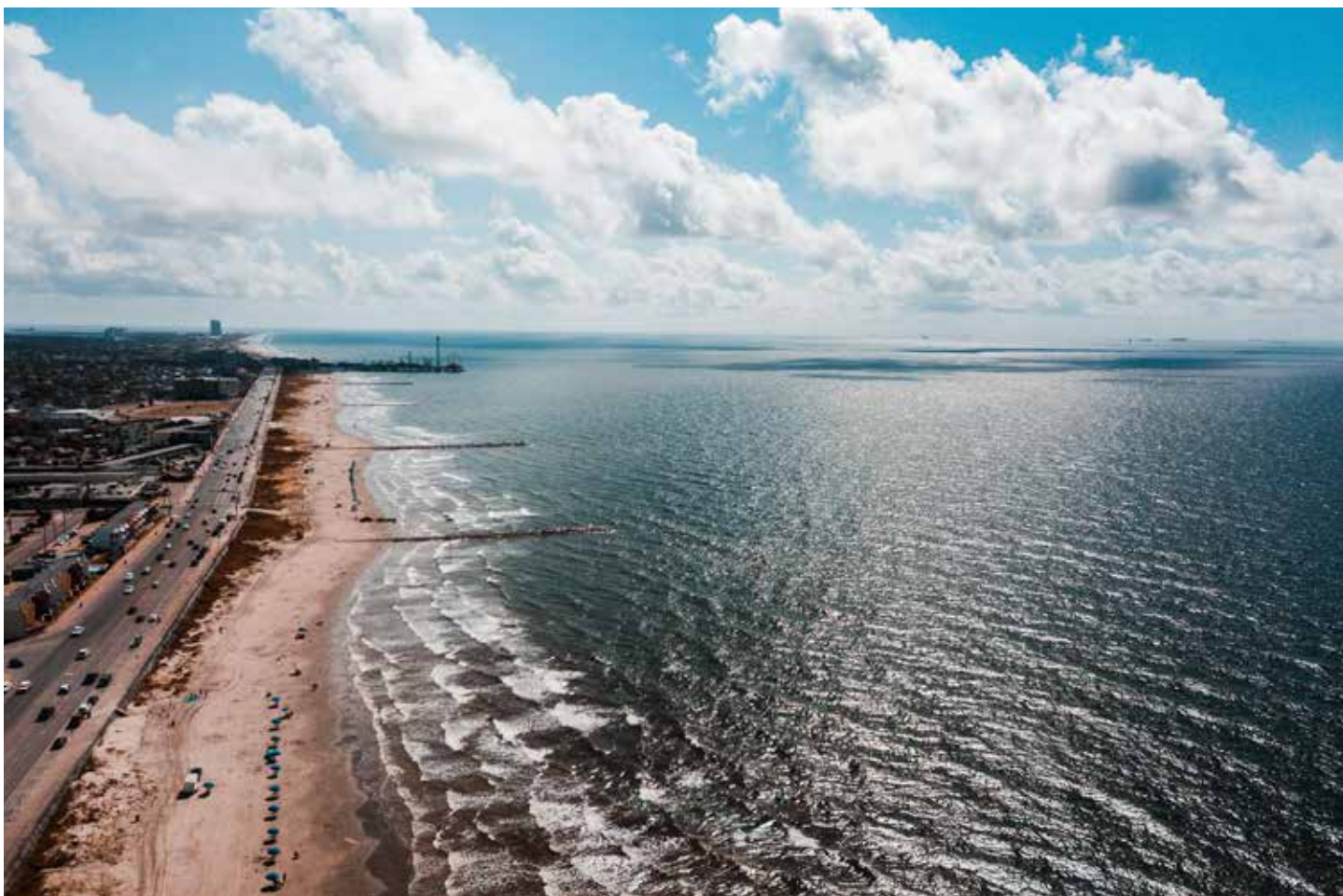
It will cost Texans a minimum of \$19.3 billion to build coastal defenses against rising sea levels and increased storm surge under a moderate sea-level-rise scenario.<sup>149</sup> Furthermore, sunny day flooding — flooding from high tides — is increasing in frequency due to climate change, with a new NOAA prediction that Galveston could experience flooding 210 days of the year by 2050.<sup>150</sup>



*Sea level rise exacerbated by climate change poses risks to Texas coast line and its inhabitants<sup>151</sup>*

Credit: Van Williams on Unsplash, <https://unsplash.com/photos/RjyB09SrH7E>





*1.5 million people could be forced to relocate from coastal regions as sea level rise continues*

Credit: Chris Ainsworth on Unsplash, <https://unsplash.com/photos/fGo01-KYdSw>

The Texas coastline is expected to continue retreating by four feet per year due to a combination of rising sea levels, subsidence and erosion,<sup>152</sup> with a 2017 study finding that about 1.5 million people could be forced to relocate from coastal regions.<sup>153</sup> Within the next 30 years, 1,397,757 properties in Texas are expected to have at least a 26% chance of being severely affected by flooding,<sup>154</sup> decreasing the attractiveness and thus the economic value of property in coastal communities. Sea level rise comes at a significant economic cost, as Texas is already “preparing to spend more than \$12 billion on sea level rise solutions,”<sup>155</sup> and expects an estimated \$30 billion of coastal property to flood at high tide by 2050.<sup>156</sup>

An overwhelming majority of insurance companies believe climate change will affect their business<sup>157</sup> and in 2021, the Reinsurance Association of America

urged Texas Insurance Commissioner Cassie Brown to “adopt guiding principles... to address the issue of climate change and its interrelationship with insurance and regulation.”<sup>158</sup>

## Precipitation and drought

Global warming is going to bring a paradox to Texas: we are going to see increased precipitation in tandem with longer and more frequent droughts.<sup>160</sup> This seemingly contradictory statement is made possible as climate change causes rain to fall less frequently but in greater intensity.<sup>161</sup> As Texas’ population continues to grow, water availability will become an increasingly important issue. Higher temperatures dry out the soil, reducing surface water and drying out vegetation.<sup>162</sup> Greater evaporation caused by these higher temperatures means that Texas could



see 4% more surface water lost in the summertime in 2036 than in 2000-2018.<sup>163</sup> Increased periods without rain mean less recharge for the aquifers that help sustain our cities, which in turn forces us to further draw from reservoir storage, further increasing pressure on already overdrawn sources and increasing water costs.<sup>164</sup> For example, in 2015, the High Plains Aquifer had 9% less total recoverable water than it had prior to groundwater irrigation development.<sup>165</sup> Projections from a 2020 study found that the second half of the 21st century is likely to be drier than even the most arid centuries of the last 1,000 years.<sup>166</sup> John Neilsen-Gammon, state climatologist, commented that “climate change is making droughts worse by increasing the temperatures and thereby increasing how rapidly everything dries out.”<sup>167</sup>

As mentioned above, water and drought go hand-in-hand. Shorter, more intense periods of precipitation that evaporates more quickly will give way to a dryer, more arid environment. “In the second half of this century, Texas could see ‘megadroughts’ worse than

any previously recorded;” of particular concern are those communities which rely entirely upon surface water (i.e. Dallas) and agricultural communities who rely upon rainfall to sustain their livelihoods.<sup>168</sup> The infamous Texas drought of 2011, which actually spanned over a five year period, resulted in roughly \$8.7 billion in agricultural losses.<sup>169</sup> In late spring/early summer of 2022, a severe drought covered over 90% of Texas, affecting more than 16 million Texans.<sup>170</sup> Water reservoirs were falling below their expected capacity, and soil moisture was so poor that many crops failed or were expected to fail.<sup>171</sup> This leads to a windmill effect, as many farmers are switching to more drought-resistant cotton from corn, protecting themselves but passing along the harm to ranchers for whom corn is a primary foodstock.<sup>172</sup> In July 2022, water levels of Edwards Aquifer dipped to the lowest levels since 2014.<sup>173</sup> As Texas needs more water to support its growing population and industry amidst hotter temperatures, groundwater sources are likely to be relied on more as surface water evaporates at higher rates.<sup>174</sup>



*Texas’ growing population strains the supply of freshwater resources<sup>175</sup>*  
Credit: Mike Erskine on Unsplash, <https://unsplash.com/photos/GKFsewk-hzQ>

Texas' population is projected to increase 73% from 2020 to 2070 – from 29.7 million to 51.5 million, primarily within urban areas.<sup>176</sup> This increase in population in turn means that total water demand in Texas is projected to increase 9%, from 17.7 million acre-feet per year in 2020 to 19.2 million in 2070.<sup>177</sup> Existing water supply, however, is projected to decrease approximately 18%, and Texas would need to add 6.9 million acre-feet to the existing water supply to meet future demand during drought.<sup>178</sup> As climate change decreases the availability of surface water and increases the frequency and severity of droughts, Texas' increasing population is going to feel the squeeze of water availability.

## Wildfire

Drought and fire are intimately linked, as “rising temperatures...evaporate more moisture from the ground, drying out soil, and making vegetation more flammable” while milder winters and changing precipitation patterns further help dry out the landscape.<sup>179</sup> A hotter, drier climate means more wildfires – and a recent study by a group of international scientists indicates that just going from

1.5 to 2 degrees in warming could greatly increase the risk of fire.<sup>180</sup> Wildfires also threaten municipal water supplies, as toxic smoke contaminates water bodies with pollutants that are difficult to remove.<sup>181</sup>

Texas has the second-highest wildfire risk in the U.S.<sup>182</sup> By the end of July 2022, wildfires had already burned more than 600,000 acres in Texas that year.<sup>183</sup> Wildfires in Bastrop County in 2011 caused an estimated \$325 million in property damage and killed two people; 2017 saw 480,000 acres burned in the Texas Panhandle, killing five people and devastating ranches in the area.<sup>184</sup> Fires in the Eastland Complex have caused \$23.1 million in agricultural losses, including lost grazing values, fence repair costs and more than 400 livestock deaths.<sup>185</sup> Wes Moorehead, fire chief at the Texas A&M Forest Service commented that Texas is “[seeing] more and more wildfires...every year.”<sup>186</sup> Even when Texas' local governments take steps to implement wildfire prevention, some community members feel like the responsibility is on them to protect their neighborhood.<sup>187</sup> However, there are limitations in what communities can do.<sup>188</sup>



*Dry, flammable vegetation increases wildfire risk and subsequent property damage across the state*  
Source: Landon Parenteau on Unsplash, <https://unsplash.com/photos/QDFbLwy0hMY>





*Changes in salinity threaten the survival of young blue crabs, a primary food source for whooping cranes.<sup>194</sup>*

Image credit: Adobe Stock.

[https://stock.adobe.com/images/tortuga-golfina-kemp-s-ridley-turtle/308034479?prev\\_url=detail](https://stock.adobe.com/images/tortuga-golfina-kemp-s-ridley-turtle/308034479?prev_url=detail)

## The Natural Environment

### Wildlife

As precipitation levels and temperatures change across Texas' ecosystems due to climate change, species will face large disturbances to both their ecosystems and existence. Animals and plants have already begun migrating into higher elevations and latitudes in search of livable climates.<sup>189</sup> In addition to terrestrial disturbances caused by climate change, warming temperatures also cause sea level rise and flooding along the Texas Coast.<sup>190</sup> Warming ocean temperatures change the chemistry of water, making it more acidic and directly impeding development of shelled organisms, such as Texas oysters.<sup>191</sup> The Mid-Coast region of Texas is also home to a series of freshwater wetlands and estuaries, which are brackish bodies of water usually found where rivers meet the sea. These act as wildlife havens, providing protection to 90-95% of commercially and recreationally important species at some point

in their lives.<sup>192</sup> However, rising sea levels allow for saltwater to intrude into previously untouched areas, decreasing the number of freshwater wetlands and moving estuary shorelines.<sup>193</sup> This in turn threatens the ecological webs of the area – for example, the subsequent changes in salinity threaten the survival of young blue crabs, a primary food source for whooping cranes.<sup>194</sup> Another example are the commercial and recreational fisheries in Guadalupe and Matagorda Bay which are threatened by increasing salinity and sea level rise as fish populations are decreasing.<sup>195</sup>

Furthermore, increasing temperatures can increase species vulnerability to other stresses and limit reproductive success.<sup>196</sup> Birds' ability to find food and reproduce shifts with corresponding weather patterns, in turn shifting the ecosystems of different regions.<sup>197</sup> For migratory birds, intensifying storm surge and increased storm severity will erode away spaces for bridging and nesting, pushing these birds to new areas and disrupting local ecosystems and tourist industries.<sup>198</sup>

Successful migration may cause other problems, as it has the potential to change pollination patterns and what species fill different ecological niches, creating ripple effects throughout the ecosystem(s).<sup>199</sup> Overall, the Texas Parks and Wildlife Department has identified 238 native animal and plant species that are vulnerable to the effects of climate change, especially when combined with factors like habitat loss from development.<sup>200</sup> A Gulf Coast native, Kemp's ridley sea turtles are threatened by rising sea levels flooding their nesting beaches — nest temperature during incubation determines the sex of their hatchlings, so populations are being increasingly skewed female, limiting their long-term reproductive success. The Aransas National Wildlife Refuge is home to roughly 430 whooping cranes who rely on freshwater inflows from the Guadalupe and San Antonio rivers to balance the salinity of the estuary. However, the Guadalupe is heavily dependent on the overtaxed Edwards Aquifer, and increasing drought periods could lead to less freshwater flowing into the estuary, upsetting the fragile balance upon which the cranes depend to survive.<sup>201</sup> Both scaled quail and

northern bobwhite populations have decreased as temperatures have increased and rainfall decreased, and the Montezuma quail is projected to lose 35-41% of its current geographic regions by 2070 due to increasing temperatures.<sup>202</sup>

## Coral reefs

Oceanic species susceptible to harm from rising ocean temperatures must also be considered as we transition away from fossil fuel consumption. As ocean temperatures increase, coral reef populations are in danger of coral bleaching, a consequence of warming that occurs when stressed coral expel important algae from their tissues, which can lead to starvation and disease.<sup>203</sup> According to a new report, many regions of the Gulf of Mexico are predicted to reach critically warm temperatures in 2050.<sup>204</sup> This excessive warming could result in a loss of habitat for species, thereby affecting tourism and fisheries that rely on the Gulf, while simultaneously making the Texas coastline more vulnerable to tropical storms.<sup>205</sup>



*Kemp's ridley sea turtles are threatened by rising sea levels flooding their nesting beaches*

Credit: Adobe Stock.[https://stock.adobe.com/images/tortuga-golfina-kemp-s-ridley-turtle/308034479?prev\\_url=detail](https://stock.adobe.com/images/tortuga-golfina-kemp-s-ridley-turtle/308034479?prev_url=detail)





*Increased power demand, malfunctioning equipment, and extreme weather threatens Texas' electric grid<sup>217</sup>*  
Credit: Andrey Metelev on Unsplash, <https://unsplash.com/photos/qpAOxji4dAo>

## Infrastructure and the Economy

### Electric infrastructure

The Electric Reliability Council of Texas [ERCOT] is the predominant energy provider in Texas, operating independently from the national grid.<sup>206</sup> ERCOT manages roughly 90% of the state's electric load, making it a critical component of the Texas electrical grid.<sup>207</sup> However, as climate change has brought increasingly severe weather, ERCOT is being tested. At least 90% of power outages result from failures in electricity distribution systems, of which weather-related events are the primary cause of damage.<sup>208</sup> Furthermore, extreme temperatures increase the risk

of equipment malfunctioning while sea-level rise and flooding increase the frequency with which electrical infrastructure is exposed to inundation.<sup>209</sup>

One of the costliest natural disasters of 2021 was Winter Storm Uri in mid-February, during which temperatures dropped to 6-40 degrees below the normal average.<sup>210</sup> The electric grid, and the natural gas supply chain that supports it, was unable to handle the massive increase in power needs, leaving nearly 70% of Texas residents and 4.5 millions businesses and homes without power.<sup>211</sup> These extreme conditions caused or contributed to the deaths of more than 210 Texans.<sup>212</sup> One group estimated that the winter storm caused losses in gross product between \$85.8 and \$128.7 billion.<sup>213</sup> A 2018 study found linkages between the warming of

the Arctic due to global climate change and increased frequency of extreme winter weather in the United States.<sup>214</sup> Thus, as our planet overall warms, the changes in the location of different air and ocean patterns will lead to shifting weather patterns across the world.<sup>215</sup> A 2021 study linked Arctic variability and Winter Storm Uri, finding that the polar vortex is breaking more frequently than in previous decades, forming patterns that allow for large blasts of cold air to penetrate further south.<sup>216</sup>

Increasingly hot weather causes similar problems. In May 2022, ERCOT asked Texans to set their thermostats to 78 degrees or higher to avoid power outages after six power generation facilities went offline.<sup>218</sup> In June 2022, Texas power demand was just over 76,600 megawatts during peak hours, breaking the previous record set a week earlier.<sup>219</sup> In early July 2022, Texas' grid operator asked residents to voluntarily conserve energy by turning up their thermostats to avoid blackouts, as heat indexes

reached over 110 degrees in southeast Texas.<sup>220</sup>

Winter Storm Uri was seen by many as an anomaly that caused the electric grid to crash. However, triple-digit days are far from an anomaly in Texas, and the number of dangerous heat days are expected to rise<sup>221</sup> — pushing more Texans to turn down their thermostat. A 2015 report found that Texas is likely to see residential and commercial energy expenditures increase by 12% by 2040-2059, translating to a statewide energy expenditure of \$3.7 billion each year by mid-century.<sup>222</sup> The question of whether or not the electric grid will be able to handle the increasing temperature extremes that climate change is bringing is a serious concern. Texas cannot afford to have its electric grid go out at moments of peak demand, as the human and economic cost will be too high.

Electrical outages due to bad weather cost the U.S. economy up to \$33 billion in an average year, a



*Texas' electric grid must handle periods of both extreme heat and freezing<sup>223 224</sup>*

Georgetown, Texas, source: Zachary Edmundson on Unsplash, <https://unsplash.com/photos/9KJ5RnppygY>



number that is only going to increase as climate change brings more extreme weather events and variations in temperature.<sup>225</sup> A 2019 study produced for the U.S. Department of Energy noted that

“extreme weather and climate-related threats to the electrical grid include but are not limited to: sea level rise and associated coastal flooding, increasing frequency, intensity, and duration of heat waves, changing precipitation patterns, ice storms, lengthening regional droughts and wildfires, and more instances of flooding and damaging winds from severe storms.”<sup>226</sup>

The physical infrastructure of the electrical grid is at risk with potentially massive economic impacts — repairing the structures or scaling down production due to threats to the equipment will have rippling repercussions. Another study, done in 2020, found that total infrastructure costs may increase as much as 25% due to climate change, and that the net present value of total costs of climate change across different regions and global warming scenarios ranges from \$120 to \$380 billion through 2099.<sup>227</sup>

In Texas, “increasing temperatures will reduce the maximum capacity of transmission lines, transformers, and substations while also reducing the efficiency of power conversion and thermal cooling,” and increasing the demand for the water used to cool and help these different components function efficiently.<sup>228</sup> Drought conditions, which are becoming increasingly common, affect power grid operations because nuclear, coal and natural gas plants require large amounts of water to keep equipment cool and functional. Thus, increasing evaporation and higher temperatures threaten the stability of the electric grid as these plants operate less efficiently or not at all.<sup>229</sup>

## Pipes and water

The infrastructure that we rely upon to ensure the efficient and safe delivery of our water is threatened

by increasing temperatures. As Texas gets hotter and sees heavier rain, underground water pipes will expand and contract more, making interruptions to our water supply more frequent.<sup>230</sup> A 2011 study found that pipes are more likely to fail during dry summer periods due to soil shrinkage, a phenomena that we are going to become increasingly familiar with.<sup>231</sup> Another study, from 2014, notes that climate change is having a “profound effect” on the reliability of our water as it puts significant stress on the infrastructure, as well as the quality and quantity of water.<sup>232</sup>

During Winter Storm Uri, nearly 15 million people in Texas lacked safe drinking water.<sup>233</sup> More than 1 million gallons of wastewater were dumped into the San Marcos River following a generator failure, leading San Marcos to recommend residents within a half-mile boil any water used.<sup>234</sup> Water pipe failures can also lead to the growth of dangerous bacteria in the water supply; in February 2021, the state government issued repeated warnings and enacted a boil order due to potentially contaminated water supplies.<sup>235</sup> Along coastlines, higher seas and more damaging floods are forcing rainfall to back up in streets and water to bubble up through drains.

## Roads and railroads

The transportation system is another sector that is going to see massive disruptions due to climate change as temperatures rise here in Texas.

In late June 2022, four miles of roadway east of Waco started to “bleed,” or melt, due to the “excessive heat” in the area, and traffic was slowed down until the issue was resolved.<sup>236</sup> A 2015 report on the vulnerability of Central Texas infrastructure notes that stakeholders experienced deterioration of roadways when temperatures exceeded 100 degrees for an extended period of time. This is concerning as the number of triple-digit days in Texas is increasing and Americans are driving more than ever.<sup>238</sup> On the opposite end of the spectrum, roads and bridges, particularly elevated ones, are at risk of icing over



Concerns for railroad infrastructure emerge as railroads with finite temperature ranges experience intense heat  
Source: Eddie Bugajewski on Unsplash, <https://unsplash.com/photos/LXwEkJZEtgU>

and cracking during extended freezes.<sup>239</sup> Although this scenario once seemed like a fairytale in Texas, Winter Storm Uri illustrated that we must prepare for both temperature extremes. A 2015 study conducted by researchers at the University of Texas at Arlington found that climate change “could lead to an increase in the type of infrastructure damage already familiar to anyone who drives on [Dallas-Fort Worth area] roads – more cracks and potholes, even buckling and melting of asphalt roadways in extreme heat, and more wildfires.”<sup>240</sup> In addition to the safety hazards they pose to the millions of Texans who use our roads every year, these vulnerabilities will mean a cost of millions of dollars to replace infrastructure that will not be able to withstand the new climatic conditions in which it exists.<sup>241</sup> Extreme heat in particular will impact Texas’ railroads, as steel tracks are designed for a specific temperature range, and the rails will buckle and expand with increased temperatures, causing derailments. A 2019 study estimated that delays

due to the need for reduced speeds in extreme heat “could cost the U.S. rail network up to \$60 billion by 2100.”<sup>242</sup> In Texas, short-line railroads contribute 1,476 jobs, \$113,769,627 in labor compensation, and \$354,443,588 in economic output.<sup>243</sup> Railroads are an important part of state and county economies, and failure to act on climate change will bring reductions in the efficiency, and thus economic losses.<sup>244</sup>

## Agriculture

Agricultural yields will be directly impacted by increased temperatures and shifting weather patterns and climate instability.<sup>245</sup> Texas’ agriculture industry is a critical component of the state’s economy, producing \$24.9 billion in cash receipts in 2021,<sup>246</sup> and is the nation’s leading producer of cotton, hay, sheep, goats, mohair, and horses.<sup>247</sup> Nearly one-in-seven Texans work in an agriculture-related job, and agriculture accounts for up to 40% of the



local economy in the High Plains region.<sup>248</sup> The agricultural sector also uses 57% of Texas' water resources, making it highly susceptible to drought and increasing temperatures.<sup>249</sup> Agricultural systems are sensitive to a myriad of factors, almost of all which climate change touches.

In 2021, Texas produced 7.7 million bales of cotton.<sup>250</sup> However, the Texas Farm Bureau predicts only 2.9 million bales will be produced by the end of 2022 - a 62% decrease from the year before.<sup>251</sup> This drop is expected to continue with a 6% drop by 2020-2039 and 14% drop by 2040-2059 without climate action.<sup>252</sup> Corn is another major crop in Texas, but a 2015 report found that "Texas will likely see corn yield declines of as much as 22% annually, absent adaptation. These losses grow to as much as 39% annually by mid-century."<sup>253</sup> These are just two of the multitude of crops that are susceptible to

a changing climate, highlighting the importance of understanding and tackling climate change head-on.

Extreme precipitation and longer, more intense droughts caused by climate change go hand-in-hand,<sup>254</sup> meaning rain will occur in shorter but more intense spurts. This means that we are likely to see more flooding when it rains, but longer stretches between rain, meaning longer droughts and increased strain on water resources.<sup>255</sup> Intense precipitation will cause problems for agriculture, as early flooding leaves fields too wet for immediate planting, leading to reduced yields or crop substitutions. Furthermore, late-season flooding causes harvest delays and issues with crop quality.<sup>256 257</sup>

All of these impacts decrease farmers' incomes and hurt Texas' bottom line as a whole. Food and other agricultural goods across the state will likely become



*Texas will likely see corn yield declines of as much as 39% annually by mid-century.<sup>253</sup>*

Source: Adobe Stock, [https://stock.adobe.com/images/cornfield-with-corn-crop-damage-and-cracked-soil-weather-drought-and-flooding-concept/456553925?prev\\_url=detail](https://stock.adobe.com/images/cornfield-with-corn-crop-damage-and-cracked-soil-weather-drought-and-flooding-concept/456553925?prev_url=detail)





*Climate change brings about droughts which affect food availability, prices, and quality.* Image source: Adobe Stock, [https://stock.adobe.com/images/desert-cattle/190770167?prev\\_url=detail&asset\\_id=190770167](https://stock.adobe.com/images/desert-cattle/190770167?prev_url=detail&asset_id=190770167)

more expensive as crop yields decrease.<sup>258</sup> Perhaps recognizing this, the Texas Farm Bureau recently added climate change resources to their website.<sup>259</sup>

Beef cattle production is another important economic part of Texas, as we lead the nation in number of farms and ranches, with 284,416 farms and ranches covering 127 million acres,<sup>260</sup> producing cattle worth \$12.3 billion on the market in 2017.<sup>261</sup> However, climate change is bringing increasing temperatures and longer, more intense droughts, which affect food availability and quality, water supply, and associated heat stress.<sup>262</sup> Heat stress for cattle means lower dairy production, lower fertility, and even death, all of which spell disaster for those communities that depend upon cattle ranching for their livelihoods.<sup>263</sup> Furthermore, severe droughts have the potential to limit the forage growth necessary to raise cattle for beef, subsequently straining food supply chains and increasing the prices of food.<sup>264</sup> An example of a possible outcome happened in June 2022. Kansas was hit with a mix of extreme heat, no wind, and high humidity. Without

access to water or shade, up to 10,000 cows in a feedlot died from heat exposure.<sup>265</sup>

Cattle ranching and other livestock rearing farms are a massively important part of Texas' economy, generating \$10.5 billion in output in 2012.<sup>267</sup> During the 2011 drought, many of the largest ranchers were forced to ship their cattle to greener pastures, totalling 150,000 cows that left the state.<sup>268</sup> Ranchers that could not afford to relocate livestock either sold or slaughtered them.<sup>269</sup> In addition to these environmental impacts, cattle ranchers are also burdened financially. Increases in the cost of feedstock crops, such as corn, means increased input costs for ranchers, additionally burdening consumers.<sup>270</sup> Droughts also limit forage growth, which in turn limits cattle's ability to reproduce, leading to a supply shortage that drives up the cost for consumers.<sup>271</sup> A 2022 megadrought across the Western U.S. — the region's worst in 1,200 years — means consumers will pay higher prices for the following two years.<sup>272</sup>



*Texas' parks draw a wide array of wildlife and outdoor enthusiasts, creating economic booms for neighboring counties*  
 Image Credit: Joshua J. Cotten on Unsplash, <https://unsplash.com/photos/NpPuWIFpARo>

## Tourism

From Big Bend to the Gulf Coast beaches, from the rolling Texas Hill Country to the Panhandle plains, much of Texas' tourism and recreation relies on the natural environment. Outdoor recreation directly created 299,940 jobs and generated an added value of \$31.7 billion in 2020, according to the U.S. Department of Commerce.<sup>273</sup> In 2018, anglers spent \$4.3 billion while fishing in Texas, and had a total economic impact of \$7.2 billion dollars.<sup>274</sup> Texas wildlife watching in ocean waters brought \$1.8 billion in 2011, with 12 million wildlife watching trips and 4 million participants that year.<sup>275</sup>

Shifts in local Texas ecosystems would impact ocean-related businesses along the Mid-Gulf Coast. As of 2015, ocean-related businesses provided 25% of total jobs in Refugio and Aransas counties and 13.1% in Jackson county.<sup>276</sup> Furthermore, the tourism and recreation sector in this region accounts for more than half of the jobs in Aransas, Calhoun, and Matagorda counties, generating about \$490 million in direct spending across Aransas, Calhoun,

Jackson, Matagorda, Refugio, and Victoria counties in 2019.<sup>277</sup> A 2012 study by Texas A&M found that the direct contribution of nature tourism in the Rio Grande Valley was \$463.0 million in economic output and 6,613 full- and part-time jobs annually.<sup>278</sup> Extreme heat index days will make outdoor activities, including those that drive visits to Texas state parks, potentially hazardous,<sup>280</sup> turning people to cooler sites for recreation. Birding is another large component of Texas' nature-based tourism as we are located in the middle of a central migratory flyway.<sup>281</sup> As birds move northward for cooler climates, Texas' share of the economic value of birdwatching is likely to decrease.<sup>282</sup>

Texas is home to a diverse range of ecosystems and an abundance of wildlife that inspires awe and supports local communities. In order to protect those communities that depend on ecotourism, fishing, birding, and other interactions with nature, we must act now to limit global warming.



# National Security

Texas is home to 14 active military bases, and these bases are important for national defense and state security. The Department of Defense (DoD) has recognized the threat of climate change for the military's operational capacity, stating that "climate change introduces an added risk factor, particularly for those installations and sites along the coast."<sup>284</sup> Associated risks include wildfires, floods, desertification and sea level rise, among others. A 2014 DoD report listed the potential effects of these climate change risks, of which the most concerning in Texas are an increased number of "black flag" (suspended outdoor training) or fire hazard days, increased health and safety risks to the Department's personnel, and increased erosion and flood damage — along with increased maintenance and repair requirements.<sup>285</sup> Cases of heat stroke or heat exhaustion in the military increased 60% from 2008 to 2018, with at least 17 members of the military dying in the last decade due to heat illnesses.<sup>286</sup> As the temperatures climb, so too do the health risks

for military personnel, both in training and active combat.

Coastal bases, such as the Naval Air Station in Corpus Christi and Ellington Field Joint Reserve Base in Houston, could be impacted by sea level rise and increased flooding, compromising their ability to support timely operations and perform their duties in the most efficient manner possible.<sup>287</sup> In June 2016, Fort Hood endured severe flash flooding that led to the death of several soldiers during a training exercise that involved a low river crossing.<sup>288</sup> Climate change is already impacting all facets of daily life, and its effects will only increase if we fail to act.



*Heat stroke and heat exhaustion threaten military bases across Texas with 17 military members dying of heat-related illness in the last decade*

Credit: Diego González on Unsplash, <https://unsplash.com/photos/nJl8WAqpn7Y>



# | Sources of Emissions and Solutions

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If Texas were its own nation, it would have ranked seventh in global emissions, just behind Japan in 2017.<sup>289</sup> Texas is the largest producer of crude oil and natural gas in the United States,<sup>290</sup> and was the top consumer of coal for electricity production in 2020.<sup>291</sup> Despite overall U.S. CO<sub>2</sub> emissions decreasing by 17% from 2005 to 2017, Texas' emissions increased by 18%.<sup>292</sup> But since Texas is such a big source of emissions, we have the potential to have a huge impact on the global emissions picture by getting our own under control.

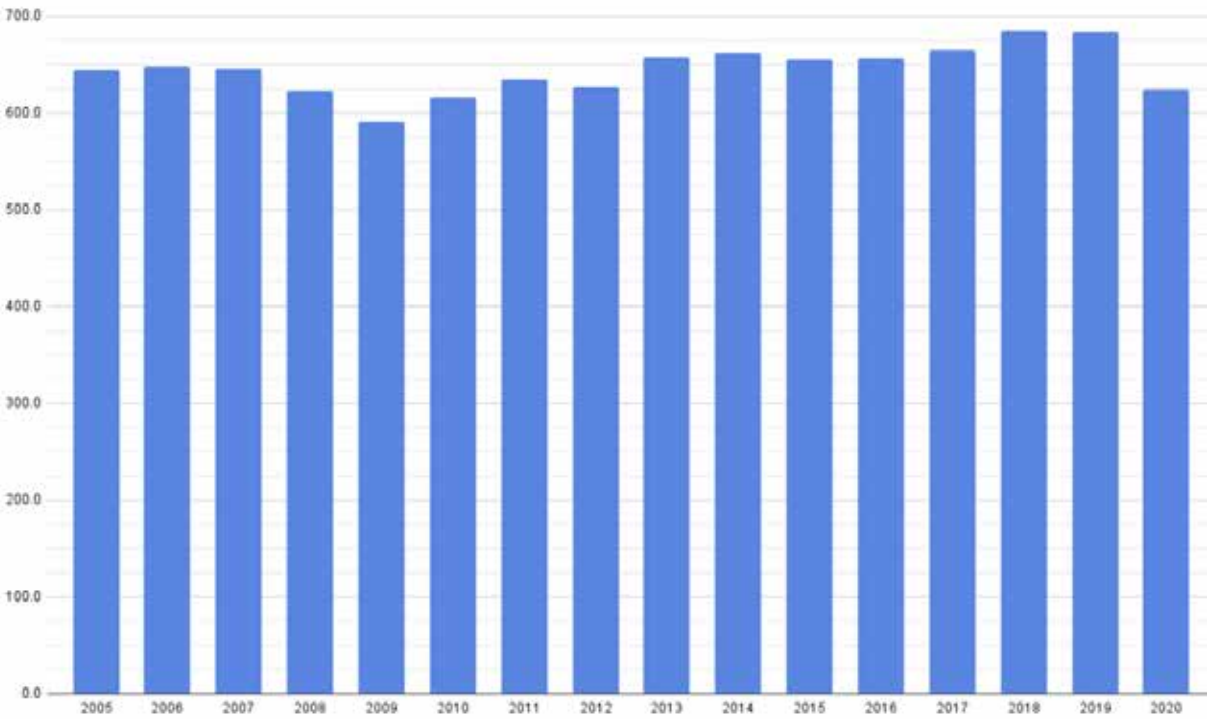
Fortunately, according to a study by University of Texas researchers, Texas could eliminate its carbon pollution in fewer than thirty years while also increasing Texas' GDP.<sup>293</sup> Switching to 100% renewable energy, electrifying transportation and buildings, stopping the buildout of new fossil fuel infrastructure, and investing in farm and nature based solutions are just a few of the many steps we can and must take to decarbonize Texas.



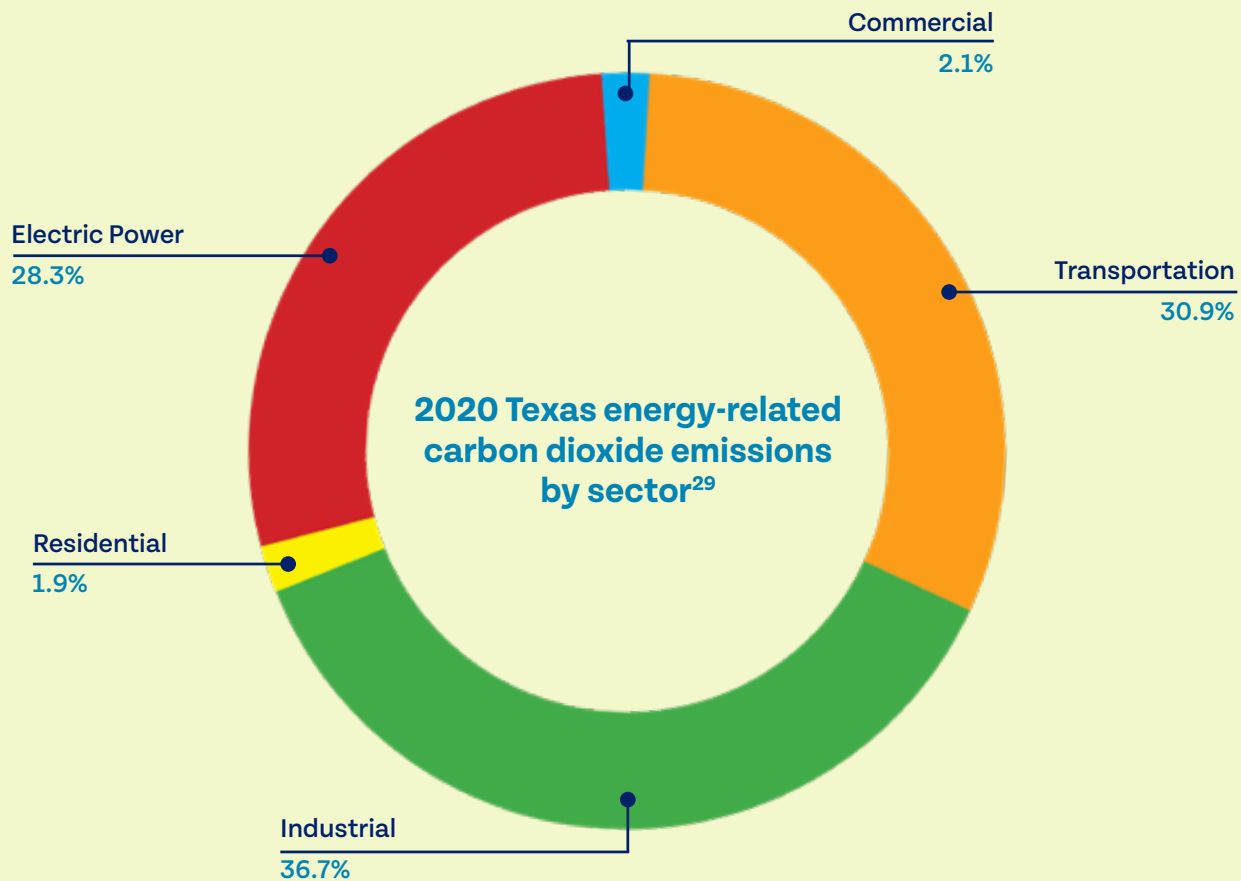
*Wind energy provides a sustainable alternative to the emission-heavy fossil fuel industries of Texas*

Image credit: Sam LaRussa on Unsplash, <https://unsplash.com/photos/Cfm1dKmCFQ>

Energy-Related Carbon Emissions in Texas (million metric tons)



While emissions dropped in 2020 due to the economic shutdown from the pandemic, emissions nationally in 2021 bounced back to near 2019 levels<sup>294</sup> and likely did in Texas too.



## Industry

The industrial sector is Texas' largest energy consumer, accounting for over half of the state's energy consumption.<sup>295</sup> In 2019, Texas was the top industrial emitter in the US, producing 21% of all industrial emissions, and released approximately 231 million metric tons of industrial CO<sub>2</sub> into the atmosphere in 2018.<sup>296</sup> This is largely due to the number of industrial facilities to which Texas is home, including the oil and gas production, refining, and chemical manufacturing. While U.S. energy-related CO<sub>2</sub> emissions are still 5% below 2019 levels, they increased 7% in 2021 compared to 2020 levels.<sup>297</sup>

### Oil and Gas Production, Transmission, and Refining

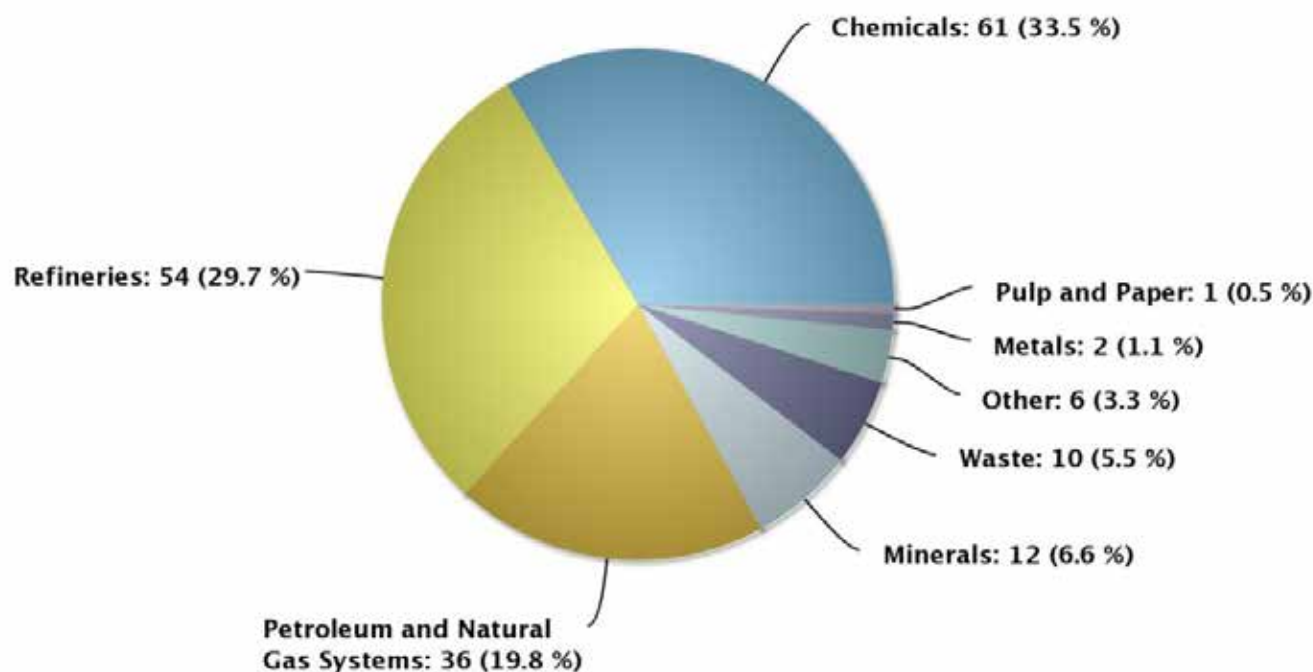
Texas is the largest emitter in the United States for

oil and gas production by far, emitting more than twice that of the second-largest emitter, California in 2020.<sup>299</sup> A 2022 report by the think tank RMI found that Texas' Permian Basin oil and natural gas fields are the third most climate-damaging in the world.<sup>300</sup> Emissions from Texas' oil and gas sector, already responsible for about half of the state's industrial emissions, will rise significantly if a planned buildout of new infrastructure is successful.

To decrease emissions from oil and gas, we must first stop emissions from increasing. That means stopping the construction of planned new LNG and oil export terminals, pipelines, and other oil and gas infrastructure. We can then make immediate progress in reducing emissions by reining in the flaring and venting of methane gas and stopping methane leaks by plugging abandoned oil and gas wells, while planning for a managed phaseout of the industry by mid-century.

### Source of industrial greenhouse gas emissions in Texas, 2021<sup>298</sup>

Texas – Direct GHG Emissions of Selected Gases Reported by Sector in Million Metric Tons of CO<sub>2</sub>e



Data reported to EPA as of 08/12/2022



*The climate-damaging oil and gas industry of Texas proposes further buildout with new infrastructure projects*

Image credit: Patrick Hendry on Unsplash, <https://unsplash.com/photos/6xeDIZgoPaw>

## Stopping new oil and gas infrastructure

New oil and gas infrastructure simply doesn't make sense in light of the threat of global warming. According to the International Energy Agency (IEA), keeping temperatures from rising above 1.5 degrees celsius requires "no new oil and gas fields approved for development."<sup>301</sup> To stop the climate crisis, we must stop the construction of dozens of new oil and gas infrastructure projects under development in Texas.

These future projects included new deepwater drilling ports in the Gulf of Mexico with accompanying onshore storage facilities, over 50 miles of pipeline for transporting crude oil across Aransas and Calhoun counties, and multiple LNG plants adding more than 1 trillion cubic feet of

natural gas production every year.<sup>302</sup> Construction of these projects would cause significant environmental damage. According to a 2020 University of Texas study, building the state's planned, under construction, and recently completed projects – including refineries, petrochemical facilities, oil and liquified natural gas terminals, and other infrastructure – would result in an emissions increase of at least 179 million tons of CO<sub>2</sub> equivalent (CO<sub>2</sub>e) by 2030.<sup>303</sup> That is equal to the annual emissions from 46 coal-fired power plants.<sup>304</sup>

Multiple agencies have the opportunity to address the threat of new infrastructure projects because local, state and federal agencies can be involved in the permitting and construction process for new infrastructure projects. For example, the Federal Energy Regulatory Commission is the lead agency for



any new liquefied natural gas terminal.<sup>305</sup> An LNG facility must also obtain an air pollution permit from the Texas Commission on Environmental Quality, while the RRC provides certification of companies and individuals who work with liquefied natural gas.<sup>306</sup> These agencies should do what they can to stop or slow the expansion of oil and gas infrastructure.

## Ending flaring and methane venting

One avoidable source of dangerous emissions is flaring/venting. Wells typically produce both oil and gas. If the company operating the well is interested only in producing oil, the gas is an unwanted byproduct to be dealt with. Well operators can send this gas into a pipeline to send to market, or burn it off onsite through a flare if pipeline infrastructure is not available. Too often in Texas, however, operators rely on flares, including those that only partially burn the gas, or directly vent uncombusted methane to the atmosphere. This is bad for the climate and public health, and is a wasteful use of Texas' fossil fuel

resources.

Methane, the primary component of natural gas, is a powerful greenhouse gas that causes 84 times more warming over 20 years than the same amount of carbon dioxide.<sup>307</sup> Burning methane in a flare reduces its global warming impact since the main combustion byproducts are carbon dioxide and water vapor, which contribute to climate change, but less significantly. This means that the climate damage from oil production is much higher when companies vent methane.

Natural gas flaring and venting is especially common in the Permian Basin. There, oil companies burned nearly 300 million cubic feet of methane in 2019.<sup>308</sup> That much gas could provide electricity to seven million homes for a year.<sup>309</sup> Worse, many companies in the Permian Basin operate faulty flares that only partially burn natural gas and release methane directly into the atmosphere.<sup>310</sup> Surveys of flares in February and March 2020 found that more than 10



*Flaring in West Texas. Flaring is bad for the climate and public health, and is a wasteful use of Texas' fossil fuel resources. Image credit: Adobe Stock, [https://stock.adobe.com/images/west-texas-gas-flare/356511991?prev\\_url=detail](https://stock.adobe.com/images/west-texas-gas-flare/356511991?prev_url=detail)*

percent of flares were malfunctioning, including five percent of flares that were not even lit.<sup>311</sup>

Flaring is authorized by the Texas Railroad Commission (RRC), who approved 27,000 flaring permits between 2012 and 2019, and almost 7,000 exceptions in 2019 alone.<sup>312</sup> The EIA estimates that companies in Texas vented or flared more than 980 billion cubic feet between 2012 and 2020 – and satellite estimates indicate the actual number is greater than double that.<sup>313</sup>

To combat excessive methane flaring, the U.S. Environmental Protection Agency has proposed new methane and flaring rules which, if adopted, would reduce methane pollution from the oil and gas sector by 87 percent below 2005 levels.<sup>314</sup> The Railroad Commission could complement federal actions with an aggressive program to end routine flaring and venting by 2025, including by improving monitoring of flaring and methane pollution, ending the practice of granting extensions to existing flaring permits and enforcing existing flaring permits and issue fines to companies in violation of their permits.

## Capping abandoned oil wells

When a well no longer produces sufficient oil or gas, the well operator is supposed to permanently plug it to prevent methane leaks and to protect groundwater. However, when operators go bankrupt they often simply walk away, leaving “orphan wells” for the state to plug.

Orphan wells add to climate pollution and are a threat to water quality as both gases and liquids can escape through faulty well casings and through fissures in rock. They can also reach the surface through the borehole. Unplugged wells leak methane at 5,000 times the rate of plugged wells.<sup>315</sup>

Texas currently has 7,400 documented orphan wells, which will cost \$482 million to plug.<sup>316</sup> In addition to orphan wells, the RRC estimates there are almost 150,000 inactive wells in the state.<sup>317</sup> Furthermore,

tax incentives encourage drillers to keep wells barely active and avoid plugging them.”<sup>318</sup> These low-producing oil and gas wells account for only 6% of the nation’s oil and gas production but contribute about half of the methane emitted from all well sites in the United States.<sup>319</sup>

Thanks to the Infrastructure Investment and Jobs Act, Texas will receive \$343,695,000 in federal funding to plug, remediate and reclaim orphaned wells.<sup>320</sup> An initial grant of \$25 million is allowing Texas to plug 800 wells.<sup>321</sup> In addition, the state’s Oil and Gas Regulation and Cleanup Fund receives financing from bonds paid for by oil companies to cover the cost of plugging a company’s wells in case of bankruptcy, and also from some regulatory and permitting fees and enforcement penalties levied on oil and gas companies.<sup>322</sup>

However, a review by the state’s Sunset Commission in 2017 found that bonds paid by oil and gas companies covered less than 16 percent of what the RRC spent plugging wells in fiscal year 2015.<sup>323</sup> Higher bonds, increased permitting fees, tighter standards on the definition of what constitutes an “inactive” well, more active monitoring and enforcement, and accelerated clean up efforts will be necessary to plug existing abandoned wells and prevent more from joining their ranks.

## Managing a transition away from oil and gas

Achieving net zero greenhouse gas emissions, which we must do in order to avoid the worst impacts of global warming, will necessarily mean a sharp decline in the demand for oil and gas. Texas needs to prepare for this decline by transitioning the state’s workforce to alternative industries (including in the clean energy sector), diversifying sources of revenue for local and state governments, and reducing environmental and health damage from the remaining activities of the petroleum industry.





*ExxonMobil's Baytown Facility Fire December 23, 2021*  
Image credit: Terri Blackwood, used by permission

## Chemical Manufacturing

Texas is the top chemical producer in the country with more than 200 petrochemical plants owned by companies such as ExxonMobil, Chevron Phillips and Dow Chemical Company.<sup>324</sup> Extensive oil and gas reserves in the Permian Basin serve as an accessible source of feedstock which is used to produce basic chemicals including ethane and propane along Gulf Coast chemical plants.<sup>325</sup>

### Stopping expansion of petrochemical production

Like with oil and gas, petrochemical companies are expanding and building new facilities. For example, ExxonMobil is working to build a new ethylene unit at the Baytown Olefins Plant. According to Oil and

Gas Watch, “the new ethylene unit will increase the production capacity of the plant by approximately 2 million metric tons per year,” increasing greenhouse gas emissions by 1,453,293 tons per year.<sup>326</sup>

### Reducing use of plastics

The best way to reduce emissions from chemical manufacturing is to manufacture fewer chemicals. Many of the chemicals Texas produces are for products which have limited value to society and contribute to serious environmental problems — for example, plastic bags and other single-use plastic products. Reducing the use of these single-use plastics will not only mean less plastic in our landfills and waterways but will also reduce the demand for the polyethylene used to manufacture them.

## Using renewable energy in manufacturing

While decarbonization is tricky due to the scope and diversity of the chemicals industry, there are a few key approaches. One principal way to reduce emissions is to switch to renewable energy in the chemicals manufacturing process, which uses heat and pressure from burning fossil fuels to create chemical reactions.<sup>327</sup> CABB Chemicals' plant in Kokkola, Finland has already transitioned to 100% electricity through hydropower, reducing the plant's CO<sub>2</sub> emissions by roughly 5,800 metric tons per year since 2020.<sup>328</sup>

## Mining, Minerals, and Metals

The extraction and production of minerals, such as coal, iron, and crushed rock aggregates, helps Texas build homes, produce energy to cool and heat them, pave roads to reach them, and create many other products that help make life more livable and enjoyable. While the processes involved currently

result in significant releases of greenhouse gases, we may have many opportunities to reduce pollution from this sector.

## Decarbonizing mining

Globally, mining accounts for 4-7% of greenhouse gas emissions.<sup>329</sup> Greenhouse gases are “emitted directly during the actual mining and indirectly released by the energy-intensive activities associated with mining equipment, ore transport, and the processing industry.”<sup>330</sup>

Texas ranks third in the U.S. for non-fuel mineral production in 2021, producing nearly \$6 billion worth of non-fuel minerals, of which 38% came from crushed stone.<sup>331</sup> It ranks ninth for coal mining, producing 23 million short tons of lignite coal in 2019<sup>332</sup> and also is home to five uranium mines.<sup>333</sup>

Texas production of lignite has declined over the last decade as mines fuelling coal burning power plants close alongside retiring power plants.<sup>334</sup> Texas' other



Mercury Mine in West Texas

Image credit: Adobe Stock,

[https://stock.adobe.com/images/deserted-mercury-mine-at-western-texas/377380323?prev\\_url=detail](https://stock.adobe.com/images/deserted-mercury-mine-at-western-texas/377380323?prev_url=detail)

mines can decarbonize by powering operations with renewables, electrifying mining equipment, and improving operational efficiency.<sup>335</sup>

## Decarbonizing production of minerals

The minerals sector consists of “cement production, glass production, lime manufacturing, soda ash manufacturing, and any other mineral production facility.”<sup>336</sup> The largest emitting subsector of the minerals sector was “cement production, which emitted 2.6 times more CO<sub>2</sub>e than the next largest subsector (lime manufacturing).”<sup>337</sup>

Cement is a binding material used for construction purposes such as building houses, hospitals, schools, and roads. Texas’ rapid population growth has led to significant demand for cement.<sup>338</sup> In 2019, Texas was both the largest concrete producing and consuming state.<sup>339</sup> As of 2021, Texas was home to 11 cement production facilities with clusters near San Antonio and Midlothian.<sup>340</sup>

CO<sub>2</sub> is released during several parts of the cement production process.<sup>341</sup> Direct emissions result from calcination in which heated limestone is broken down from calcium carbonate into calcium oxide and CO<sub>2</sub>. Calcination accounts for roughly 50% of all emissions from cement.<sup>342</sup> Indirect CO<sub>2</sub> emissions also result from the combustion of fossil fuels such as coal, oil and natural gas used to heat the cement kiln – roughly 40% of emissions.<sup>343</sup> Fuels used to power additional facilities and final cement transportation represent 5-10% of emissions.<sup>344</sup>

There are several approaches to decarbonizing the cement industry. Operational measures can be implemented, which include renewable energy fuels and substituting different materials for clinker, the binder in many cement products. According to the Energy Policy Solutions simulator, reducing clinker to 60% by substituting the share of clinker with alternatives such as slag or fly ash would reduce emissions by four million metric tons per year by 2050.<sup>345</sup>

## Decarbonizing metals

Production of metals, including steel, requires massive amounts of energy for mining, smelting, and refining, and is responsible for approximately 10% of global GHG emissions.<sup>346</sup> According to the MIT Climate Lab, “the metals industry could drastically lower emissions by using renewable electricity instead of carbon-containing chemicals to extract metals from minerals. More reductions can come from cutting down on energy use. For example, we could improve the quality of ore going into mills by changing the way it’s blasted from the earth and sorted, which would reduce the energy needed to crush and grind that ore.”<sup>347</sup>

Steel is an important construction material in transportation infrastructure, machines, electrical appliances, and more and is responsible for the vast majority of greenhouse gas emissions from the metals sector.<sup>348</sup>

There are ten steel service centers/distributors and four steel manufacturers located in Texas. CMC Steel headquartered in Irving, Texas, touts its use of “100% recycled steel in their steel products and has invested in sustainable processes that use 84% less energy than traditional steel-making” and “produce eight times less CO<sub>2</sub> emissions per ton of steel manufactured.”<sup>349</sup>

## Waste

When we think of greenhouse emissions, obvious contributors like oil wells and car exhaust is what most often comes to mind. Less obvious but still important is waste. For example, landfill methane produced the equivalent of 114.5 million metric tons of CO<sub>2</sub> in the U.S. in 2019.<sup>350</sup> Food waste and yard trimmings, which make up 31.3% of waste sent to landfills, produce methane – a greenhouse gas 86 times more potent than carbon dioxide<sup>353</sup> in the short term – as they degrade in dark, low-oxygen conditions. This is a large missed opportunity, because composting organic matter builds soil and



traps carbon by helping microorganisms and plants to grow.

Texas threw out over 38 million tons of municipal solid waste in 2021.<sup>354</sup> Recycling rates in Texas reveal one of the more wasteful states in the nation. At 23 percent, the statewide rate falls almost twelve points below the national average 34.7 percent.<sup>355</sup>

## Zero Waste

It doesn't have to be this way. Texas can create a circular material economy that moves towards producing zero waste.

This goal can be achieved by replacing the wasteful linear material economy with a circular, or closed-

## A Note On Carbon Capture And Carbon Dioxide Removal

According to the U.N. Intergovernmental Panel on Climate Change (IPCC), carbon capture and storage and carbon dioxide removal strategies may be necessary to fully decarbonize.<sup>361</sup> Carbon capture is a process that captures carbon dioxide emissions from factory smokestacks and stores it deep underground into geological formations so it will not enter the atmosphere.

Carbon Dioxide Removal (CDR), on the other hand, refers to approaches that remove carbon dioxide directly from the atmosphere, including natural solutions such as soil carbon sequestration, reforestation, and ocean-based methods (discussed below in the Agriculture and Nature Based Solutions sections of the report, and technological approaches such as Direct Air Capture (DAC).

Heavy industry such as steel, cement, and chemicals is among the most difficult to decarbonize, “owing to technical factors like the need for very high heat and process emissions of carbon dioxide.”<sup>362</sup>

Any underground, including under the ocean floor, carbon sequestration should be permitted only after being proven to be safe; when energy- and cost-effective compared with other greenhouse gas reduction strategies; and if it has minimal impacts on the environment. Facilities that sequester carbon must be strictly regulated for safety. The Railroad Commission has applied to the EPA for sole regulatory authority over the carbon capture permitting process in Texas, which environmental groups oppose given the RRC's poor track record of regulating and the oil and gas industry.<sup>363</sup>

Further research is needed into the sequestration of carbon dioxide in durable products such as concrete and direct capture of carbon dioxide from the air or capture from industrial processes. But carbon capture and storage that enable further consumption or production of fossil fuels that encourage the combustion of unsustainably sourced biomass, or that result in the creation of synthetic fuels that emit greenhouse gases to the atmosphere when used should be rejected.

For example, Occidental Petroleum, its subsidiary 1PointFive, and climate tech company Carbon Engineering broke ground this year on a large-scale Direct Air Capture plant in Ector County, Texas. Occidental plans to use some of the captured carbon in a process called enhanced oil recovery, which extracts hard-to-reach oil reserves by shooting CO<sub>2</sub> into the ground. “While that takes CO<sub>2</sub> out of the air and stuffs it underground, it still leads to more polluting fossil fuels.”<sup>364</sup>

Occidental has also leased 106,000 acres within the historic King Ranch in South Texas for Direct Air Capture, but not for enhanced oil recovery. Instead, the company will “sell credits from the carbon removal project to other companies looking to reach net-zero emissions goals.”<sup>365</sup>

loop, economic system. In this system, less would be consumed, products would be built to last and be easy to repair and, once they fulfilled their original purpose, would be easily reused, recycled or composted, eliminating the need for harmful landfills and incinerators. Then, new products would be made using the reused and recycled materials, replacing the need for harmful and wasteful extraction processes.

## Recycling

Using recycled materials instead of virgin materials for manufacturing saves energy and keeps materials out of incinerators and landfills, both of which save significant amounts of climate pollution.<sup>356</sup> In 2018, recycling and composting in the U.S. prevented more greenhouse gas emissions than almost 42 million passenger cars produce in a year.<sup>357</sup> One 2008 study estimated that reducing waste generation and disposal via zero waste strategies could enable the U.S. to reduce its greenhouse gas emissions by more than 406 million metric tons of CO<sub>2</sub> equivalent per year by 2030 – equivalent to shutting down one-fifth of the coal-fired power plants in operation in the U.S. at the time that study was conducted.<sup>358</sup>

Using recycled material instead of virgin materials also saves significant amounts of energy – according to the Institute of Scrap Recycling Industries in 2017, energy saved from using recycled materials is up to 95% for aluminum, 75% for copper, 88% for plastic, 60% for paper, 60% for steel and 34% for glass. It also conserves natural resources.<sup>359</sup> Recycling 1 ton of steel conserves 2,500 pounds of iron ore, 1,400 pounds of coal and 120 pounds of limestone; and recycling 1 ton of aluminum conserves more than 4 metric tons of bauxite ore.<sup>360</sup>

## Transportation

With 192.7 million metric tons of carbon dioxide released in 2020,<sup>366</sup> Texas' transportation sector alone is responsible for more global warming pollution than the entire economies of all but three

states and more than 179 countries, including Pakistan, Venezuela and Iraq.<sup>367</sup>

Light-duty vehicles – including cars, pickups and SUVs – are the biggest contributors to greenhouse gas emissions – accounting for nearly three-fifths of emissions – from the transportation system nationally.<sup>368</sup>

High transportation emissions result in large part from individual Texans driving nearly 10,000 miles each year<sup>369</sup> – cumulatively more than 271 billion miles a year – and using 17% more fuel than the national average<sup>370</sup> by driving larger and more inefficient vehicles.<sup>371</sup>

Factors driving high emissions from light-duty vehicles include:

- Oversized, inefficient vehicles that run on dirty fuels. Typical Texas vehicles are bigger, heavier and more powerful than those in most other states and countries, contributing to relatively high fuel use and carbon dioxide emissions per mile of travel.
- Lack of transit access. 45 percent of Americans lack access to public transit.<sup>372</sup> And even in areas ostensibly served by transit, many Texans live in places where transit is inaccessible, unreliable, infrequent or low quality.
- Dangerous walking and biking. In 2021, 841 pedestrians<sup>373</sup> and more than 92 bicyclists<sup>374</sup> were killed in traffic in Texas, increases of 15 percent and 12 percent, respectively, from 2020. These deaths reflect infrastructure that is unsafe, and that can dissuade people from choosing to get around without a car.
- Car-dependent land use patterns. Many communities in Texas have attributes that make it hard to get around without a car, including low density and single-use zoning that separates homes and workplaces. Research shows that Americans who live in low-density areas travel more often by driving, drive more miles, and tend to own more vehicles.



*With a lack of public transport and a heavy reliance on light-duty vehicles, Texas' transportation industry is one of the most polluting sector in the state*  
 Credit:Dillon Kydd on Unsplash, <https://unsplash.com/photos/G6VnKqR8NvM>

Texas also has 13 million tractors, work trucks, transit and school buses, and other medium- and heavy-duty vehicles, almost all of which run on diesel.<sup>375</sup>

The Texas Department of Transportation plans to spend \$34.58 billion for highway widening projects alone over the next ten years.<sup>376</sup> A Georgetown Climate Center analysis found that such a focus on highway expansion could increase greenhouse gas emissions by up to 1.6 percent.<sup>377</sup>

The expansion of Interstate 35 through Austin alone is projected “generate 255 million to 382 million additional vehicle miles traveled per year, resulting in 1.2 to 2.6 million metric tons of carbon dioxide equivalent emissions by 2050, roughly equal to the annual greenhouse gases generated by a small coal-fired power plant,” according to estimates by Grist.<sup>378</sup>

Texas law requires the vast majority of revenues for transportation be spent on roads, leaving only about 3% of its remaining budget to spend on other

travel modes such as pedestrian improvements, bike lanes and transit (G. Chu, Texas Department of Transportation, personal communication, December 6, 2022)

Revolutionizing the way Texans travel is the first step towards lowering GHG emissions. There are two primary ways to accomplish this: incentivize traveling by bike or foot and expanding electric transportation.

### **Get more people traveling by foot, bike and transit**

In 2017, more than four in five trips taken by Americans were taken by car, pickup truck, SUV, or van.<sup>379</sup> Shifting some of these trips to transit, walking and biking is an important way to reduce transportation emissions, especially if all vehicles are eventually powered by electricity from renewable sources.

For one thing, shifting modes of travel can make



an impact right away, even as the nation transitions its automobile fleet to electric cars, builds out its infrastructure for charging them, and transitions to an electricity system powered by 100 percent clean energy. In addition, expanding transportation options can reduce the total energy demand of the transportation system, making it easier to power the system with renewable energy. Finally, shifting from driving to transit, biking, and walking can address the many other impacts of widespread automobile dependence, including dangerous and congested streets.

Making sure that low-carbon transportation options are safe, affordable, accessible and enjoyable is key to increasing the number of people who travel without a car.<sup>380</sup> Places that have invested in improved infrastructure and better service have seen subsequent improvements in safety and increased ridership. Three approaches in particular – adopting “complete streets” principles, investing in

transit improvements, and building more walkable communities – can get more people traveling by foot, bike and transit.

### Create “complete streets” that work for everyone

There are a wide variety of design and policy factors that affect the safety and quality of walking and biking, ranging from road design, to speed limits, to infrastructure elements like sidewalks and bus and bike lanes.<sup>381</sup> Many of these disparate elements fall under the concept of “complete streets,” which, as described by U.S. Department of Transportation, are “streets designed and operated to enable safe use and support mobility for all users,” including “people of all ages and abilities, regardless of whether they are traveling as drivers, pedestrians, bicyclists, or public transportation riders.”<sup>382</sup> A number of Texas cities, including Austin,<sup>383</sup> Houston,<sup>384</sup> and Dallas,<sup>385</sup> have adopted “complete streets” policies.



*“Complete street” with bike lane and sidewalk, Austin, Texas*

Image credit: Adobe Stock,[https://stock.adobe.com/images/spring-2016-austin-texas-usa-central-street-of-austin-texas-empty-bike-lane-next-to-the-roadway/397129502?prev\\_url=detail](https://stock.adobe.com/images/spring-2016-austin-texas-usa-central-street-of-austin-texas-empty-bike-lane-next-to-the-roadway/397129502?prev_url=detail)

## Expand and improve transit

There are many ways to make transit service better. Cities and transit agencies can add routes, build better platforms and transit stations, dedicate lanes to buses, reduce the cost of riding, and more. Improving frequency, reducing crowding, and ensuring safety and reliability are all important ways to improve rider satisfaction.<sup>386</sup>

While every region is different, the evidence is clear that when transit service is expanded or improved, more people ride. A TransitCenter analysis of the National Transit Database found that in 2018, transit ridership increased in seven of the 35 regions with the highest transit usage.<sup>387</sup> Of those seven regions, six – Seattle, Houston, Austin, San Antonio, Las Vegas and Pittsburgh – had either substantially increased transit service since 2013, or had recently reoriented their transit networks to meet growing demand.<sup>388</sup>

Houston's MetroNext is working to expand public transportation options in part to help meet the city's climate goals. MetroNext is planning 500 miles of transit improvements, which help increase the efficiency with which Houstonians can move around the city, as well as public health.<sup>389</sup> The expansion of public transit will require more stations, vehicles, and route options, as well as lanes dedicated to public transit in order to make routes more efficient. Reduced fees and more frequent cycles can help increase accessibility as well – and more accessible transportation has been shown to lead to increased ridership.<sup>390</sup>

## Building compact, walkable communities

Compact development is a land use settlement pattern that seeks to minimize land conversion while enabling population growth. To do so, compact development concentrates people and jobs in mixed-use neighborhoods, and features housing from single-family homes on small lots

and townhomes to apartments and high-rises, to provide access to affordable housing and convenient employment opportunities. Compact development uses less energy for construction, building operation and transportation, which results in lower greenhouse gas emissions.<sup>391</sup>

Reducing minimum parking requirements and minimum lot sizes, changing zoning to allow multi-family properties, and focusing new growth along transit corridors and within urban centers can encourage compact development.

## Electric vehicles

Gas-powered vehicles produce an immense amount of emissions throughout their lifecycle,<sup>392</sup> but the majority of the environmental impact is due to fuel consumption – each gallon of gas combusted releases roughly 20 pounds of CO<sub>2</sub>.<sup>393</sup> Electric vehicles produce lower tailpipe emissions than conventional vehicles, greatly reducing the carbon footprint of driving.<sup>394</sup> Electric vehicles are not carbon neutral, as they require electricity to charge, but their emissions are still lower than traditional gas-powered cars. Furthermore, as renewables produce more of Texas' energy, the emissions from charging these vehicles will decrease. Electric vehicles also produce GHG emissions during the creation of the batteries necessary; however, these emissions are still lower than those associated with a traditional gasoline car,<sup>395</sup> and improved recycling programs for these batteries can further reduce these emissions.<sup>396</sup>

According to the American Lung Association, shifting to 100 percent sales of zero-emission passenger vehicles by 2035 and medium- and heavy-duty trucks by 2040, coupled with renewable electricity, would reduce greenhouse gas emissions by 93% by 2050. In addition, less air pollution saves lives. The group estimates electrifying transportation would save 9,320 lives in Texas due to reduced particulate pollution and save the state \$104 billion by 2050.<sup>397</sup>



*Texas will receive at least \$408 million over five years from the Federal Highway Administration to install EV chargers.*

Image credit: Adobe Stock, [https://stock.adobe.com/images/electric-car-charging-station-for-charge-ev-battery-plug-for-vehicle-with-electric-engine-ev-charger-clean-energy-charging-point-at-car-parking-lot-green-power-future-transport-technology/404217948?prev\\_url=detail](https://stock.adobe.com/images/electric-car-charging-station-for-charge-ev-battery-plug-for-vehicle-with-electric-engine-ev-charger-clean-energy-charging-point-at-car-parking-lot-green-power-future-transport-technology/404217948?prev_url=detail)

Over the past decades, electric vehicles have become increasingly popular, with Texas reporting having sold over 36,000 in 2019.<sup>398</sup> This is only 0.12% of the total cars registered in Texas, and with the number of miles that Texans drive each year, transitioning to electric vehicles would help substantially reduce Texas' emissions.<sup>399</sup> As of July 5, 2022, 134,072 electric vehicles are registered in Texas, and ERCOT estimates that there will be 1 million electric vehicles on Texas roads by 2028, while the Texas Department of Motor Vehicles estimates we'll hit that milestone by 2031.<sup>400</sup>

### **Reduce financial hurdles to EV adoption**

As a result of low fuel and maintenance costs, EVs are typically cheaper to own than conventional vehicles

over the vehicle's lifetime. In the face of higher upfront costs and the usual uncertainty surrounding new technologies, however, financial incentives are an important tool for increasing EV sales.

The recent passage of the Inflation Reduction Act extended existing and created new incentives for EV purchases. Federal tax credits up to \$7500 are available for the purchase of new EVs and \$4000 for the purchase of used EVs. The state of Texas also offers a limited number of \$2500 rebates for the purchase of both electric light duty<sup>401</sup> and medium and heavy duty<sup>402</sup> vehicles. Together, the incentives significantly reduce the cost of purchasing an EV, which help increase their widespread adoption.

### **Expand and improve the EV charging**



## network

For electric vehicles to become mainstream, they need to be easy to charge. But today, in many parts of the state, EV chargers can be both hard to find and hard to use. One 2019 survey found that a majority of consumers considering an EV purchase believed there were too few charging stations around their home and work areas, suggesting that lack of a ubiquitous charging network presents a barrier to wide scale adoption.<sup>403</sup>

Texas had 5,010 EV charging stations as of 2021, fourth most in the nation.<sup>404</sup> Thanks to the Infrastructure Investment and Jobs Act, Texas will receive at least \$408 million over five years from the Federal Highway Administration to install EV

chargers. With these funds, the Texas Department of Transportation plans to create a network of chargers throughout the state. These chargers will allow most electric vehicles to go from 10% to 80% charge in about 30 minutes,<sup>405</sup> and will be placed every fifty miles along major highways and at least every seventy miles everywhere else, helping make sure EVs will be accessible for all Texans.<sup>406</sup>

## Electrifying public transit

Enabling more Texans to shift from driving to public transit is a critical step to reducing transportation emissions. So, too, is converting public transportation from polluting fossil fuels to electricity. By electrifying all modes of transit, public transportation can eventually be powered



Texas A&M University operates three electric buses for students  
Image credit: Texas A&M Division of Marketing & Communications

with clean, renewable energy. Such a system would emit no pollution from charging and driving. The IPCC notes, for example, that electrified rail transit powered by clean energy can enable transportation that is “deeply decarbonized.”<sup>407</sup>

Among transit modes, buses are the biggest source of global warming pollution.<sup>408</sup> While buses emit far less pollution per passenger than personal vehicles per mile of travel, they emit significant quantities of both global warming pollution and air pollutants that pose an immediate threat to public health.<sup>409</sup>

Electrifying buses would reduce global warming pollution and bring important public health benefits to both the densely populated areas that transit buses often serve, and to young people who ride school buses.<sup>410</sup> Electric buses provide other benefits, too. They are quiet, and can help bring down noise levels in urban environments. They also have lower operational costs, can provide cities and school districts with long term financial savings, and can provide backup power to electric grids.<sup>411</sup>

Texas has made important progress in electrifying transit. Transit agencies in Austin<sup>412</sup> and Houston<sup>413</sup> have committed to convert their entire bus fleets to all electric or zero emission and other transit agencies, including in Dallas<sup>414</sup> and Port Arthur,<sup>415</sup> have purchased electric buses. Everman Independent School District near Fort Worth already has three electric buses,<sup>416</sup> Austin ISD has committed to an all electric fleet for its school buses by 2035,<sup>417</sup> and another thirteen Texas school districts will soon have electric buses thanks to funding from EPA’s Clean School Bus Program.<sup>418</sup> An additional fifty school districts applied for electric bus funding, but were waitlisted.<sup>419</sup>

## Encouraging e-bikes

Electric bikes can extend the range someone is willing to bike to work, the grocery store, or anywhere else with proper bike-friendly infrastructure. This in turn can reduce the number

of cars on our roads – an important way to reduce the transportation sector’s climate impact. E-bikes are also much cheaper to purchase than cars, providing a lower cost means of transportation. Electric bikes outsold electric cars and plug-in hybrids in the United States in 2021.<sup>420</sup> Incentives programs, like rebates offered by Austin Energy,<sup>421</sup> and incorporating them into city bike-share programs, like in Houston,<sup>422</sup> are key tools for getting more Texans on these clean vehicles.

## Planes and boats

Other forms of transportation, including aerospace and cargo ships, are also significant contributors to greenhouse gas emissions.

### Aerospace

The largest sector of the aerospace industry, the commercial aircraft industry, contributed 8% of U.S. transportation emissions in 2020<sup>423</sup> and Texas is a major contributor. 18 of the 20 largest aerospace companies in the world, including American Airlines and Southwest Airlines, have major operations in Texas.<sup>424</sup>

Aircraft engines produce CO<sub>2</sub> – roughly 70% of emissions – from fuel burned in the engines. Around 30% of CO<sub>2</sub> emissions are ground level emissions and 70% of emissions are at higher altitudes.<sup>425</sup> These indirect emissions, Scope 3 emissions account for the majority of emissions from the industry but are the most difficult to address.<sup>426</sup> Beyond the aircraft itself, the industry also produces emissions through transportation to and from the airport, equipment operating the aircraft and airport, electricity needs, and the manufacture of aviation vehicles. With growing demand for commercial aircrafts, aerospace is one of the fastest-growing sources of CO<sub>2</sub> emissions.<sup>427</sup>

A report from Clean Air Task Force finds that “decarbonizing the global aviation sector will require significant investment in and policy support for an



expanded suite of clean energy solutions beyond only biofuels, including low-emissions hydrogen and synthetic fuels, electricity, and direct air capture.”<sup>428</sup>

## **Ships and boats**

According to TxDOT, Texas ports, including in Houston and Corpus Christi, “move more cargo than any other state—more than 607 million tons in 2020, including 464 million tons of international cargo and 143 million tons of domestic cargo.”<sup>429</sup> With the expansion of the Panama Canal, freight traffic at the Port of Houston is expected to increase by 56% over the next 20 years, according to the Healthy Port Communities Coalition.<sup>430</sup> Most freight ships, carrying chemicals, foods, furniture, machinery, motor- and military vehicles, footwear, and garments, are fueled by diesel oil, which has a very high carbon footprint.<sup>432</sup> Alternative fuels, including green ammonia and green hydrogen, offer pathways to decarbonizing shipping.<sup>433</sup> The Ship it Zero campaign is urging Amazon, IKEA, Target, and Walmart to abandon dirty fossil-fueled ships, and commit to ship products on zero-emissions ships by 2030. Port Houston has committed to carbon

neutrality by 2050, “working toward eventually eliminating dockside emissions, transitioning trucks to low/no emissions vehicles, helping implement green shipping corridors as well as green marine and road fuels.”<sup>434</sup>

## **A Note on Hydrogen**

Hydrogen, an energy carrier and fuel which has been proposed as a tool for decarbonization – especially in transportation and industry – is colorless, odorless, highly flammable, and explosive, presenting serious potential safety risks. It is also currently very energy-intensive to produce, and much of it is produced using fossil fuels as an energy source and a feedstock. Hydrogen fuel is prone to leaking and may cause warming effects as an indirect greenhouse gas if released, hindering large-scale production.

It may be useful in the future to decarbonize the trickiest end-uses of energy, and should be researched to try to find more efficient production methods and ways of using it, but should not be the primary tool of decarbonization for the moment.



*Port Houston has committed to carbon neutrality by 2050*

Image credit: Adobe Stock, [https://stock.adobe.com/images/aerial-view-of-the-houston-ship-channel-with-oil-and-gas-infrastructure/552495625?prev\\_url=detail](https://stock.adobe.com/images/aerial-view-of-the-houston-ship-channel-with-oil-and-gas-infrastructure/552495625?prev_url=detail)





*With Texas ranked as the second largest producer of solar energy in the country, it is clear that renewables are on the rise*  
Source: Photo American Power Association on Unsplash, <https://unsplash.com/photos/XGAZzyLzn18>

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## Electricity Generation

Texas produces and consumes more electricity than any other state.<sup>436</sup> Within the Electric Reliability Council of Texas (ERCOT) grid in 2021, 61 percent of electricity was produced by fossil fuel sources, with 28 percent from wind and solar energy, and the remainder from nuclear and other sources.<sup>437</sup>

Texas has made significant progress in reducing greenhouse gas emissions from the electricity sector. We have more wind and solar energy, which have zero emissions, installed than any other state. Poor economics for coal-fueled by the low cost of renewables and natural gas<sup>438</sup> in the last decade led to the retirement of 8500 megawatts of coal-fired power plants in Texas since 2010<sup>439</sup> and another six coal units will either retire or switch to gas by 2028. As a result, emissions from the electricity sector dropped 17.3% from 2005 to 2019.

However, Texas still currently has fourteen coal plants operating and remains the largest consumer of coal in the United States.<sup>440</sup> Total emissions from just

the state's power sector exceed the pollution from the entire economies of all but six states. Out of the ten dirtiest power plants in the nation, three of them—NRG's W.A. Parish, Martin Lake, Oak Grove—are located in Texas.<sup>441</sup> Emissions from CPS Energy's Spruce plant increased 38% from 2020 to 2021.

Meanwhile, absent action to restrain it, demand for electricity is expected to grow 20% by 2026 as our population continues its rapid growth, industrial demand increases with new industries such as cryptocurrency<sup>444</sup> and LNG export facilities straining the grid, and global warming-fueled heat waves increase use of air conditioning.

### Continuing the decarbonization of the Texas electric grid

With widely available clean and affordable solutions and fewer, more centralized assets than other sectors, the electricity sector is considered the easiest to decarbonize.<sup>445</sup> President Biden has set a goal of generating 100 percent of U.S. electricity from carbon pollution-free sources by 2035. With rapidly

## Coal plants currently operating in Texas<sup>442</sup>

FACILITY	LOCATION	CAPACITY (MW)	# OF UNITS	PARENT COMPANIES	CO <sub>2</sub> EMISSIONS 2021	STATUS
Martin Lake	Rusk County	2,380	3	Luminant/Vistra	13,502,540	No announced plan to retire
W A Parish	Greater Houston	2,736	4	NRG Energy Inc	12,840,973	No announced plan to retire
Oak Grove	Robertson County	1,796	2	Luminant/Vistra	12,557,659	No announced plan to retire
Sam Seymour	Fayette County	1,690	3	Lower Colorado River Authority Austin Energy Corp	10,987,934	No announced plan to retire
J K Spruce	Bexar County	1,444	2	CPS Energy	7,998,098	Spruce 1 retiring by 2028
Limestone	Jewett	1,850	2	NRG Energy Inc	5,961,022	Retiring in 2030
Sandy Creek	Riesel	1,008	1	Sandy Creek Energy Associates Brazos Electric Power Cooperative Inc Lower Colorado River Authority	5,414,276	No announced plan to retire
Harrington	Potter County	1,080	3	Xcel	4,987,248	Converting to gas by 2025
Welsh	Mount Pleasant	1,116	3	AEP	4,71,890	Retiring in 2028
Coletto Creek	Fannin	622	1	Luminant/Vistra	3,580,251	Retiring in 2027
HW Pirkey	Hallsville	721	1	SWEPSCO	3,067,585	Retiring in 2023
Twin Oaks	Robertson County	349	2	Blackstone	2,722,575	No announced plan to retire
Tolk	Lamb County	1,136	2	Xcel	2,612,560	Retiring in 2028
San Miguel	Christine	390	1	San Miguel Electric Coop	2,359,262	No announced plan to retire

growing wind and solar energy and battery storage energy capacity, and vast untapped reserves of energy efficiency, Texas is well positioned to achieve this goal.

**1. Rapidly deploy clean energy.** Renewable energy in Texas is on the rise. Texas tripled net wind electricity generation to 92,989 GWh and increased

solar electricity net generation from 77 GWh in 2011 to 9,519 GWh in 2020.<sup>446</sup> Technology and price trends point the way toward far faster progress in the years to come.

- Today's wind turbines and solar panels produce more energy, in less space, for less cost, and with more flexibility than ever before. The cost of wind power fell by 71% and utility-scale solar

by 90% from 2009 to 2020.<sup>447</sup> In 2019, the median new residential solar panel was 37% more efficient than one installed in 2010. And in 2019, the average installed wind turbine had 42% greater power capacity than one installed in 2010.<sup>448</sup>

- A staggering 209 gigawatts of additional solar, wind and battery storage are under development in ERCOT.<sup>450</sup>
- Modeling by Rice University researchers found that “a portfolio of just 72 of the 108 wind projects and 42 of the 262 solar projects in the queue would be sufficient to replace most coal generation in ERCOT.” The study notes that “the complementary timing of solar and wind in Texas, with sunshine peaking midday and winds peaking overnight in the west and on summer evenings near the coast, enables these high levels of displacement to be achieved.”<sup>451</sup>
- Renewables have played a key role in providing energy to Texans throughout the record-breaking heat of the summer months of 2022, and have helped to keep costs lower as natural gas prices skyrocket.<sup>452</sup> RMI estimates that wind and solar projects have helped save Texans \$20 million per day compared to the cost of fossil fuel-based power plants to meet electricity demand amidst an extremely hot summer and global energy uncertainty.<sup>453</sup>
- New renewable energy technologies that could one day help provide more stable and diverse options for providing renewable energy are on the way. The Biden administration announced plans for the Gulf of Mexico’s first offshore wind farm along the Texas and Louisiana coasts in late July, 2022.<sup>454</sup> Amanda Lefton, Director of the U.S. The Bureau of Ocean Energy Management, said “the Gulf is ripe for clean energy, and offshore wind is a really clear opportunity” given the shallow waters, warm temperatures, small wave heights, and a primed workforce with experience in offshore industry.<sup>455</sup> Offshore wind has the technical potential to provide Texas with 166% of its electricity needs.<sup>456</sup> And advances in enhanced geothermal technology may soon allow

Texas to tap into the nation’s enormous potential for generating electricity using underground heat.<sup>457</sup>

- Increasing numbers of Texans are adding solar panels to their roofs as upfront costs fall and long-term benefits rise.<sup>458</sup> Texas’s technical potential for rooftop solar generation alone is 978,000 MW, which could produce the equivalent of 33% of the state’s total electricity use in 2020. During the winter storm of February 2021, rooftop solar could have supplied more than enough power to meet the daily shortfall in power demand in eleven out of the thirteen days in which power production fell short.<sup>459</sup>
- The rise of renewables will only increase with the passage of the Inflation Reduction Act, which extends the production tax credit and investment tax credit for wind and solar for another ten years. These extensions ensure that renewables remain a solid investment choice, and will help current and future projects develop – annual installations of clean energy are expected to exceed 50 GW by the mid-2020s and over 90 GW by 2030.<sup>460</sup>

**2. Modernize the grid.** Texas has laid the groundwork for providing reliable renewable power when we need it with a modern grid capable of storing energy, delivering energy across long distances, and reacting to changes in weather conditions.

- Battery storage capacity has skyrocketed as the cost per watt-hour of utility-scale battery storage has fallen dramatically, down 70% from 2015 to 2018.<sup>461</sup> Batteries are now often deployed alongside new wind and solar farms both for their ability to store energy for when energy output is low and to assist grid function by helping regulate grid frequency and respond to grid disturbances.<sup>462</sup> Long-term or seasonal energy storage solutions, like renewably-produced hydrogen, are being developed that could one day help the grid achieve renewable energy penetrations approaching 100%.<sup>463</sup>



## A Note on Cryptocurrency

Cryptocurrency such as Bitcoin, Ethereum and Dogecoin are a form of currency that is decentralized and digital. Unlike traditional currency, cryptocurrency is “mined”. “Mining” is executed by using complex technology that solves extremely difficult computational mathematical problems. Transactions are recorded on a “blockchain,” a digital ledger of transactions that is duplicated and distributed across the entire network of participating systems. Mining involves large amounts of power to be successful. Globally, it is estimated that the cryptocurrency industry per year uses more energy than the country of Norway.<sup>474</sup>

The biggest environmental concern regarding cryptocurrency is the amount of energy that mining uses and the energy intensive processes of the blockchain. Mining often occurs in farms which are filled with specialized computers specifically programmed to solve the complex computational problems. One day of bitcoin mining uses approximately 9.37 GWh of power,<sup>475</sup> more than 320,000 homes.<sup>476</sup> Transactions and storing the information take up energy as well. The blockchain is estimated to use over 2,000 GWh of electricity per year.<sup>477</sup>

In Texas, cryptocurrency miners have applied to draw up to 33 GWh annually, or about as much as the entire state of New York.<sup>478</sup> This electricity usage is concerning considering approximately 67% of electricity generated in Texas comes from fossil fuels.<sup>479</sup> Such an increase in demand has led to “zombie” fossil fuel plants reopening in Montana and New York<sup>480</sup> and with the largest Bitcoin mining facility in North America located in Rockdale,<sup>481</sup> a town approximately 60 miles east of Austin, it is easy to imagine the same happening in Texas.

- Expanding transmission connections allows for more efficient and flexible use of renewable resources, such as Texas’s Competitive Renewable Energy Zone (CREZ) process, where new transmission lines helped unlock enormous wind and solar resources in rural parts of the state.<sup>464</sup> Additional intrastate transmission lines will be needed to reduce constraints and take full advantage of our renewable energy resources. In addition, connecting ERCOT and the eastern and western U.S. grid systems with high-voltage direct current lines could allow for greater integration of renewables and greater grid reliability.
- New technologies and tools are ready to help build a smarter, more modern grid. Smart inverters, along with strategies like extracting stored kinetic energy from wind turbines, are already allowing clean energy technologies to respond to changes in grid conditions.<sup>465</sup> And sophisticated computing tools are making possible advanced forecasting that can provide grid operators with precise and granular information about renewable generation.<sup>466</sup>

**3. Reduce and manage energy demand.** Texas has enormous potential to cut energy use and make energy demand more flexible, which would reduce the amount of new infrastructure needed for a shift to renewable energy.

- According to the U.S. Department of Energy, Texas has the largest energy efficiency potential of any state and could reduce statewide energy use by almost 19%.<sup>467</sup> According to the American Council for an Energy Efficient Economy, in just the next five years, efficiency could cut summer peak demand for electricity by 7650 megawatts, or almost ten percent of the 2022 peak.<sup>468</sup>
- Demand response programs can reduce peak energy demand and enable the grid to respond to changes in renewable energy supply. Research from 2019 found that by 2030 demand response could provide 200 GW of “economically feasible load potential,” equivalent to 20% of peak load levels.<sup>469</sup> Now, new technologies



Today's wind turbines and solar panels produce more energy in less space and for a fraction of the cost compared to fossil fuel industries  
Image credit:Markus Spiske on Unsplash, [https://unsplash.com/photos/rNn\\_TU8dvoY](https://unsplash.com/photos/rNn_TU8dvoY)

like smart thermostats and advanced metering infrastructure are enabling advanced demand response programs that can help create a more flexible and responsive electric grid.<sup>470</sup>

- Texas has received \$173 million in federal funding through the IIJA to weatherize homes.<sup>471</sup>

**4. Electrify everything.** We have the technology and the resources to stop burning fossil fuels in our homes and commercial buildings.

- New and improved technologies are putting clean, efficient electric space heating and water heating, and electric appliances like stoves within the reach of most American households. Analysis shows that electrifying the vast majority of America's residences and commercial spaces by 2050 could reduce net greenhouse gas emissions from the residential and commercial sectors by about 306 million metric tons of CO<sub>2</sub> in 2050.

That is the equivalent of taking about 65 million of today's cars off the road – almost three times the number of vehicles in Texas.<sup>472</sup>

- The Inflation Reduction Act includes “\$10 billion in consumer home energy rebate programs to provide financial assistance for homeowners to purchase heat pump space, water heaters, clothes dryers, electric stoves, improved insulation and windows, and wiring upgrades needed for home electrification.” The funding to aid in home electrification and increases in efficiency will help Texans save money and reduce emissions.<sup>473</sup>

# Agriculture

State level data on greenhouse gas emissions from agriculture are not available, but farming activities in the United States accounted for 11.2 percent of U.S. greenhouse gas emissions in 2020.<sup>482</sup> “Emissions come from cropping activities that emit nitrous oxide, such as fertilizer application and manure storage and management, and enteric fermentation (a normal digestive process in animals), which produces methane.”

Agriculture is one of the largest industries in Texas. The state leads in the number of farms and ranches with 247,000 farms covering more than 126 million acres of agricultural land.<sup>483</sup> Texas ranks first in the nation in the number of cattle and calves, which account for \$8.5 billion dollars of its \$20.2 billion agriculture economy.<sup>484</sup>

Texas farmers have the opportunity to serve a powerful role in solutions to climate change. As noted by the House Select Committee on the Climate Crisis, “climate stewardship practices, such as no- and low-till farming, planting cover crops, diversified crop rotations, rotational grazing, and improved nutrient management, increase carbon sequestration in roots and soils and reduce agricultural greenhouse gas emissions.”<sup>485</sup>

## Improving cropland management

Soil management practices are responsible for over half of greenhouse gas emissions in the Agriculture sector. Specific activities include the application of fertilizers, growth of nitrogen-fixing crops, drainage of organic soils, and unsustainable irrigation techniques. These practices increase the availability of nitrogen in the soil and result in emissions of N<sub>2</sub>O (nitrous oxide), a greenhouse gas. Other sources of agricultural emissions include burning crop residues which produce methane and nitrous oxide, the release of methane from rice cultivation and CO<sub>2</sub> generated from farming-related electricity use.

Cropland management practices, such as improved crop rotations, reduced soil tillage, improvements in fertilizer composition and application, improved flooding practices in rice cultivation could reduce agricultural process emissions in 2050 by 2%.<sup>486</sup>

## Reducing emissions from meat

Feeding supplements or drugs to prevent enteric methane formation, and thus methane emissions, could reduce agricultural process emissions in 2050 by 10%. Reducing meat consumption would have the biggest impact on emissions. If Texans cut their meat consumption in half, by eating more plant based products or cultivated meat, Texas agriculture emissions would be cut 47% by 2050.<sup>487</sup>

The Inflation Reduction Act invested \$27 billion in agricultural conservation and climate programs, which provides a historic opportunity for Texas agriculture to further grow climate solutions.<sup>488</sup>



# Nature-Based Solutions

According to the White House, “nature-based solutions, like protecting forests or restoring coastal marshes, are a fundamental pillar of fighting the climate crisis, just like reducing greenhouse gas emissions, deploying renewable energy, and increasing energy efficiency.”<sup>489</sup>

Nature-based solutions to climate change involve conserving, restoring, or better managing ecosystems to remove carbon dioxide from the atmosphere. The Institute for Carbon Removal at American University notes that “some nature-based solutions, such as conserving existing wetlands, serve mainly to prevent greenhouse gas emissions. Others, such as restorative agriculture and regrowing clear-cut forests, actively remove CO<sub>2</sub> from the atmosphere.”<sup>490</sup>

The Infrastructure Investment and Jobs Act and Inflation Reduction Act made “unprecedented investments in nature-based solutions,” including \$5 billion for forest management actions that can reduce wildfire risk, store carbon, and cool

communities, over \$8.7 billion to support nature-based solutions and other approaches to build climate resilience into transportation systems, and another \$8.6 billion to restore and conserve coastal habitats.<sup>491</sup>

Texas’ Flood Infrastructure Fund<sup>492</sup> and the Texas Nonpoint Source Management Program<sup>493</sup> provide additional opportunities to use nature-based solutions to reduce flooding and water pollution while promoting climate solutions. Expanding the state parks system and the Texas Farm and Ranch Lands Conservation Program will slow the conversion of natural land and support restoration of damaged ecosystems.

Reforestation existing and previously forested land,<sup>496</sup> “blue carbon” strategies to capture carbon in aquatic vegetation through protection or replanting of seagrass beds, marshes and mangroves,<sup>497</sup> and other nature-based strategies also hold great promise in both reducing greenhouse gas emissions while making the state more resilient to climate change.



*Reforestation can help make Texas more resilient to climate change. Image credit: Adobe Stock, [https://stock.adobe.com/images/female-forester-planting-seedlings/360183188?prev\\_url=detail](https://stock.adobe.com/images/female-forester-planting-seedlings/360183188?prev_url=detail)*

# Texas Cities Lead On Climate Action

Texas does not have a statewide action plan, but individual cities and towns are taking the lead in tackling climate change head-on.<sup>498</sup> The cities of Austin, San Antonio, Dallas, Houston and Laredo, and Dallas and Travis counties have committed to decarbonize by 2050<sup>499</sup> and have developed detailed plans to achieve the goal.

## Increasing use of renewable energy

Both Dallas and Houston are committed to 100% renewable energy use for municipal operations.<sup>500</sup> The City of Waco has a contract with MP2 Energy Texas, LLC for 100% green, renewable energy,<sup>501</sup> and in January 2022, took a step toward creating a new citywide strategic energy guide plan.<sup>502</sup> Houston is also home to Project Sunroof, which is looking to utilize Houston's solar potential by increasing the number of solar panels on small and larger building rooftops.<sup>503</sup>

### Reducing the carbon footprints of buildings

The City of Austin is looking to reduce the carbon footprint of buildings via the materials used to build them by 40% by 2030 through using and incentivizing the use of lower-carbon materials.<sup>504</sup> Austin,<sup>505</sup> Dallas,<sup>506</sup> and Houston<sup>507</sup> are looking to expand participation in utility energy incentive programs and create more incentives for businesses to go green(er).

### Improve electric vehicle infrastructure

Dallas has set the explicit goal of installing 1,500 EV charging outlets by 2030<sup>508</sup> while Austin is looking to increase the number of charging stations and ensure that future needs are addressed in energy and building codes.<sup>509</sup> The City of Houston is working with EVolve Houston to expand public and private charging options across the city to help overcome barriers to adoption.<sup>510</sup>

## Increase the number of electric vehicles on the road

Going hand-in-hand with the above solution, Austin, Dallas, Houston, and Waco all have electric and hybrid vehicles in their city-fleets, setting an example for EV adoption. Dallas has a Clean Fleet Vehicle Policy and is committed to shifting regional bus and light duty vehicles to 100% electric by 2040,<sup>511</sup> and Austin is looking to partner with regional public fleets to participate in the Climate Mayors Electric Vehicle Purchasing Collaborative to lower the upfront costs of new electric vehicles to improve adoption and decrease barriers to access.<sup>512</sup>

## Create a skilled workforce

Austin,<sup>513</sup> Dallas,<sup>514</sup> and Houston<sup>515</sup> are all partnering with local community colleges and other higher education institutions to create programs that will train people in the skills necessary for the transition to clean energy.

# Adaptation

It is not enough to be thinking about how to mitigate the effects of climate change somewhere down the road, but we also have to confront and adapt to the consequences already impacting Texas.

## Increasing tree cover

of the major impacts of climate change is that the world is getting hotter, and cities experience what is known as the urban heat island effect. Buildings, roads, and other infrastructure absorb more heat than natural bodies, making dense cityspaces substantially warmer than surrounding areas.<sup>516</sup>

One way to help cool cities off is to plant trees, which provide shade, deflect solar radiation, and release moisture into the atmosphere.<sup>517</sup> Various cities around Texas are looking to increase tree cover to cool down and reduce further emissions. The City of Dallas is implementing an Urban Forest Master Plan,<sup>518</sup> the City of Austin has set itself the goal of at least 50% citywide tree canopy cover and the adoption of a “no net loss” policy,<sup>519</sup> and the Houston Parks and Recreation Department is planning a Legacy Tree Program to propagate native seedlings and is developing a tree nursery.<sup>520</sup>

## Increasing green infrastructure

Green infrastructure goes hand-in-hand with increased tree cover, but has greater variation in its application. Green infrastructure is a range of measures that allow for greater filtration, absorption, and even reuse of rainwater.<sup>521</sup> Examples include green roofs, layers of vegetation on conventional roofs that help reduce stormwater runoff and cool cities; rainwater harvesting, the collection of stormwater runoff for non-potable processes; urban forestry, the management of trees and plants in developed areas, and more.<sup>522</sup> Austin, Dallas and Houston all include green infrastructure in their city-wide plans for climate adaptation and resilience, with each city looking to adapt the myriad of measures included in green infrastructure to best fit

their city. As climate change brings heavier storms and increased flooding, green infrastructure will be an important part of reducing flooding and risks to human life and property.

## Cooling centers

Texas is getting hotter as climate change shifts weather patterns, and the electric grid is being placed under increasing pressure to perform as Texans look to cool off. One way that cities are adapting to this are cooling centers and promoting air-conditioned public facilities as places where people can escape the heat.<sup>523</sup> Austin has 48 cooling centers set up throughout the city to offer people places to escape the heat, a critical service as early numbers suggest at least 10 people had died due to heat-related issues as of June 2022.<sup>524</sup> Early July 2022 saw the City of San Antonio urging residents to take advantage of cooling stations to cool off and avoid the worst health-implications of the extreme heat rolling across Texas.<sup>525</sup>



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