The Proposed Plant at Big Bend

A Review of Climate Impacts

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ERRATA SHEET

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This report has been revised to address a unit conversion error in Section 4, page 10, paragraph 3 (sentence provided below):

A major study by the well-known British climate economists Simon Dietz and Nicholas Stern found a range of optimal carbon prices (i.e., SCC values), depending on key climate uncertainties, ranging from ~~$45~~ $42 to ~~$160~~ $198 for emissions in 2025, and from ~~$111~~ $103 to $394 for emissions in 2055.

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1. LIFETIME EMISSIONS FROM THE PROPOSED PLANT: 99 MILLION TONS CO_2e

Construction and operation of Tampa Electric Company's ("TECO" or "Company") proposed combined-cycle power plant ("proposed plant") will result in significant greenhouse gas emissions for decades. Based on the Company's air permit application for the proposed plant (permit no. 0570039-119-AC), and the assumption that the proposed plant will operate for 30 years, from 2023 to 2052, the Company's annual generation estimates imply that lifetime emissions from the proposed plant will be almost 99 million tons CO_2e – an annual average of 3.3 million tons.[1] Note that this is a conservative estimate, based solely on combustion emissions; it does not include upstream methane leaks, which also contribute significantly to lifecycle emissions from gas use.[2]

The Company claims its proposed plant will reduce emissions compared to the units that are currently in operation at Big Bend. This comparison is woefully inappropriate, for several reasons. Big Bend Units 1 and 2 are old and inefficient units that are near the end of their useful lives. They consume more fuel per unit of electricity produced and are more expensive to operate than more efficient generation resources. As a result, they are not used frequently. During the last 12 months of available U.S. Energy Information Administration ("EIA") data, the two units each operated with capacity factors of less than 20 percent, i.e., producing less than 20 percent of the energy they could generate if running full-time.[3] Even though Units 1 and 2 are inefficient, their emissions are relatively low due to their reduced operation.

Additionally, Units 1 and 2 recently switched to burning gas instead of coal. The result is that current emissions from Units 1 and 2 at Big Bend are much lower than the Company reports. In 2018, emissions from the two units were a total of 860,000 tons, or less than one fourth of the potential emissions from the proposed combined-cycle unit.[4] Emissions would increase substantially if the proposed plant were constructed and operated at the high capacity factors that the Company assumes.

Further, comparing the current units to the proposed plant presents a false choice. The current units are old and serve mainly as a peak capacity resource. Thus, the real choice is not between the proposed plant and the current units; rather, it is between the proposed plant and alternative new generation

[1] Calculated from data in Big Bend 1 Modernization Project Air Construction Permit Application, Appendix C. See TECO Discovery Response IRR-7. The calculation includes assumed emissions from two new combustion turbines projected to come on line in 2023 and 2026, as well as the projected combined cycle plant. Here and elsewhere, TECO reports emissions in short tons.

[2] Methane, the principal component of the gas that would fuel the proposed plant, is itself a greenhouse gas—more potent per unit than carbon dioxide. Even modest leaks of methane, in the course of delivering gas to a power plant, can add substantially to the overall climate impact of a gas-burning facility. This is relevant to the Siting Board's analysis of whether the proposed plant will "serve and protect the broad interests of the public," per section 403.509(3)(g) of the Siting Act.

[3] Energy Information Administration Form 923. Data for December 2017 through November 2018.

[4] EPA Air Markets Program Data.

resources. These alternative resources include solar, battery storage, energy efficiency, and demand response, as discussed in Ms. Glick's report.

By utilizing clean alternatives, TECO can provide cost-effective capacity and energy without causing harm to Florida's residents and environment. Clean energy options such as solar, battery storage, efficiency, and demand response should be carefully considered before launching such a large, costly, environmentally damaging project that will remain in operation for decades.

2. TECO'S CLAIMED LIFETIME ECONOMIC BENEFIT TO CUSTOMERS

TECO claims that its plan to replace Big Bend's existing Units 1 and 2 with the proposed plant will result in $747 million in savings to TECO's customers.[5] While the analysis the Company has provided is far from complete, it is clear that TECO's reference case is not a proper baseline, as discussed further in Ms. Glick's report.

First, the Company uses the wrong fuel type, comparing the proposal to a reference case where Big Bend Units 1 and 2 are operating on coal, whereas the units have operated entirely on gas since 2017.[6] Presumably, the switch from coal to gas reduced costs, or the utility would not have chosen to make the change. Cost reductions that have already been achieved by previous, unrelated choices should not be counted as benefits of the proposed plant. In other words, the benefits of using gas instead of coal will accrue to TECO's customers regardless of whether the proposed plant is constructed at Big Bend.

There may be additional problems with the analysis in the Company's application, though it is impossible to be sure due to the limited information TECO has provided. For example, TECO is using historical data from several years ago, when Big Bend Units 1 and 2 were still burning coal, to calculate reference case revenue requirements (see Ms. Glick's report). In that case, the Company would be overestimating the capacity factors of Units 1 and 2. The units' capacity factors have decreased from 78 and 76 percent in 2014 to just 16 and 19 percent, respectively, in the last 12 months for which data is available.[7] With these units running much less often, the savings from retiring them (or reusing some portion of one of them in the proposed plant) will be less than it would have been several years ago. Fuel costs, in particular, are now much lower for these units.

Most of the savings that TECO projects comes from reductions in fixed operation and maintenance ("O&M") costs, reductions in capital costs for Units 1–4 (presumably focused on Units 1 and 2), and fuel

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[5] TECO DOAH Case No. 18-2124EPP, Sierra Club Second Request for Production of Documents, No. 26, page 1633. January 16, 2019.

[6] TECO, Letter to US Environmental Protection Agency re completion of permanent coal to gas conversion of Big Bend Units 1 and 2 (July 2018).

[7] Energy Information Administration Form 923. Data for December 2017 through November 2018.

savings.[8] Fuel savings will likely be less than the Company claims because there are no longer any coal purchases for Units 1 and 2. As to the other two categories of purported savings (reduction in O&M and capital costs), TECO provides no satisfactory explanation. The proper scenarios for comparison with the proposed plant would be combinations of supply-side and demand-side resources that TECO could utilize instead of the proposed combined-cycle unit. While TECO claims $747 million in potential customer savings, the true value of the proposed plant is likely to be substantially less because TECO's claim relies on an expensive reference case that reflects neither actual present conditions nor realistic future conditions.

3. CLIMATE IMPACTS ON FLORIDA: SELECTED RESEARCH STUDIES

The world is increasingly threatened by and worried about climate change—a problem recognized at every level, from global to local. The World Economic Forum, which hosts the annual Davos meeting of economic, political, and cultural leaders, conducts an annual poll of the most serious global risks perceived by its participants. The latest survey opens with the question, "Is the world sleepwalking into a crisis?" and observes that environmental risks "accounted for three of the top five risks by likelihood and four by impact." Extreme weather events and the risk of failure of national climate policies topped the list of environmental hazards.[9]

Meanwhile, local voices are raising the same concerns—and for good reason. The Tampa Bay Regional Resiliency Coalition, organized in late 2018, aims to help local governments cope with sea level rise and climate change. Modeled on the South Florida Regional Climate Change Compact, the Tampa Bay group is focusing on adapting to or combating the local effects of climate change. The Tampa Bay region is the metropolitan area in the country most vulnerable to storm surge, with potential losses amounting to a reported $175 billion, according to an insurance industry group.[10]

Florida is not alone; climate change will have impacts on every state (and other countries as well). But Florida, facing the combination of rising temperatures and sea levels, will be among the hardest hit. By some measures, it will experience the worst climate losses of the 48 contiguous states.[11] A recent study from the Brookings Institution finds that under a business-as-usual scenario, 8 of the 10 hardest-hit

[8] Staged Modernization with 600 MW of Solar. DOAH Case No. 18-2124EPP, Sierra Club's Second Request for Production of Documents, Document No. 26. January 16, 2019.

[9] World Economic Forum (2019), "The Global Risks Report 2019," http://www3.weforum.org/docs/WEF_Global_Risks_Report_2019.pdf.

[10] Craig Pittman (2018), "Tampa Bay local governments join to combat climate change effects," *Tampa Bay Times*, October 5, https://www.tampabay.com/news/environment/globalwarming/Tampa-Bay-local-governments-join-to-combat-climate-change-effects_172405263.

[11] Many interstate comparisons exclude Alaska and Hawaii, focusing only on the remaining 48 states.

metropolitan areas in the country are in Florida; Tampa-St. Petersburg is number 2 on the list, with potential losses of 16.8 percent of metropolitan area income by the end of the century.[12]

It would be impossible to present a complete survey of all recent research related to climate impacts on Florida. This section presents selected research findings that highlight a broad range of impact categories.

3.1. Tourism

Tourism is the number one industry in Florida, by some accounts generating employment for 17 percent of the state labor force.[13] The state's beautiful beaches and appealing climate, among other attractions, draw visitors from around the country and from abroad. Yet the natural assets that attract tourists to Florida are vulnerable to over-warming, rising sea levels, and increasing storm activity. Ocean warming has already led to widespread coral reef bleaching and other coral diseases off the coast of Florida, diminishing one natural attraction.

If Florida becomes hotter and stormier, storm surges and rising sea levels will erode or submerge beaches. A recent survey found that protecting coastal destinations will require expensive adaptation measures. For example, the already-expensive process of beach nourishment – restoring beaches degraded by erosion – will become even more costly in the future: by 2060 a one-time treatment to restore beaches damaged by sea-level rise could cost $2.4 billion; and this treatment may be needed every six to ten years.[14]

3.2. Human health

Higher temperatures will be harmful to health in many respects. Under a business-as-usual scenario, Florida is projected to have 18 to 32 days per year over 95°F by 2020–2039, and 30 to 76 days per year over that temperature by 2040–2059. Temperature-related deaths could surge by as many as 1,737 to 5,083 per year in the latter time period.[15]

Higher temperatures also increase vulnerability to several tropical diseases. For example, transmission of dengue fever is impossible in most of the United States, due to its high temperature threshold, but is

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[12] Mark Muro et al. (2019), "How the geography of climate damage could make the politics less polarizing", Brookings Institution, https://www.brookings.edu/research/how-the-geography-of-climate-damage-could-make-the-politics-less-polarizing/.

[13] Oxford Economics (2018), "The Economic Impact of Out-of-State Visitors in Florida: 2016 Calendar Year Analysis," https://www.visitflorida.org/media/30679/florida-visitor-economic-impact-study.pdf.

[14] Robert Atzori and Alan Fyall (2018), "Climate change denial: vulnerability and costs for Florida's coastal destinations," *Journal of Hospitality and Tourism Insights* 1, pp. 137-149.

[15] Risky Business Project (2015), "Come heat and high water: Climate risk in the southeastern U.S. and Texas," p.37, https://riskybusiness.org/site/assets/uploads/2015/09/Climate-Risk-in-Southeast-and-Texas.pdf.

currently possible in southern Florida in the summer months. With projected increases in temperature, dengue fever will become able to spread in Florida for most or all months of the year.[16]

In addition, higher temperatures reduce labor hours and productivity, especially (but not only) in outdoor occupations such as construction. By the end of the century, some Florida counties could lose 6 percent of their annual labor hours to extreme heat.[17]

3.3. Ecological health

By 2060, a recent study found, climate change is expected to cause temperature and precipitation changes that will reduce the reproductive capacity of populations of native wildlife in the Everglades, including wading birds, fish, alligators, native apple snails, and amphibians. Climate change, and the resulting decline of native species, will increase the likelihood of the intrusion and expansion of invasive species.[18] Warmer weather in Florida favors invasive species such as the Burmese python (which devastates local mammals) and the Brazilian pepper tree (which transforms native ecosystems), according to the U.S. Fourth National Climate Assessment.[19]

3.4. Impacts of sea level rise and storm surges

Multiple researchers have investigated the damaging impacts of sea level rise on Florida's environment and economy. The studies are not all based on the same projection of the extent of sea level rise, and no attempt is being made here to support any specific sea level rise projection. Rather, the point is that many scientists have identified reasons why some amount of sea level rise would prove harmful.

The Florida Department of Health, for one, indicates that storm surges, which can be up to 20 feet above normal tides, are a leading cause of death in coastal areas. More rain is falling in extreme events, making flash floods more likely.[20]

Meteorologists have found that even on moderate projections of sea level rise—20 inches to 4 feet by 2100—the "sunny day flooding" that southeastern Florida experienced in September 2015 will happen more than twice a year by 2030, and about once a month in the 2040s.[21]

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[16] Melinda K. Butterworth, Cory W. Morin, and Andrew C. Comrie (2017), "An analysis of the potential impact of climate change on dengue transmission in the southeastern United States," *Environmental Health Perspectives* 125, pp.579-585.

[17] U.S. Global Change Research Program (2018), "Fourth National Climate Assessment – Volume II," Figure 19.21.

[18] Christopher P. Catano et al. (2014), "Using scenario planning to evaluate the impacts of climate change on wildlife populations and communities in the Florida Everglades," *Environmental Management* 55, pp. 807-823.

[19] "Fourth National Climate Assessment."

[20] Emrich et al. (2014), "Climate-sensitive hazards in Florida," Florida Department of Health.

[21] William V. Sweet et al. (2016), "In tide's way: Southeast Florida's September 2015 sunny-day flood," *Bulletin of the American Meteorological Society* 97, pp. S25-S30.

Researchers at Florida State University have projected that by 2080, 7-foot storm surges in Miami-Dade County (comparable to Hurricane Wilma) could occur once every 21 years (under a scenario with one foot of sea level rise) to once every 5 years (with two feet of sea level rise). Property losses in such a storm, at today's property values, could reach $12 billion in Miami-Dade County alone.[22]

On a business-as-usual climate trajectory, one detailed study found that sea level rise is likely to mean that $34 billion to $69 billion of existing property in Florida is below mean high tide by 2030, and $127 billion to $152 billion by 2050.[23] Projecting farther out, Florida faces a 1 in 20 risk of more than $346 billion of property being below sea level by 2100 under a worst-case scenario. Of Miami-Dade County's 38 hospitals, 4 would face inundation from a Category 2 hurricane (assuming landfall at high tide), and 26 from a Category 5 hurricane. Even 1 meter (3.3 feet) of sea level rise would put at least 11 gigawatts of Florida's electricity generation and numerous major substations at risk of flooding.[24]

By 2100, sea level rise of 3 feet would displace 1.2 million people in Florida, or 28 percent of the total number of displaced Americans. Sea level rise of 6 feet, by contrast, would displace 6.1 million people in Florida, or 46 percent of the national total. At 6 feet of sea level rise, one-fourth of the U.S. population displaced by sea level rise would be in Florida's Miami-Dade and Broward Counties alone.[25]

It is worth emphasizing again that these studies are based on differing, inconsistent projections of sea level rise. This report is not seeking to settle their disagreements about the expected pace of sea level rise. (Recent research attempts to reconcile differences in estimates of ocean warming, a key driver of sea level rise. It finds a near-consensus that oceans are now warming faster than projected in earlier studies.[26]) However, the range of impacts cited here, as well as in the previous subsections, emphasizes the extent to which Florida faces many varieties of climate damages—by some measures, it will face more severe damages than any other state in the nation.

4. Quantifying Climate Damages: The Social Cost of Carbon

The complex, multi-dimensional portrait of climate damages presented in the last section leads naturally to the question of whether damages can be measured by a single number. The most widely used measure is the social cost of carbon ("SCC"), defined as the present value of the incremental damages done by an additional ton of CO_2 emissions (or an equivalent amount of another greenhouse gas).

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22 Julie Harrington and Todd L. Walton, Jr. (2015), "Climate Change in Coastal Florida: Economic Impacts of Sea Level Rise," Florida State University.

23 "Come heat and high water," p.37.

24 "Fourth National Climate Assessment".

25 Matthew E. Hauer, Jason M. Evans and Deepak R. Mishra (2016), "Millions projected to be at risk from sea-level rise in the continental United States," *Nature Climate Change* 6, pp.691-695.

26 Lijing Cheng et al. (2019), "How fast are the oceans warming?" *Science*, 11 January, vol. 363, 128-129.

The logic of the SCC calculation is illustrated in Figure 1, below. Start with a scenario for projected carbon emissions (left graph, blue dotted line); create a second scenario that differs from the first only in one year's emissions (left graph, solid orange line). Calculate the climate damages expected from each scenario over time (right graph, top two lines); then calculate the difference between the damages from the two scenarios (right graph, bottom line). The present value of the difference, divided by the number of tons of CO_2 in the emission "spike" (left graph), is the SCC.

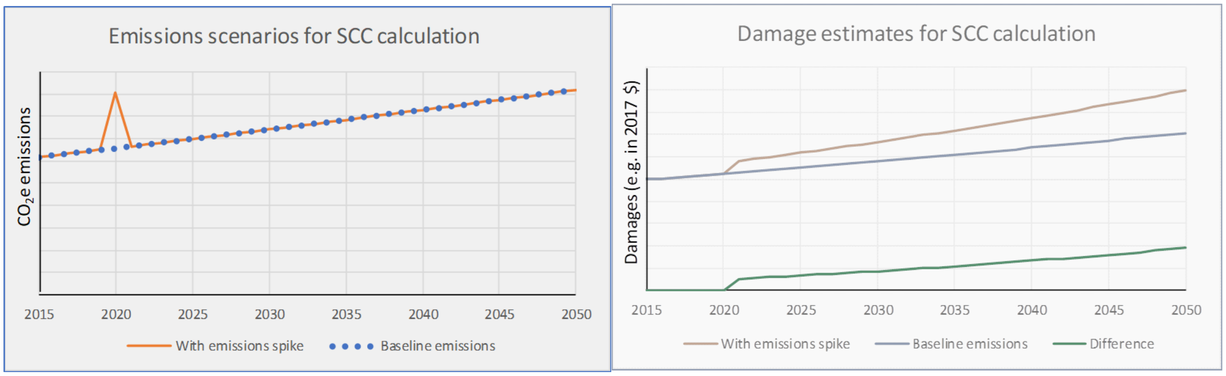

Figure 1. Calculating the SCC. Two emissions scenarios (left) and resulting damage estimates (right).

While the logic of the SCC calculation appears straightforward, there is an obstacle lurking in the relationship of the left graph to the right one in Figure 1 — namely, in the translation from emission scenarios to monetary estimates of damages. Some climate damages, such as extinction of endangered species, or loss of unique, irreplaceable environments, are difficult or impossible to monetize. And even if damages can be monetized, it remains necessary to project the pace at which damages increase with temperatures or other climate indicators. These issues have given rise to a wide range of SCC estimates.

The federal government's Interagency Working Group on the Social Cost of Greenhouse Gases developed and refined estimates of the SCC from 2010 to 2016 for use in cost-benefit analyses of federal programs and regulations. The group presented four estimates: three use the estimated average value of climate sensitivity (a measure of how fast the world is warming in response to rising concentrations of greenhouse gases), combined with discount rates of 5, 3, and 2.5 percent; a fourth variant uses a much higher estimate of climate sensitivity, and a 3 percent discount rate. In practice, most users have cited the version with a 3 percent discount rate and average climate sensitivity, sometimes called the "central estimate."

In the final, August 2016 iteration, the federal SCC estimates for emissions in 2020 ranged from $15 to $149, rising to $31–$257 in 2050. The "central estimate" rose from $51 for 2020 to $83 for 2050 emissions (all SCC values in this section have been converted to 2018 dollars per metric ton of CO_2.)[27]

[27] Interagency Working Group (August 2016), "Technical Support Document – Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866", https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf.

The Interagency Working Group relied on an average of results from three simple models of climate economics, all of which minimized or ignored some of the most serious climate risks. In particular, these models ignored or minimized the risks of tipping points and abrupt, irreversible losses, one of the most damaging features of future climate projections. This and other criticisms of the methodology are spelled out in an extensive evaluation and critique of the federal SCC by the National Academy of Sciences.[28]

Concerns about limitations of the Interagency Working Group methodology have led to research by many economists on risks and uncertainties, producing alternative SCC values that are often higher than the Working Group estimates. A review of the effect of climate risks on the SCC found that, in order to reflect well-known major risks, the SCC needs to be at least $131.[29]

A major study by the well-known British climate economists Simon Dietz and Nicholas Stern found a range of optimal carbon prices (i.e., SCC values), depending on key climate uncertainties, ranging from $42 to $198 for emissions in 2025, and from $103 to $394 for emissions in 2055.[30]

In our own research, we found that a small number of major uncertainties—concerning low-temperature damages, high-temperature damages, climate sensitivity (roughly, the speed of warming), and the discount rate—led to an extremely wide range of possible values, from $34 to $1,079 for emissions in 2010, and from $77 to $1,875 in 2050.[31]

The high but widely varying estimated values for the SCC lead to a quandary for valuation of emissions. There are good reasons to think that damages are very large, but nobody knows exactly how large. The Interagency Working Group numbers are a useful conventional standard because they are so widely cited and recognized. Nonetheless, they are almost certainly an underestimate of the true value of climate damages and should be interpreted as a floor under the true value, not an accurate estimate.

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[28] National Academy of Sciences, Engineering, and Medicine (2017). *Valuing Climate Damages: Updating Estimates of the Social Cost of Carbon Dioxide* (Washington, DC: The National Academies Press), https://www.nap.edu/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of.

[29] J.C.J.M. van den Bergh and W.J.W. Botzen (2014), "A lower bound to the social cost of CO_2 emissions," *Nature Climate Change* 4, pp. 253-258.

[30] Simon Dietz and Nicholas Stern (2015), "Endogenous growth, convexity of damage and climate risk: how Nordhaus' framework supports deep cuts in carbon emissions," *Economic Journal* 125, pp. 574-620, Table 4.

[31] Frank Ackerman and Elizabeth A. Stanton (2012), "Climate risks and carbon prices: revising the social cost of carbon," *Economics E-Journal* 6, article 2012-10.

5. Big Bend's share of global emissions and damages: 1 in 20,000

To understand the role of the proposed plant at Big Bend in causation of climate change, it is helpful to estimate its share of worldwide carbon emissions. (Here and in the remainder of this discussion, we examine the projected emissions from the entire proposed plant, including two new combustion turbines as well as the combined-cycle plant.)

The periodic reports from the Intergovernmental Panel on Climate Change ("IPCC") provide consensus projections for global emissions. On a business-as-usual trajectory (i.e., with no success in any new major emission reduction initiatives), emissions at the midpoint of the proposed plant's lifetime, in 2038, will amount to 61.5 billion metric tons of CO_2e.[32]

Big Bend emissions, averaging 3.3 million short tons CO_2e per year (see above), are equivalent to 3.0 million metric tons. Thus, the ratio (Big Bend emissions / global emissions) is equal to:

3.0 million / 61.5 billion = 49 parts per million = roughly 1/20,000

That is, Big Bend will be responsible for roughly one part in 20,000 of global climate damages caused by all worldwide emissions during the plant's lifetime.

If these damages were correctly described by the Obama administration's SCC, how much would they amount to? The four values calculated by the Interagency Working Group, extrapolated to 2038 (and converted to 2018 dollars per metric ton of CO_2) range from $24 to $214; the "central estimate" amounts to $70.

At the $70 rate, estimated damages due to 2038 emissions alone are 3.0 million tons * $70 / ton = $210 million. Over the 30-year lifetime of the proposed plant, the estimated cumulative emissions of almost 99 million short tons, or about 90 million metric tons, are worth 90 million tons * $70 / ton = $6.3 billion. Using the lowest and highest of the four Obama administration SCC estimates, global climate damages due to Big Bend could be as low as $2.2 billion, or as high as $19 billion.

These estimates of damages caused by Big Bend's emissions, which may be underestimates of the true values, are many times larger than TECO's projected benefits to customers from the proposed project. In short, widely used estimates of the SCC (i.e., the value of climate damages) imply that the proposed plant causes damages much greater than its economic value to customers.

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[32] This is the interpolated value of emissions in 2038, on the IPCC's RCP8.5 scenario (the closest to business-as-usual), converted from PgC to billion metric tons of CO_2e. See https://www.ipcc.ch/site/assets/uploads/2017/09/WG1AR5_AnnexII_FINAL.pdf, Table AII.2.1c, p.1410. Projected global emissions are gradually rising over the lifetime of Big Bend, so the midpoint year provides a reasonable comparison to the global total for the period.

6. MEASURING FLORIDA CLIMATE DAMAGES

An alternate approach to valuation of Florida climate damages, and Big Bend's responsibility for those damages, rests on a detailed recent study that estimates values, by state, for six categories of climate impacts.[33] The study has been cited dozens of times, and the authors have published highly regarded articles in leading scientific journals drawing on the same database. We are not aware of other studies that provide similar state-level detail on expected climate studies.

The six impacts highlighted in the study are not an exhaustive list of important climate impacts; rather, they are six categories for which it was possible to develop meaningful monetary estimates by state. These six categories are:

1. **Agriculture:** economic impacts of changes in corn, wheat, oilseeds (soybeans), and cotton yields caused by projected temperature and precipitation changes. Earlier research, from the 1990s, projected that the first few degrees of warming might be good for U.S. agriculture. A newer research paradigm, reflected in this study, observes that there are temperature thresholds above which many crop yields drop precipitously; climate change leads to an increase in the number of summer days above those thresholds, and hence to a decline in yields.
2. **Labor:** changes in labor supply and productivity caused by rising temperatures. It is well known that people work more slowly, and work shorter hours, as temperatures rise above a comfortable level, particularly for outdoor occupations.
3. **Health:** changes in mortality caused by rising temperatures (fewer cold-related deaths, more heat-related deaths). An extensive research literature has documented the close relationship between temperatures and death rates.
4. **Crime:** increases in crime rates associated with rising temperatures. There is a well-known correlation between temperatures and crime.
5. **Energy costs:** rising temperatures lead to reduction in heating costs and increase in air conditioning costs, as well as making electric systems less efficient. These trends cause a net increase in required generation capacity and costs as temperatures rise.
6. **Coastal impacts:** Mean sea level rise alone leads to inundation of valuable coastal property, including beaches as well as structures. Losses are much greater when sea level rise amplifies the effects of storm surges, as it increasingly does. The best projections of storm activity imply that future storms will become more intense and damaging.

Impacts are measured as percentage losses in state gross domestic product ("GDP") in 2080–2099, assuming the world follows a high-emission, business-as-usual scenario (the IPCC's RCP8.5 scenario). Florida has the largest climate impacts of any of the 48 states covered in the study, with a likely cost range between 10.1 percent and 24.0 percent of state GDP, most of it due to heat-related mortality and

[33] Trevor Houser, Solomon Hsiang, Robert Kopp, and Kate Larsen (2015), *Economic Risks of Climate Change: An American Perspective* (New York: Columbia University Press).

coastal impacts.[34] "Likely" in this context means that the researchers estimate there is a two-thirds probability that impacts will fall in this range (following an approach adopted in other climate analyses). The wide gap is the 17th percentile and 24 percent is the 83rd percentile. Notice that this implies between 10.1 percent and 24 percent losses reflects the fact that we are uncertain about exactly how fast the climate will worsen. In effect, the researchers have estimated a probability distribution for damages, in which 10.1 percent a one-in-six chance that climate damages in Florida will be even greater than a loss of 24 percent of GDP by the last two decades of this century.

Florida's GDP was $967.3 billion in 2017.[35] Assuming a 2.24 percent real growth rate for the long term (matching the average from 1997 to 2017[36]), Florida's GDP in 2090 (the midpoint of the 2080–2099 range) would be $5,020 billion, in 2018 dollars. Climate losses of 10.1 percent to 24.0 percent of that amount would mean losses ranging from $507 billion up to $1,205 billion per year, again in 2018 dollars.

Recalling that the proposed Big Bend plant represents a projected 49 parts per million of global emissions, its share of projected Florida climate losses in 2090 would be $25 million to $59 million per year. Discounted to 2018 present values, the Big Bend share of these projected losses would be $9.2 to $21.7 million per year.[37] Over the 20-year span from 2080 through 2099, the Big Bend share of projected Florida losses might reach $184 million to $434 million (i.e., 20 times the annual estimate), again in 2018 present value terms.

This is not a precise calculation of Big Bend's contribution to Florida climate losses in 2080–2099. The proposed plant, projected to be online from 2023 to 2052, will also cause damages both before and after 2080–2099, while other, newer sources of emissions will contribute to damages at the end of this century. Nonetheless, it may be a reasonable approximation of the share of projected Florida climate losses in 2080–2099, as calculated above.

It is also important to remember that this estimate of damages caused by Big Bend's emissions is sure to underestimate the true value, for at least two reasons. First, this estimate looks only at damages in Florida, ignoring damages in other states, let alone other countries. Big Bend's share of nationwide U.S. climate damages would be much larger than its share of Florida damages alone. Its share of global damages, consistent with SCC calculations, would be larger still.

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[34] *Ibid.*, p. 141, 148. Numbers in the text refer to costs using the "value of a statistical life" (VSL) valuation of mortality, which has become common in cost-benefit analysis of environmental policy, and projected levels of future hurricane activity.

[35] Downloaded from Bureau of Economic Analysis, May 4, 2018.

[36] Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org/series/FLRGSP.

[37] Since this calculation involves intergenerational climate impacts, it is appropriate to use a low discount rate. In this case, the calculation employs the Stern Review's recommended long-run climate discount rate of 1.4 percent per year. For the source of this discount rate, and economic and philosophical arguments for very low discount rates in intergenerational climate calculations, see Nicholas Stern, *The Stern Review on the Economics of Climate Change* (London: HM Treasury, 2006; Cambridge, UK: Cambridge University Press, 2007).

Second, the Florida damages considered here are not an exhaustive list of all climate damages. Ecosystem damages and losses in the tourism industry, two categories discussed above, are excluded. Rather, the estimates considered here are only the projected Florida damages from the six categories of climate impacts mentioned above.

Thus, the full extent of climate damages attributable to Big Bend emissions is sure to be greater than the numbers discussed in this section—probably much greater. As noted above, the estimates presented here are a floor under the true value of climate damages, not an accurate estimate.

7. Conclusion

TECO claims that its proposed project would lead to cumulative present value savings for customers of $747 million, or $24.9 million per year for the 30 years of expected operation.[38] Putting aside the errors in TECO's calculation discussed in Ms. Glick's report, TECO's claimed savings are dwarfed by the SCC valuation of damages attributable to the proposed plant's emissions, $210 million per year (for the SCC "central estimate"). The Company's projected savings for its customers amounts to roughly $7 per ton of CO_2 emissions, while the damage costs measured by the federal SCC methodology reach $70 per ton around the midpoint of the combined-cycle unit's lifetime.

Even the much smaller, highly conservative estimate of the proposed plant's share of Florida damages—again, ignoring all damages outside the state boundaries and all damages other than six specific categories—has a present value of $9.2 to $21.7 million per year. In other words, the likely values of the Big Bend share of selected in-state Florida damages alone would be on the same order of magnitude as the claimed customer benefit. The true degree of climate damages caused by the project, including a broader geographical scope and a fuller picture of damage categories, would be far greater.

In summary, TECO has failed to show that the benefits of its proposed project outweigh the climate costs that it will impose on Florida, let alone the rest of the United States or the world. We have identified two ways to quantify some of the impacts of Big Bend's greenhouse gas emissions. As explained above, these methods underestimate the true extent of damages; they are floors under the actual costs, not a best guess at the true costs. Yet even with such underinclusive estimates, the quantified damages from the proposed plant's emissions are at least comparable to, and likely larger than, the projected benefits to TECO's customers. (The benefits from construction, meanwhile, can be achieved by building anything: a new headquarters, or new generation facilities relying on any fuel and technology, would achieve the same construction benefits; thus, they are not specific to the proposed Big Bend combined-cycle unit.)

[38] TECO DOAH Case No. 18-2124EPP, Sierra Club Second Request for Production of Documents, No. 26, page 1633. January 16, 2019.

In sum, even a partial profile of the climate damages posed by TECO's proposed plant outweighs its supposed customer benefits (even under the Company's flawed calculations). This conclusion is of utmost importance to the evaluation of TECO's proposed plant. Construction of the proposed plant will lock in a 30-year commitment to a large absolute quantity of emissions—millions of tons of CO_2 per year—that is much too high for the rapid reduction required to stabilize the climate and mitigate future damages, in Florida and beyond.