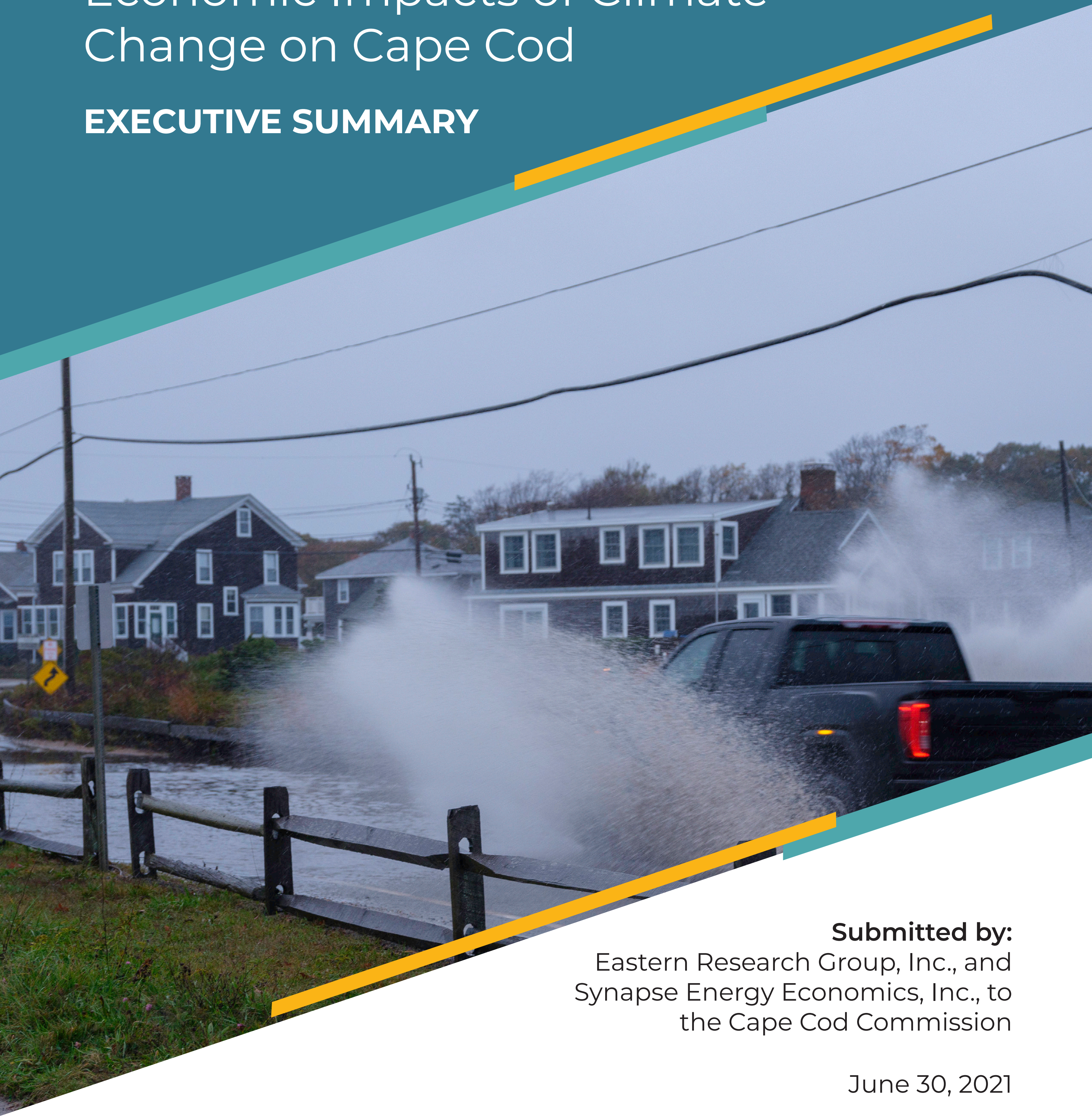
Economic Impacts of Climate Change on Cape Cod

EXECUTIVE SUMMARY



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the Cape Cod Commission

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Background and Purpose

Cape Cod (Barnstable County) is experiencing impacts from climate change today that are anticipated to worsen in the coming decades. Climate change and continued reliance on fossil fuels will affect all sectors of Cape Cod's economy. Sea level rise will increase instances of flooding and damage to coastal property and infrastructure. Warming ocean temperatures will alter fisheries and encourage harmful algal blooms. Burning of fossil fuels will continue to emit pollutants with adverse effects on public health.

The Cape Cod Commission engaged Eastern Research Group, Inc. (ERG), and Synapse Energy Economics, Inc. (Synapse), to put climate risks—and options to address those risks—into a monetary context to inform policy decisions. ERG and Synapse assessed the impacts climate change may have on the region's economy, revenues, and investment decisions and evaluated costs and benefits of key strategies that the Cape Cod Commission and stakeholders identified to address climate change. The results of this assessment will inform the Cape Cod Climate Action Plan and potential amendments to its Regional Policy Plan.

The assessment consists of three parts:

- **Costs of not adapting to climate change:** This analysis estimates the losses that Cape Cod and its residents will face without taking action to mitigate climate change impacts and minimize their greenhouse gas (GHG) emissions.
- **Cape Cod emissions analysis:** This analysis establishes a sustained policy baseline for energy use and emissions baseline given current state and regional policies. It also assesses four primary scenarios for meeting the Cape's GHG reduction goals (and key sectors for targeted mitigation) while continuing to meet energy needs. In addition, this analysis identifies key metrics for tracking the mitigation scenarios.
- **Economic analyses of adaptation and mitigation strategies:** These analyses provide context for key adaptation and mitigation strategies identified through its Climate Action Plan stakeholder engagement and planning process. To the extent possible, these analyses provide costs and benefits or the cost-effectiveness value of strategies.

Together, these analyses demonstrate that without action on climate change, the impacts on the economy, communities, and resources of Cape Cod will be severe. However, strategies exist to cost-effectively offset many of these impacts.

Methods

The analyses look at climate change impacts in the short term (2021–2030), medium term (2031–2050), and long term (2051–2100). ERG and Synapse estimated GHG emissions in the short term and medium term only because of the uncertainty in technology beyond 2050. High-level approaches that cut across our analyses are presented below; the technical report describes in detail the methodology for each analysis.

Costs of not adapting to climate change: As coastal flooding is the major contributor to climate-change-related losses, ERG used the sea level rise projections in Table ES-1 and storm surge heights in Table ES-2 to estimate losses across the analyses.

Table ES-1. Sea Level Rise Projections for Cape Cod

Year	Sea Level Rise (ft)*
2030	1.20
2050	2.45
2070	4.25
2100	7.70

*ft above North American Vertical Datum of 1988 (NAVD 88)

Table ES-2. Storm Probability Associated with Storm Tides and Probabilities

Return Period	Storm Tide (ft)*	Annual Probability
1-year storm	2.26	1
5-year storm	3.89	0.2
10-year storm	4.51	0.1
20-year storm	5.22	0.05
50-year storm	6.34	0.02
100-year storm	7.37	0.01
200-year storm	8.50	0.005

*ft above NAVD 88

Cape Cod emissions analysis: Synapse modeled a sustained policy case (i.e., baseline trajectory based on policies in place) for the electricity sector and four emissions reductions scenarios in the transportation and buildings sector. Synapse used the following modeling tools and approaches:

- **EV-REDI:** EV-REDI is a custom-built stock-flow model for modeling multiple impacts of transportation electrification for individual states. EV-REDI contains data on vehicle sales, stock, efficiencies, carbon dioxide (CO_2) emissions, and criteria pollutant emissions.

- **Buildings Decarbonization Calculator (BDC):** The BDC is a custom-built calculator for modeling the evolution of building energy consumption for space and water heating in the residential and commercial sectors.
- **Independent System Operator (ISO) of New England modeling:** The ISO produces models using existing forecasts for the electricity sector, which Synapse used to estimate GHG emissions based on the average New England-wide emissions per megawatt-hour (MWh). The baseline trajectory for the electric sector's GHG emissions assumes the state meets its existing regulatory goal of supplying 80 percent of all electricity in 2050 with zero-carbon renewable sources of generation.

Benefit-cost analysis: ERG worked with the Cape Cod Commission to quantify the costs and benefits of several adaptation and mitigation strategies that lent themselves to monetization and were deemed the highest priority strategies to analyze. ERG did not perform this analysis for all strategies because of resource and data limitations.

Key Findings

Costs of Not Adapting to Climate Change

The cost of not adapting to a changing climate is high and will accelerate over time. Sea level rise and coastal flooding are the greatest overall threats.

Building damage from sea level rise and storm surge: ERG estimates that between 2021 and 2100, private, commercial, and public buildings will incur about $13.4 to $17.8 billion in damage as a result of sea level rise and storm surge combined (see Figure ES-1). This estimate does not include the lost value of another $14.5 billion in land that will be at least partially inundated by 2100. The average annual damage will be approximately $69 million per year in Barnstable County between 2021 and 2030, $89 million between 2031 and 2050, and $256 million between 2051 and 2100. The technical report presents expected damage by town.

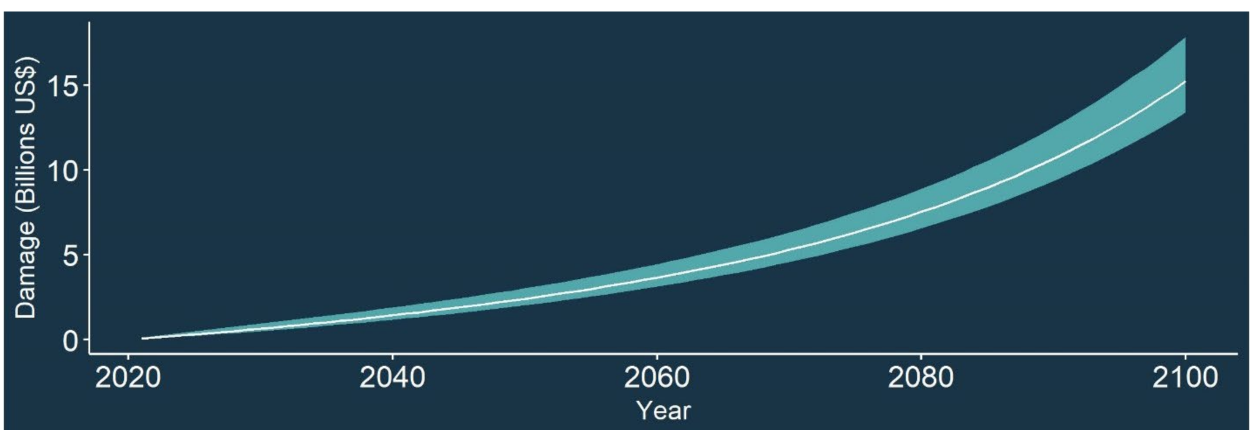

Figure ES-1. Cumulative private, public, and commercial building damage from coastal flooding.

Reduced tax revenue from vulnerable properties: ERG estimates that from 2021 through 2100, properties vulnerable to sea level rise and tidal flooding will cumulatively pay approximately $8.6 billion less in tax revenue than they would have if they were not threatened by this flooding. These vulnerable properties will be inundated or are near roads that will be inundated by sea level rise and tidal flooding. Therefore, their property values will grow more slowly (or decrease faster) than non-affected properties. This will either lower the tax revenue of towns or shift the burden to non-affected houses. The annual average tax revenue loss from these properties will be about $13 million between 2021 and 2030, $81 million between 2031 and 2050, and $330 million between 2051 and 2100. The technical report presents losses by town and community activity center (CAC).[1]

Impacts to roads from sea level rise: By 2050, sea level rise is expected to inundate approximately 31 miles of road and isolate another 83 miles of road. By 2100, these figures will increase to over 200 miles of road inundated and 700 miles of road isolated—resulting in approximately $1.5 billion in damage based on the cost of road construction per mile. Economic losses, however, go far beyond the damage to roads; they also include losses associated with isolated houses (captured under "Reduced tax revenue from vulnerable properties" above), increased driving times due to the need to take alternative routes, and slower emergency response time.

Lost economic value to beachgoers: Beachgoers in Barnstable County place an economic value of more than $246 million each year on their beachgoing experience, which comprises more than 5.5 million beach user days per year. However, as the sea level rises, the beach width will decrease and lower the value that these beachgoers place on their experience. This will lead to a cumulative loss of approximately $9.7 billion between 2021 and 2100. The annual lost value will be approximately $113 million in 2050 and $188 million in 2100. This annual loss is a non-market value—that is, no money changes hands from the degraded experience. However, because the beachgoing experience is an important driver for tourism in Barnstable County, this lost value will likely translate into significant losses in tourism-related revenue.

Job impacts from sea level rise: ERG estimates that by 2050, approximately 45 businesses, 415 jobs, and $16 million in annual wages will be located at establishments inundated by sea level rise. By 2100, inundated establishments will include 377 businesses, over 6,600 employees, and $271 million in annual wages. Figure ES-2 presents the timing of these impacts. These losses underestimate the likely overall impacts from flooding, as they only consider business locations flooded by sea level rise and do not consider the temporary loss of business from single flooding events (e.g., storm surge) or the loss of access to businesses from inundated/isolated roads.

[1] The 2018 Cape Cod Regional Policy Plan identifies areas with similar natural and built characteristics as distinct "Placetypes," which serve as a conceptual framework for regional planning and regulation. One such Placetype is CACs. These areas have a concentration of business activity, community activity, and a compact built environment. The vision for these areas is to accommodate mixed use and multifamily residential development in a walkable, vibrant area; to preserve historic buildings; and to provide diverse services, shopping, recreation, civic spaces, housing, and job opportunities at a scale of growth and development desired by the community, with adequate infrastructure and pedestrian amenities to support development.

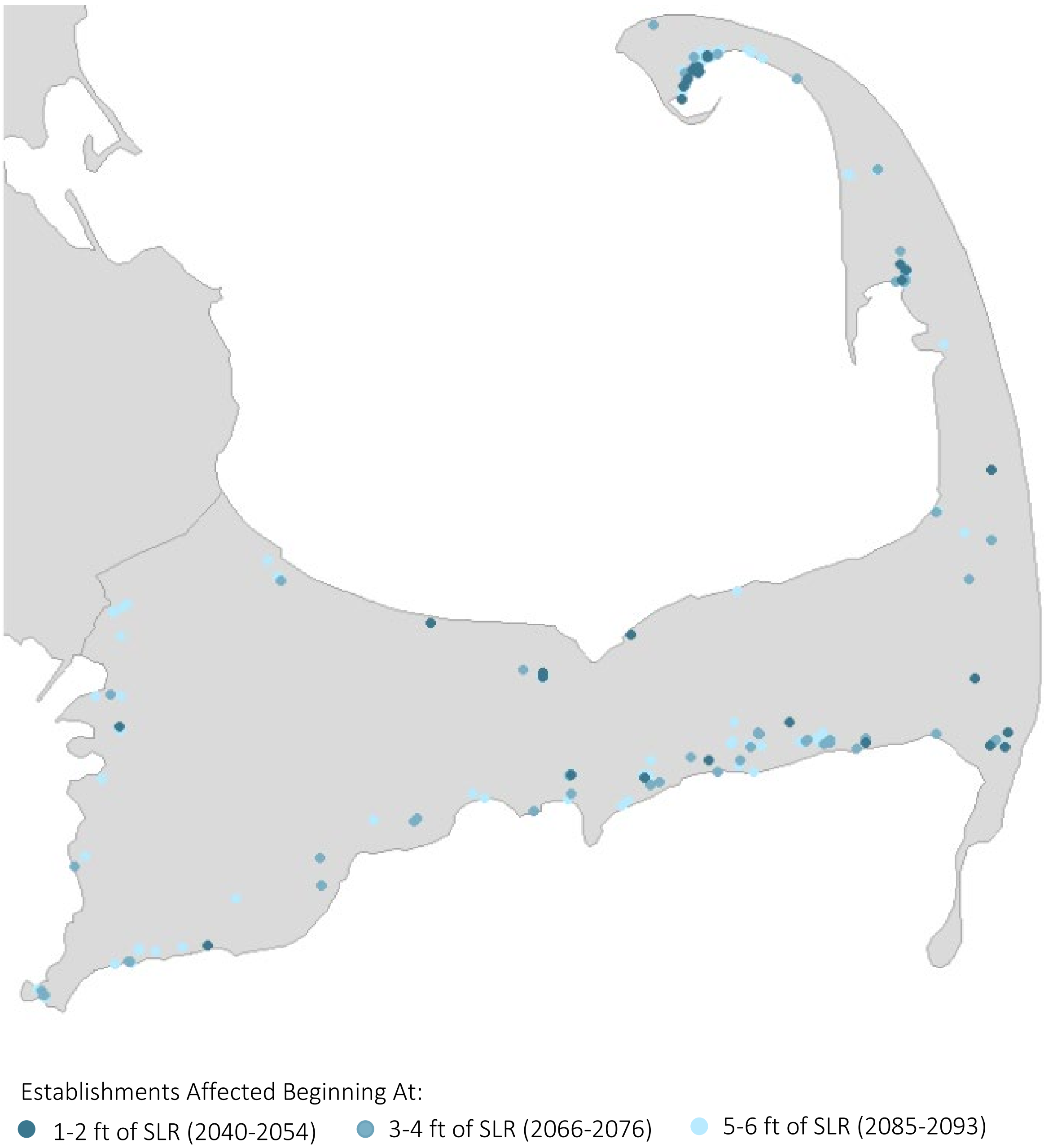

Figure ES-2. Locations of establishments affected by 1 to 6 feet of sea level rise.

Ecosystem service value losses to marshes and eelgrass: Salt marshes and eelgrass are complex ecosystems that support the wellbeing of communities and wildlife throughout the Cape. ERG projects that by 2040, nearly 14,000 acres of salt marsh will be lost to sea level rise (assuming no migration). This will result in annual losses of $34 to $62 million from reductions in nitrogen removal, $0.9 to $1.6 million from lost carbon sequestration, and $3.2 million from lost biomass for commercial fisheries. Over 12,000 acres of eelgrass—which provide an annual value of $50 million in nitrogen removal and $21 million in enhancing commercial fisheries—are at risk.

Commercial fisheries at risk: In 2017, fishing, aquaculture, seafood processing, and seafood markets in Barnstable County employed 1,175 people, of whom more than 822 were self-employed. These industries contributed $14.9 million in annual wages and $34.2 million in annual gross domestic product to the region's economy. Climate change puts this multimillion-dollar sector of the economy at risk, threatening the livelihoods of over 1,000 county residents. Because of the uncertainty in projecting how climate change will impact these fisheries, ERG did not project what portion of this vulnerable sector would be lost by year.

Economic impact from cranberry bog loss due to sea level rise: Cranberries are native to the region and represent an important part of Cape Cod's history, culture, and economy. Salt water from sea level rise is projected to impact these cranberry bogs; Figure ES-3 presents the timing of when they will be lost. The cumulative loss in revenue will be approximately $80 million between 2021 and 2100. Over 160 acres of bogs will be inundated by about 2050 with an annual revenue loss of $830,000, and 410 acres of bogs will be inundated by about 2100 with an annual revenue loss of over $2 million. In addition, many manufacturers throughout Massachusetts rely on these cranberries to produce cranberry-based products, so the overall economic impact would expand beyond directly lost revenue.

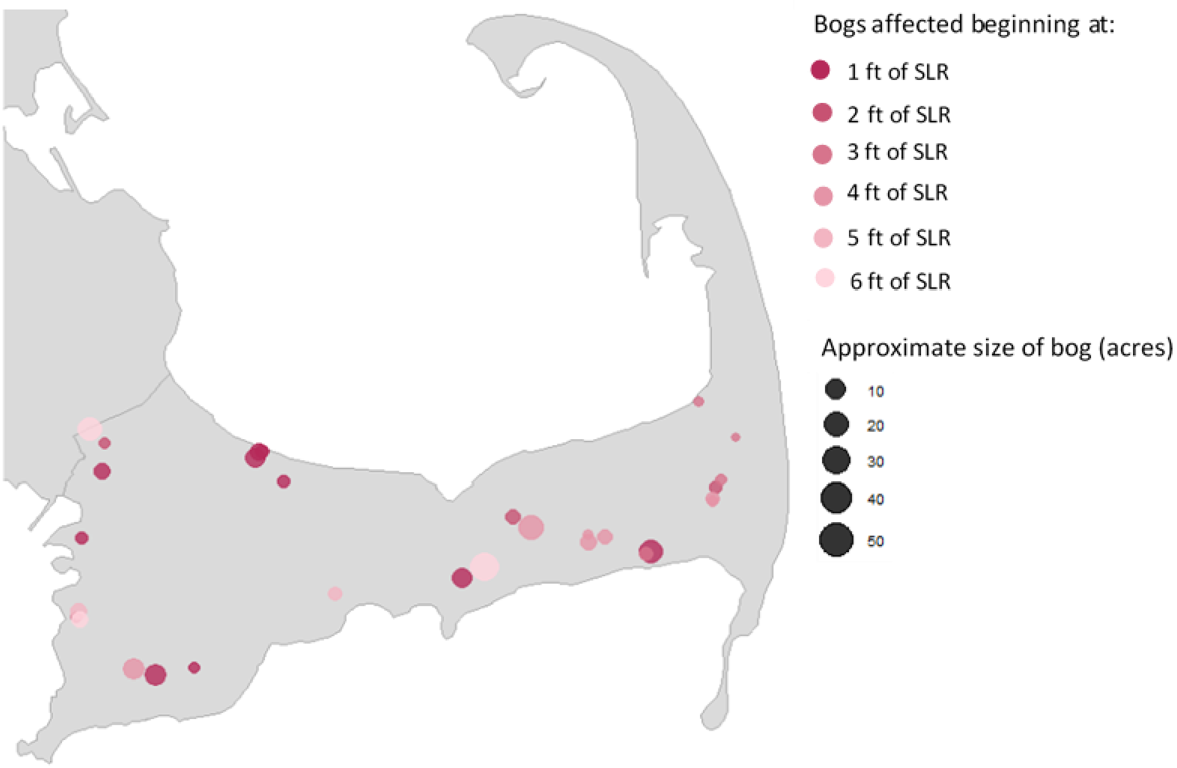

Figure ES-3. Cape Cod cranberry bogs affected by sea level rise.

Cape Cod Emissions Analysis

Synapse modeled emissions from the transportation, building, and electricity sectors from 2021 through 2050.

The baseline modeling in each sector used a sustained policy approach, which assumes that the current policy goals are met, thus representing a snapshot in time given the current policy context.

Figure ES-4 shows that the sustained policy scenario fails to reduce GHG emissions to 50 percent below 1990 levels by 2030 and to 85 percent below 1990 levels by 2050 in Barnstable County, which ERG and Synapse selected to be consistent with the overall goals in Massachusetts. Emissions are projected to decline through the study period. However, total regional emissions in 2050 are projected to be 1.5 million metric tons, which is a little less than 1 million metric tons above the 2050 target. The transportation sector continues to be the largest source of emissions through 2050, representing 48 percent of economywide GHG emissions.

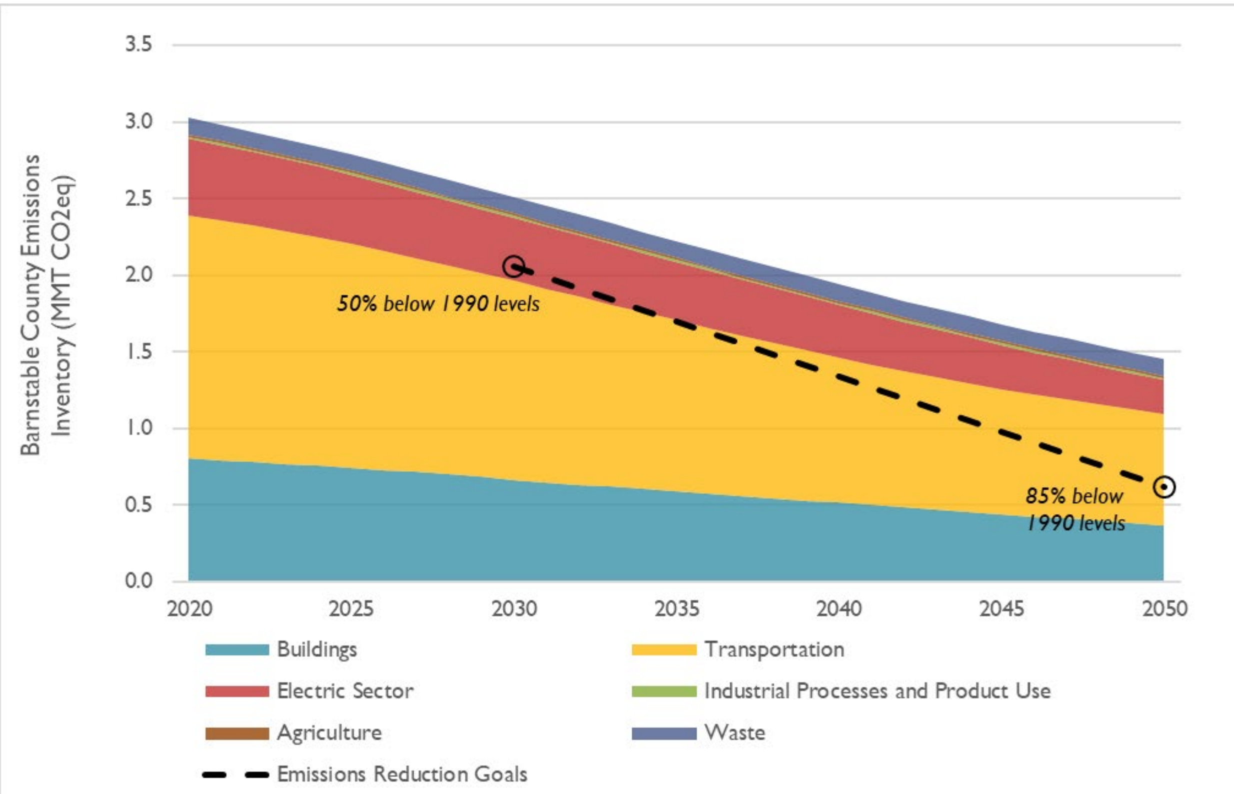

Figure ES-4. Economywide GHG emissions for sustained policy scenario in Barnstable County relative to Commonwealth Emissions Reduction Goals.

To develop scenarios that could meet the 2030 and 2050 goals, Synapse and the Cape Cod Commission developed the following four decarbonization scenarios:

- The state-level emissions reduction baseline scenario (referred to as “SER1” below) determines the level of beneficial electrification necessary to meet GHG emissions reduction goals for Massachusetts given baseline energy efficiency gains.
- The carbon emissions neutrality reduction determines the level of beneficial electrification necessary to meet the goal of carbon neutrality in 2050 given baseline energy efficiency gains.
- The state-level emissions reduction aggressive efficiency scenario determines the level of beneficial electrification necessary to meet GHG emissions reduction goals for Massachusetts, assuming aggressive efficiency efforts. This includes targeted programs and policies on Cape Cod to aggressively reduce vehicle miles traveled and improve the energy performance of homes and businesses through weatherization.
- The state-level emissions reduction year-round residency sensitivity scenario determines the level of beneficial electrification necessary to meet GHG emissions reduction goals for Massachusetts, assuming 50 percent of seasonal residents convert to year-round residents relative to historic patterns.

Figure ES-5 shows the SER1 dropping to 2.05 million metric tons of carbon dioxide equivalent (MMT CO_2e) per year in 2030 and 0.61 MMT CO_2e in 2050, meeting the goals of a 50 percent reduction from 1990 levels by 2030 and 85 percent reduction from 1990 levels by 2050. The technical report presents the results from the other three decarbonization scenarios, which all meet these goals.

The differences between the four decarbonization scenarios are small when compared with the much larger difference between the decarbonization pathways and the sustained policies case. Rapid transformations are required across all sectors to be on pace to meet decarbonization targets. Even the sustained policies case is quite different from the situation in 2020 (many more electric vehicles [EVs] and heat pumps, and much more carbon-free electricity), and the decarbonization cases show that more change is necessary.

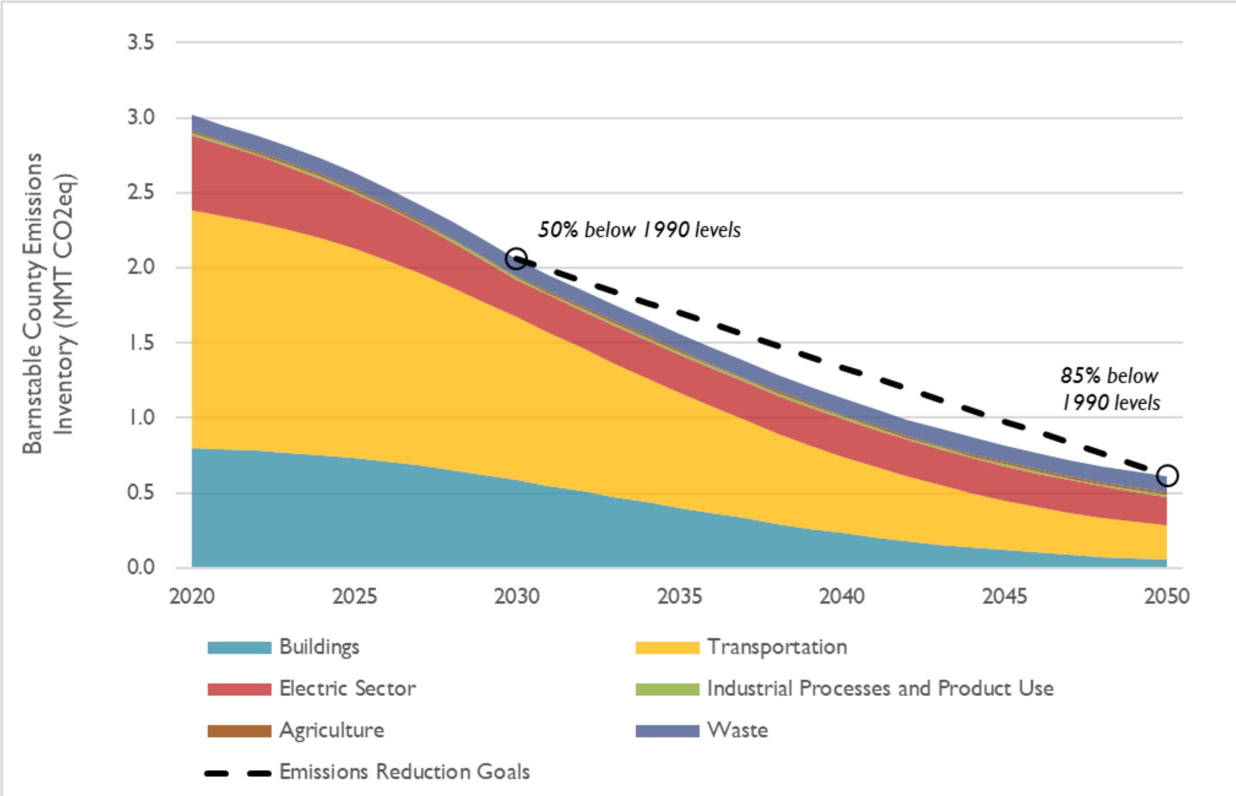

Figure ES-5. Economywide GHG emissions for SER1 scenario.

Adaptation Strategies

A mix of adaptation strategies will be needed to deal with building and land losses from sea level rise and storm surge over time; regional solutions will need to be considered. ERG estimates that \$15.3 billion in building damage could occur, another \$14.5 billion in land could be at least partially inundated by sea level rise, nearly \$9 billion in tax revenue would be lost, based on 2020 housing and land prices, and \$600 million in wages could be impacted between 2021 and 2100. If Barnstable County theoretically universally protected its shorelines against a water level increase of up to eight feet (sea level rise plus surge), for example, this would help avoid \$28 billion of loss, and \$38 billion would be avoided if the shorelines were protected against a water level increase of up to 12 feet. The approximate benefit-cost ratio for shoreline solutions (i.e., sea walls and natural infrastructure) around the entire Cape is about 2:1 for protecting against up to 12 feet of water level increase and about 2.2:1 for protecting against up to eight feet. This indicates it is theoretically beneficial to protect; however, there are a couple substantial caveats:

1) Because shoreline solutions are expensive, it will be most cost-effective for Barnstable County to use a more targeted approach of implementing shoreline solutions in denser areas and along high-value assets while considering building-level solutions in the near term combined with longer-term retreat options for less dense areas. More selective protection will improve the overall benefit-cost ratio above about 2:1.

2) This analysis does not reflect losses related to beach, coastal resources, and other ecosystem services that would be lost by widespread shoreline protection solutions. Future studies will need to evaluate these losses to ensure these valuable resources and recreation opportunities are also protected.

For example, the technical report shows that raising buildings has a benefit of about $3 to $5 for every dollar spent. Areas with less density per mile of shoreline may benefit from building-level strategies (e.g., flood-proofing and raising buildings) in the near term (to prevent damage from single events). However, retreat and possible buyouts may be more appropriate in the long term when permanent inundation from sea level rise threatens those areas and access to these buildings is no longer feasible. ERG found that moving buildings was a much less cost-effective strategy and should potentially be reserved for historic or culturally valuable buildings that cannot be protected with shoreline solutions.

In denser areas, shoreline solutions become much more cost-effective, as a mile of protection reduces damage to properties that amount to a much higher value. However, coordination will be necessary to ensure that flood waters do not go around protective infrastructure in one neighborhood or town and into another.

A mix of adaptation strategies will be needed to cost-effectively deal with the impacts from flooded roads. Flooded roads will lead to the loss of approximately $290 million in tax revenue between 2021 and 2100 and will isolate just over $1 billion in property. To rebuild the 212 miles of roads expected to be flooded by 2100 would cost about $1.4 billion, but costs to raise these roads might be eight to 10 times that. In short, the cost of raising *all* roads will far exceed the benefit of the avoided financial losses. Raising roads will be most cost-effective for segments that serve highly traveled or critical routes, whereas longer-term retreat may make sense in areas that are less dense. Shoreline solutions that can both protect buildings and keep roads dry will provide a dual benefit and make economic sense in denser areas. Further analysis is needed to determine how, when, and where to apply strategies to raise roads, re-route roads, abandon roads, and protect roads from flooding with shoreline solutions.

Restoring salt marshes can have a wide range of benefits, and siting can often determine whether these projects will be cost-effective. Marshes provide ecosystem services, including nitrogen removal, carbon sequestration, support for commercial fisheries, and flood protection. Costs for some restoration projects have ranged from about $11,000 to $18,000 per acre. The benefits from sequestration alone do not justify the costs; however, nitrogen removal, fisheries, and flood protection can make these projects break even in a matter of just a few years. Thus, site-specific analysis should be performed to assess the value of flood protection, particularly to determine the benefit-cost ratio at that site. Additionally, the ability of the marsh to migrate with sea level rise is an important consideration for the longevity of the project. If there is no space to migrate, the lifetime of the benefit will be much shorter.

Mitigation Strategies

A comprehensive and diverse set of strategies will be needed to meet 2030 and 2050 emissions reduction goals. To achieve a 50 percent reduction from 1990 levels by 2030 and 85 percent reduction by 2050 will likely require substantial action and assistance from state and federal governments. At the same time, homeowners, drivers, and business owners on the Cape are the fundamental actors who can choose electric options for their next heating system or vehicle. Organizations such as the Cape Light Compact can be key enablers for electric sector decarbonization, as well as for engaging customers about their energy choices.

Implementation of electric air-source heat pumps is cost-effective for residents, leads to substantial health benefits, and is essential to reaching 2030 and 2050 GHG emissions reduction goals. The SER1 scenario calls for aggressive residential electrification: 18,568 year-round residences (19% of residences) with heat pump retrofits by 2030 and 45,295 (47% of residences) by 2050; 15,100 year-round residences (16% of residences) with whole-home heat pumps by 2030 and 46,223 (48% of residences) by 2050. Adoption of heat pumps is one of the major contributors to reaching the 2030 and 2050 GHG emissions reduction goals. It will lead to a cumulative health benefit of approximately $244 million between 2021 and 2050 by reducing criteria pollutants that cause asthma, cancer, and other health impacts. At the consumer level, the average annual cost of operating a heat pump when considering purchase price and electricity is less than $2,000 (without any incentives). This cost is comparable to natural gas and much lower than propane or fuel oil, which are about $800 to $900 more per year. Given this, it may be easier to push early adoption among residents who use propane or fuel oil to heat their homes.

Renewable energy adoption is becoming price competitive and will be an important strategy for meeting GHG emissions reduction goals. The levelized cost of energy (i.e., price per MWh, including capital and operating costs) for natural gas ranges from about $32 to $105 per MWh; for coal, it ranges from about $65 to $159 per MWh. While renewable energy was generally more expensive several years ago, the cost has fallen dramatically as renewable energy technologies have improved and become more mainstream. The levelized cost of energy is now about $9 to $43 per MWh for onshore wind, $26 to $54 per MWh for offshore wind, $31 to $42 per MWh for concentrated/utility-scale solar, and $150 to $227 for rooftop residential solar.

As the grid becomes cleaner, massive health benefits and GHG reduction benefits will result. While not all the benefits will be in Barnstable County, because emitting sources of energy are from all over New England, the value of reduced criteria pollutants in scenario SER1 compared to the sustained policy baseline scenario is approximately $147 million between 2021 and 2050. These GHG reductions will be challenging to achieve as it requires increasing the share of renewable (non-emitting) energy from 47 percent (sustained policy) to 75 percent (SER1) in 2030 and 80 to 89 percent in 2050.

Outreach and infrastructure around EV adoption is necessary to reach emissions goals and save consumers money, and the adoption of EVs will provide a major health benefit. Aggressive EV adoption is necessary to reach 2030 and 2050 GHG emissions reduction goals. The four decarbonization scenarios require that new sales of EVs account for 63 to 93 percent of all vehicle sales by 2030. All four scenarios require 100 percent of new vehicle sales to be EVs by 2050. As EVs continue to become mainstream, their incremental price relative to conventional vehicles will drop while consumers will save on operational costs related to maintenance and fuel. In the absence of any subsidies, the point at which consumers will start saving money relative to purchasing a conventional vehicle occurs in the 10th year of ownership for a car purchased in 2030 (or 12th if they need to purchase another in-home charger) and in the 4th year of ownership for a car purchased in 2050 (or 7th year if they need to purchase another in-home charger). The point in time where owners start saving money for EVs will improve if subsidies become available.

From a regional standpoint, aggressive electrification results in major health benefits by reducing health impacts associated with criteria pollutants from tailpipe emissions. Electrification will also be one of the most cost-effective mitigation strategies for reducing GHGs. To accommodate about 214,000 light-duty EVs on the road by 2050 (as required to reach 2050 emissions goals), around 8,800 public charging stations will need to be installed, which is nearly 4,000 more (at an additional cost of around $10 million) than would be needed in the sustained policy case. However, the incremental benefit is a decrease of over 6.2 million metric tons of CO_2, yielding a cost-effectiveness of about $1.6 per metric ton of CO_2 reduced. Additionally, the reduction in tailpipe criteria pollutants in this aggressive electrification scenario compared to sustained policy will lead to more than $82 million in health benefits for the Barnstable County community between 2021 and 2050. Outreach surrounding the economics of ownership, health impacts, and an EV-friendly charging infrastructure will help encourage EV adoption.

Implementing aggressive electrification and renewable energy will bring green jobs into the region. Installing heat pumps alone will add about 1.3 million to 1.8 million hours of labor or more than 600 job-years (i.e., 600 jobs in a year or 20 jobs that last 30 years) from 2021 through 2050, and these numbers do not include maintenance hours. Solar installation creates about 15.5 job hours per megawatt installed and will lead to about 9,300 job-years over this period (i.e., 310 jobs that last 30 years). Developing 0.6 GW of offshore wind capacity on Cape Cod by 2050, requires approximately 75 jobs sustained over the life of the projects (plus construction jobs) to serve the Cape's capacity. Additional jobs will be created by the installation of thousands of public charging stations, which the technical report does not quantify.

Conclusion

This executive summary has presented key findings that demonstrate the large and accelerating costs Barnstable County faces if it does not adapt to climate change. Additionally, there are paths to meet 2030 and 2050 emissions reductions goals that align with the goals for the Commonwealth of Massachusetts; however, achieving these goals will require aggressive electrification and renewable energy implementation. Finally, many strategies with strong returns on investment can help offset the impacts of climate change or mitigate emissions. The technical report provides more details about the methods, results by time period and town, and citations for all these key findings.