Greenhouse Gas Reduction Goal Planning Report

Prepared for Tucson Electric Power

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Executive Summary

In 2014, the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) stated that warming of the climate system is unequivocal and that many changes to the system have been unprecedented over decades to millennia. In particular, greenhouse gas (GHG) concentrations have increased, the sea level has risen, the atmosphere and ocean have warmed, and snow and ice amounts have decreased. With each successive IPCC report, the evidence has strengthened that human activity has been the dominant cause of global warming since the mid-20th century. In response to the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement, the US Federal Government established its Nationally Determined Contribution (NDC) in 2015, aiming to put the US on a path to reduce its emissions by 2050 to 80% of 2005 levels. Due to state and federal targets and regulations, along with the decreasing costs of renewables and natural gas, public pressure for carbon reductions, and other factors, utilities in the US have been setting targets to reduce their emissions. Groups such as the Task Force on Climate-related Financial Disclosures (TCFD), the Science Based Targets Initiative (SBTi), and the Electric Power Research Institute (EPRI) have conducted research and written reports to aid companies in their climate change scenario planning.

This report analyzes 24 US utilities that have set reduction targets for carbon emissions. We found a significant range of reduction targets across the US utility landscape, with 21 distinct targets for the 24 utilities analyzed in this report. The report sorts the utilities' targets into three categories: low, medium, and high targeted levels of carbon reduction. The anchor among all the targets identified is the US's NDC formulation of "80% reductions under 2005 emissions by 2050". The different baseline dates adopted by utilities makes it challenging to compare the targets. Even comparing two utilities with the same target is difficult, because the size of the reduction needed to go below a previous baseline emissions amount depends on how much the utility has grown in the intervening years.

This report also divides the 24 utilities into a four-part typology based on their energy capacity in megawatts (MW), and the percentage of their energy mix that is coal. This gives us four types of utilities: small/low-carbon, small/high-carbon, large/low-carbon, and large/high-carbon. The larger and more high-carbon utilities tend to have low targeted levels of carbon reduction, though the exact formulation of the targets varies across the utilities. The most pronounced pattern among the utilities is that small utilities with low-carbon portfolios tend to have much higher targeted levels of carbon reduction. This report classifies Tucson Electric Power (TEP) as a small/high-carbon utility, characterized by the greatest proportion of low targeted levels of carbon reduction among its members.

Part 1: State of the Science

1. Introduction

Part 1 of this report provides an overview of our current scientific understanding of observed and projected global climate change, with an emphasis on the evidence behind these global processes and their impacts. We draw primarily on the IPCC Fifth Assessment Report for the global picture, and on the Fourth National Climate Assessment (NCA4) for the depiction of the US Southwest under climate change. Multiple lines of evidence have been used to link human activities to higher global temperatures and associated impacts such as sea-level rise and an increase in extreme weather/climate events. With each successive IPCC report, the evidence has strengthened that human activity has been the dominant cause of global warming since the mid-20th century.

2. Current Scientific Understanding of Observed and Projected Global Climate Change

In this report, we deploy two ways of describing the certainty of the evidence, as used by the IPCC.[1]

The first concept is the *likelihood* of the statement being true. The table to the right translates a prose statement, such as "very likely," into an approximate quantitative measure.

Term	Likelihood of the Outcome
Virtually certain	99–100% probability
Very likely	90–100% probability
Likely	66–100% probability
About as likely as not	33–66% probability
Unlikely	0–33% probability
Very unlikely	0–10% probability
Exceptionally unlikely	0–1% probability

The second concept is the *confidence* in a finding's validity. This is derived from the "type, amount, quality and consistency of evidence (e.g., mechanistic understanding, theory, data, models, expert judgement) and the degree of agreement."[2] Measures of confidence are expressed qualitatively drawing on five terms: very low, low, medium, high, and very high.

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[1] Thomas F. Stocker et al., "2013: Technical Summary," in *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2013), 36.
[2] Stocker et al., 36.

2.1. The processes of climate change

DRIVERS OF CLIMATE CHANGE. Climate change is driven by alterations in the Earth's energy budget that derive from both natural and anthropogenic substances and processes. In particular, when radiative forcing[3] is positive, the climate system takes up additional energy, leading to surface warming. Increases in atmospheric carbon dioxide (CO_2) since 1750 have been the largest contributor to total radiative forcing. CO_2 and other greenhouse gases lead to increased radiative forcing by retaining energy within the Earth's atmosphere that is then radiated back to Earth instead of escaping to space.[4] (See Figure 1.)

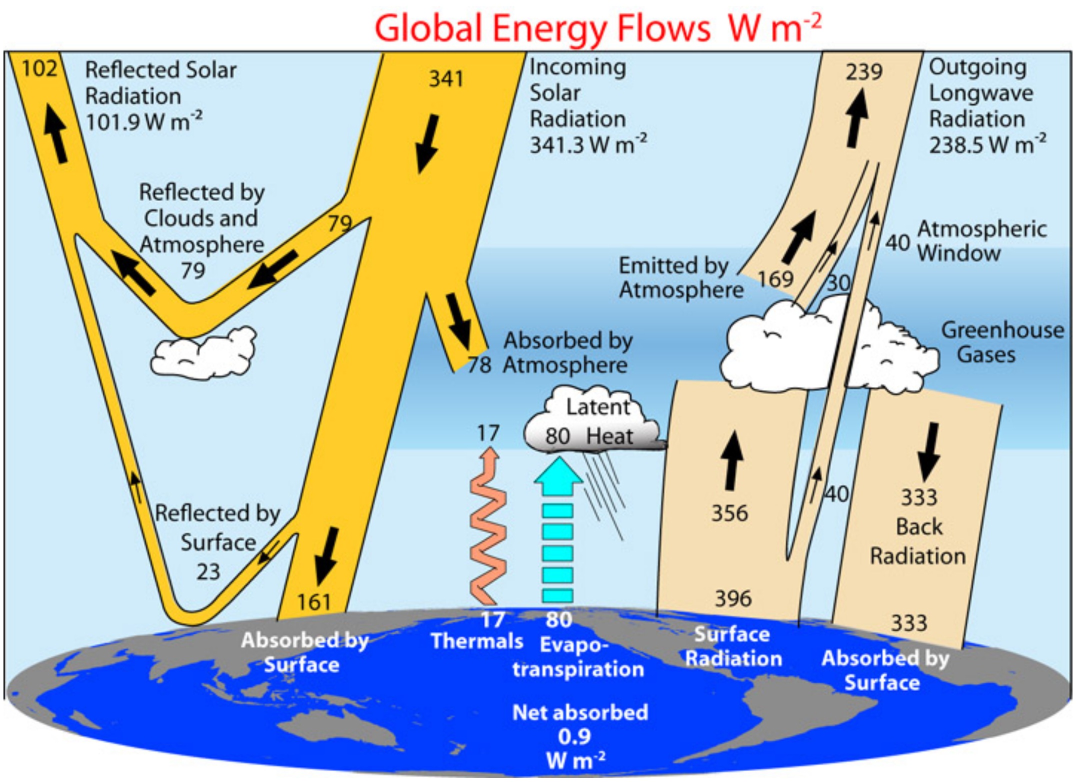

Figure 1. The Earth's energy budget.[5]

HOW WE KNOW WHAT WE KNOW. Our understanding of the processes of climate change and the larger climate system is based on bringing together observations and model simulations. Observations come from many timescales: paleoclimate reconstructions go back millions of

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[3] The change in energy transfer to the Earth.

[4] Thomas F. Stocker et al., "IPCC, 2013: Summary for Policymakers," in *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2013), 13.

[5] K. Trenberth, J. Fasullo, and J. Kiehl, "The Energy Budget", *UCAR: Center for Science Education.* University Corporation for Atmospheric Research. https://scied.ucar.edu/longcontent/energy-budget

years, global-scale observations go back to the mid-19th century, and more detailed observations, using direct measurements and remote sensing of land, oceans and the atmosphere, go back to the 1950s. Climate models, also known as general circulation models (GCMs), use mathematical equations to represent how energy and matter move through the ocean, atmosphere, and land. Models are tested by using historical data to predict past weather and climate, using observations to check their accuracy. Projections are used to predict future climate under different possible scenarios. The IPCC Fifth Assessment Report created new scenarios known as Representative Concentration Pathways (RCPs), and each RCP shows the amount of radiative forcing expected to occur given a specific amount of GHGs in the atmosphere in 2100.[6]

2.2. Observed global climate change

The IPCC Fifth Assessment Report stated that warming of the climate system is "unequivocal" and that many of the changes to the system have been "unprecedented over decades to millennia."[7] For example, GHG concentrations have increased, the sea level has risen, the atmosphere and ocean have warmed, and snow and ice amounts have decreased. Below, we provide more detail on the observed changes to five elements of the climate system.

CARBON AND OTHER BIOGEOCHEMICAL CYCLES. Concentrations of carbon dioxide, methane, and nitrous oxide in the atmosphere have increased at levels unmatched in at least the past 800,000 years.

OCEAN. More than 90% of the additional energy accumulated within the climate system between 1971 and 2010 has been stored within the oceans (high confidence), making it virtually certain that the upper ocean (0−700 m) has warmed from 1971 to 2010. Since pre-industrial times, CO_2 concentrations have increased by 40%, with the oceans absorbing about 30% of the emitted anthropogenic CO_2, resulting in ocean acidification.

ATMOSPHERE. Climate change has led to near-universal surface warming of the Earth. (See Figure 2.) From the period 1880-2012, the global average temperature increase for both the land and ocean has been 0.85 °C (1.5 °F). Moreover, in the Northern Hemisphere, the 1983-2012 period was likely the warmest three-decade span in the last 1400 years (medium confidence). Also in the Northern Hemisphere, precipitation has increased since 1901 (medium confidence for before 1951, and high confidence for the period thereafter).[8]

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[6] Stocker et al., "2013: Technical Summary."
[7] Stocker et al., "IPCC, 2013: Summary for Policymakers," 4.
[8] Stocker et al., 5.

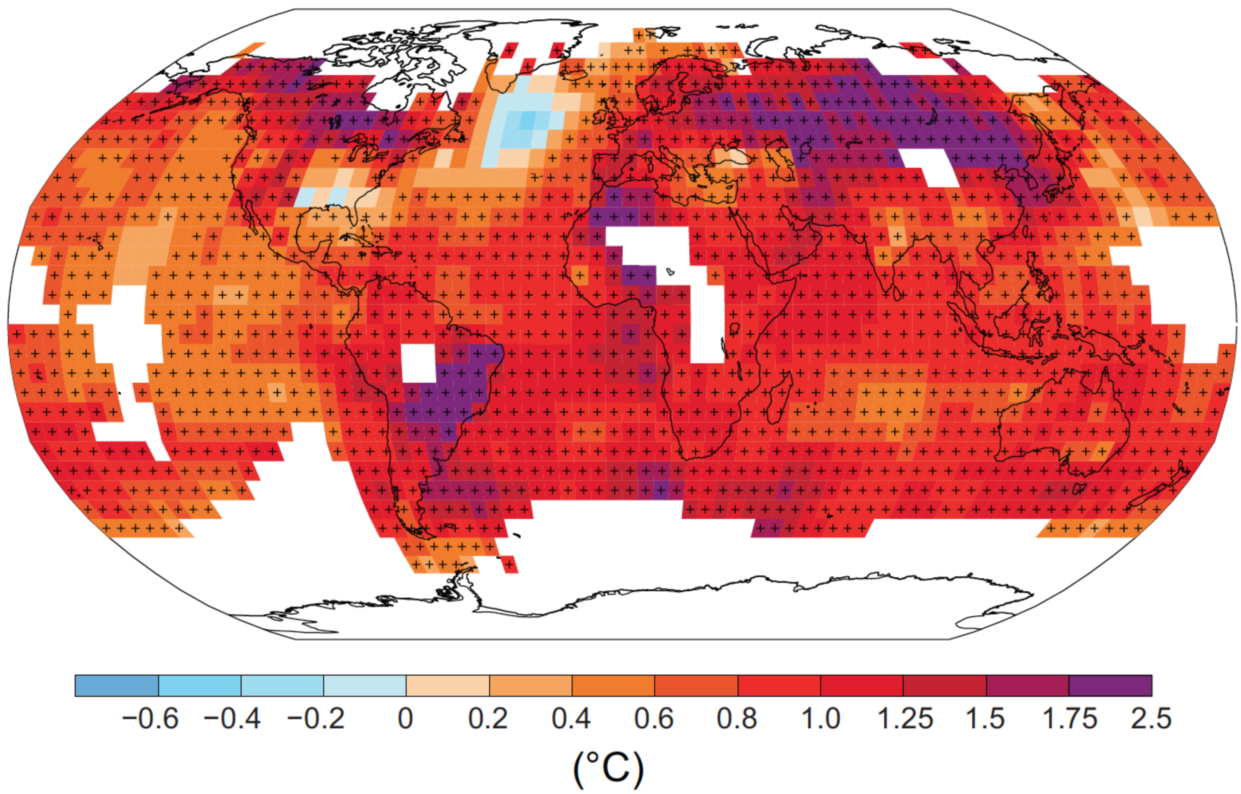

Figure 2. Observed changes in surface temperature 1901–2012.[9]

CRYOSPHERE. For the past two decades, Arctic sea ice and Northern Hemisphere spring snow cover has decreased, the Greenland and Antarctic ice sheets have lost mass, and glaciers have shrunk across the world (high confidence).

SEA LEVEL. Since the mid-19th century, the rate of sea-level rise has exceeded the average rate of the past two thousand years (high confidence), leading to a global mean sea level increase of 0.19 m over the 1901-2010 period. Taken together, shrinking glaciers and ocean thermal expansion account for 75% of the observed global mean sea-level rise since the early 1970s (high confidence).

2.3. Projected global climate change

Atmospheric concentrations of CO_2, methane (CH_4), and nitrous oxide (N_2O) are substantially higher than the highest concentrations found in ice cores during the past 800,000 years. And the mean rates of their increase over the last century are unprecedented in the last 22,000 years (very high confidence), though have been higher prior to 22,000 years ago. In particular, CO_2

[9] Stocker et al., 6.

concentrations, at over 400 parts per million, are at a level not seen in the past 3 million years.[10] As greater amounts of GHGs are emitted into the atmosphere, all components of the climate system will change as the Earth continues to warm.[11]

ATMOSPHERE: TEMPERATURE. Across all but one Representative Concentration Pathway (RCP; see section 2.1), global surface temperature is likely to exceed 1.5 °C (2.7 °F) above pre-industrial levels by 2100. It is virtually certain that heat extremes will become more frequent and last longer, and that cold extremes will become less frequent.[12]

ATMOSPHERE: WATER CYCLE. The global water cycle will not change uniformly across the globe. Rather, there will be differences in impacts in different regions. In general, dry areas will get drier and wet areas will experience increased precipitation with increasing variability. Over most of the mid-latitude land masses, extreme precipitation events will very likely become more frequent and intense. And monsoon precipitation is likely to intensify.

OCEAN. During the 21st century, the ocean will continue to warm, and heat will increasingly penetrate the deep ocean, affecting its circulation. Melting ice will also affect circulation patterns.

CRYOSPHERE. During the 21st century, Arctic sea ice cover will decrease in surface area and thickness, and spring snow cover in the Northern Hemisphere will shrink (very likely).

SEA LEVEL. Under all RCPs, the rate of sea-level rise will exceed that of the period 1971-2010 (very likely), and for the period 2081-2100 its rise will be in the range 0.26 to 0.82 m, depending on the RCP (medium confidence).

CARBON AND OTHER BIOGEOCHEMICAL CYCLES. Greater CO_2 concentrations in the atmosphere (high confidence) will lead to further uptake of carbon by the oceans, resulting in greater ocean acidification.

3. The Regional Impacts of Climate Change

The Fourth National Climate Assessment provides an overview of the observed and projected climate impacts on the American Southwest, including the states of Arizona, California,

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[10] USGCRP, "Climate Science Special Report: Fourth National Climate Assessment, Volume I," ed. D. J. Wuebbles et al. (U.S. Global Change Research Program, 2017), 31.
[11] Stocker et al., "2013: Technical Summary."
[12] Stocker et al., "IPCC, 2013: Summary for Policymakers," 20.

Colorado, New Mexico, Nevada, and Utah.[13] We draw on this report to articulate the impacts for the Southwest.

3.1. Observed impacts for the Southwest

ATMOSPHERE: TEMPERATURE. The Southwest has warmed 0.89 °C (1.6 °F) for the period 1986–2016 compared to the average for the first half of the last century (1901 to 1960). This increase in temperature is greater than that for all other US regions except for Alaska.[14]

WATER AND DROUGHT. The drought in the Colorado River Basin has in part been caused by increased temperatures from climate change. The resulting reductions in snowpack, lower runoff, and a 17%–50% reduction in streamflow between 2000 and 2014 has stressed water resources in the region. As a result of the drought, Lake Mead on the Colorado River lost 60% of its volume since 2000, leading to the lowest level since the reservoir was filled in 1936.[15]

COASTS AND SEA-LEVEL RISE. Observed sea-level rise at the Golden Gate Bridge in San Francisco was 22 cm (9 inches) between 1854 and 2016, and 24 cm (9.5 inches) at San Diego from 1906 to 2016.

FOOD. Increased temperatures in the Southwest over the 1981-2010 period resulted in lost agricultural productivity. With falling groundwater tables, there is an economic cost of increased pumping and drilling new wells in order to irrigate fields.

INDIGENOUS PEOPLES. The Southwest is home to the largest population of Indigenous peoples in the US: 1.5 million Native Americans in 182 federally recognized tribes, and many state-recognized and other non-federally recognized tribes. Within the Southwest, traditional Indigenous staple foods, including acorns, corn, and pine nuts have decreased due to drought. And wildfires have reduced tribes' access to fish, wildlife, and plants used for food and cultural practices.

HUMAN HEALTH. In a 2006 heatwave that affected California and Nevada for over two weeks, there were an additional 600 deaths, 16,000 emergency room visits, 1,100 hospitalizations in California, and economic costs of $5.4 billion (in 2008 dollars).

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[13] USGCRP, "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II," ed. D. R. Reidmiller et al. (U.S. Global Change Research Program, 2017).
[14] USGCRP, "Climate Science Special Report: Fourth National Climate Assessment, Volume I," 187.
[15] USGCRP, "Impacts, Risks, and Adaptation in the United States."

ENERGY. Drought in California reduced hydroelectric generation in the state by two-thirds over the 2011 to 2015 period. This resulted in increased fossil fuel use to make up for the shortfall.

3.1. Projected impacts for the Southwest

ATMOSPHERE: TEMPERATURE. Using the RCP with the highest expected GHG emissions (RCP 8.5), climate models project up to a 4.8 °C (8.6 °F) increase in annual average temperatures in the Southwest by the end of the century.

WATER AND DROUGHT. An increase of 4.8 °C (8.6 °F) in the Southwest would make megadroughts (droughts lasting longer than a decade) more likely. Increased temperatures would also lead to aridification, reduced snow cover, and earlier snowmelt. At the same time, climate models also project increasingly intense heavy downpours and an increase in daily extreme summer precipitation.

COASTS AND SEA-LEVEL RISE. Two hundred thousand California residents live in areas that are less than 0.9 m above sea level, placing them at risk of inundation by the end of the century. A combination of sea-level rise and storm surges could entirely erode two-thirds of beaches in Southern California by 2100. Ocean salinity has increased in the range of 25% to 40% from pre-industrial levels. And as early as 2030, oxygen levels in the Pacific Ocean may become lower than any naturally occurring levels, resulting in the loss of economically important aquatic species.

FOOD. Increased drought, heat waves, and reduced winter chill hours can cause widespread harm to food systems by killing crops and livestock, increasing food insecurity, and increasing competition for water and energy.

INDIGENOUS PEOPLES. With the expected reductions in water supply reliability in the Southwest, tribes that have water agreements to sell or lease water to neighboring communities may find themselves at risk of inadequate supplies of water during severe shortages. Reduced populations of fish, wildlife, and plants that serve as traditional foods may contribute to poorer nutrition and an increase in diabetes and heart disease.

HUMAN HEALTH. People in the Southwest will be increasingly subject to deaths and illnesses from extreme heat, poor air quality, and conditions conducive to the growth and spread of pathogens. Under the higher RCP, the Southwest would experience the highest increase of premature deaths from extreme heat in the country, with a projected 850 additional deaths per year, and economic losses totaling $11 billion by 2050. Under all emissions scenarios, deaths and economic losses would more than double by 2050.

ENERGY. Increased temperatures can reduce the energy efficiency of water-cooled electric power plants that rely on external cooling water by up to 15% by 2050, although such infrastructure and technology may be different by that date. And higher temperatures can lead to electricity losses of up to 5% in transmission lines as electric resistance increases.

4. Status of International Efforts to Address Rising Temperatures

4.1. The United Nations Framework Convention on Climate Change (UNFCCC)

The primary international body that supports actions to respond to climate change is the United Nations Framework Convention on Climate Change (UNFCCC) secretariat. The UNFCCC is an international environmental treaty that was adopted in 1992 at the Earth Summit in Rio de Janeiro. It had 197 signatory parties as of December 2015. According to Article 2 of the convention, the UNFCCC is designed to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." A series of protocols or agreements have been subsequently negotiated to set specific goals to achieve the convention's overarching mission.

4.2. Kyoto Protocol

The adoption of the Kyoto Protocol in 1997 created emission reduction targets for developed countries that are binding under international law. The Kyoto Protocol has had two commitment periods, the first of which lasted from 2008-2012. During this time, 36 industrialized countries and the European Union stated that they would reduce their average emissions by 5% from 1990 levels by 2012. Although the Protocol has faced many challenges, including the US's refusal to ratify it and Canada's withdrawal from it, actual emissions from the participating countries were 22.6% below 1990 levels by 2012, significantly below the target of 5%. However, much of that reduction came from the rapidly falling emissions of former Soviet states that occurred after 1990 but before the Protocol was signed.[16]

4.3. Paris Agreement and 1.5°C Target

In recognition of the increasingly precise and alarming predictions from the IPCC reports, the international community and the UNFCCC have continued to seek agreements to limit the consequences of climate change. The target of keeping warming to 2 °C (3.6 °F) above pre-industrial levels was seen as essential, while existing efforts were seen as inadequate to do so. As a result of ongoing efforts to develop an international climate treaty, a UN Climate Change Conference was held in Paris in 2015 that resulted in the Paris Agreement. Within the

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[16] UNFCCC, "UN Climate Change Annual Report 2017," 2018, https://unfccc.int/resource/annualreport/media/UN-Climate-AR17.pdf.

Agreement, countries pledged to keep global average temperature below 2 °C (3.6 °F), with a target of 1.5 °C (2.7 °F) above pre-industrial levels. A key way to do this was the establishment of Nationally Determined Contributions (NDCs), which are the plans that countries make to mitigate climate change and adapt to its impacts. (See section 1.1. in the second part of this report on "Corporate Science Based GHG Emission Reduction Targets".)

5. The Role of Negative Emissions to Achieve Average Temperature Goals

In adopting the Paris Agreement, the 21st Conference of Parties of the UNFCCC requested a "Special Report in 2018 on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways."[17] The resulting *Special Report: Global Warming of 1.5 ºC* ("1.5 ºC Report") details the expected impacts of both 2 ºC (3.6 °F) and 1.5 ºC (2.7 °F), nearly invariably showing how the latter target will result in less harm.

Diana Liverman, Regents' Professor in the School of Geography and Development at the University of Arizona, was a lead author for that Special Report. On April 30, 2019, Liverman testified before the House Select Committee on the Climate Crisis at the hearing "Solving the Climate Crisis: Drawing Down Carbon and Building Up the American Economy." She stressed the social justice implications of addressing climate change: "Climate change is affecting our most vulnerable or historically disadvantaged citizens—the poor, the elderly, and children, tribal members, farm and construction workers who labor outside—who cannot escape the heat or afford the increased air conditioning and water costs."[18]

In discussing how we can keep to only 1.5 ºC by the end of the century, the 1.5 ºC Report authors use the concept of temperature overshoot. Overshoot occurs when warming temporarily exceeds a specified level of global warming.[19] For example, overshoot would occur if the Earth were to warm more than the target of 1.5 ºC for a certain amount of time. The higher and longer we are above the target, the greater the impacts.

The different emission pathways can be placed into three categories of temperature overshoot.

1. "No overshoot" characterizes those pathways with at least a 50% probability of limiting global warming to below 1.5 °C by 2100 without ever going over 1.5 °C.

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[17] Decision 1/CP.21, paragraph 21.
[18] https://uanews.arizona.edu/story/liverman-testifies-house-climate-committee
[19] Valérie Masson-Delmotte et al., "IPCC, 2018: Summary for Policymakers," in *Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty* (Geneva, Switzerland: World Meteorological Organization, 2018), 24.

2. "1.5 °C limited-overshoot" are those pathways where warming is kept below 1.6 °C (2.9 °F) and returns to below 1.5 °C (2.7 °F) by 2100.
3. "Higher-overshoot" are those which surpass 1.6 °C but still return to below 1.5 °C by 2100.

The emissions pathways with limited or no overshoot would require rapid social transformations of unprecedented scale involving changes to land use, transportation and building infrastructure, and industrial and energy systems (high confidence).[20]

In particular, these transformations that keep warming to 1.5 °C with limited or no overshoot would also require carbon dioxide removal (CDR) from the atmosphere.[21] Examples of CDR include: increasing forestation; using biomass for energy in the industrial, power or transportation sectors, for example, ethanol from corn; and removing carbon dioxide directly through the air and then storing it (carbon capture and storage). CDR would be necessary to compensate for residual emissions and to achieve net negative emissions, with the greater the overshoot, the greater amount of needed CDR (high confidence)[22]. The greater the temperature reduction needed (i.e. the larger the overshoot), the greater amount of needed CDR. We cannot count on the speed, scale, or efficacy of CDR to meet the challenge of climate change due to limitations in our understanding of its social acceptability and its interactions with the carbon cycle and climate system.

Part 2: Corporate Science Based GHG Emission Reduction Targets

1. Protocols for Emission Reduction Targets

1.1. National targets

In response to the Paris Agreement, the US Federal Government established its Nationally Determined Contribution (NDC) near the end of President Obama's second term in 2015. The US established the following as its NDC:

[20] Masson-Delmotte et al., "IPCC, 2018: Summary for Policymakers."
[21] Masson-Delmotte et al., "IPCC, 2018: Summary for Policymakers." Section C.3 - "All pathways that limit global warming to 1.5°C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 $GtCO_2$ over the 21st century."
[22] Masson-Delmotte et al., "IPCC, 2018: Summary for Policymakers." Section C.3.3 - "Pathways that overshoot 1.5°C of global warming rely on CDR exceeding residual CO_2 emissions later in the century to return to below 1.5°C by 2100, with larger overshoots requiring greater amounts of CDR."

"The United States intends to achieve an economy-wide target of reducing its greenhouse gas emissions by 26%-28% below its 2005 level in 2025 and to make best efforts to reduce its emissions by 28%."[23]

This NDC was part of what the Obama Administration called the Mid-Century Strategy (MCS). It saw the NDC as putting the "country on a path to a reduction in emissions of 80% by 2050." This strategy was intended to follow the near-term cuts with "deep, economy-wide" transformations.[24] The Trump Administration has announced its intention to withdraw from the Paris Agreement at the end of 2019 following the mandated three-year notice period. Until the US withdraws from the Agreement, however, its NDC legally remains in place.

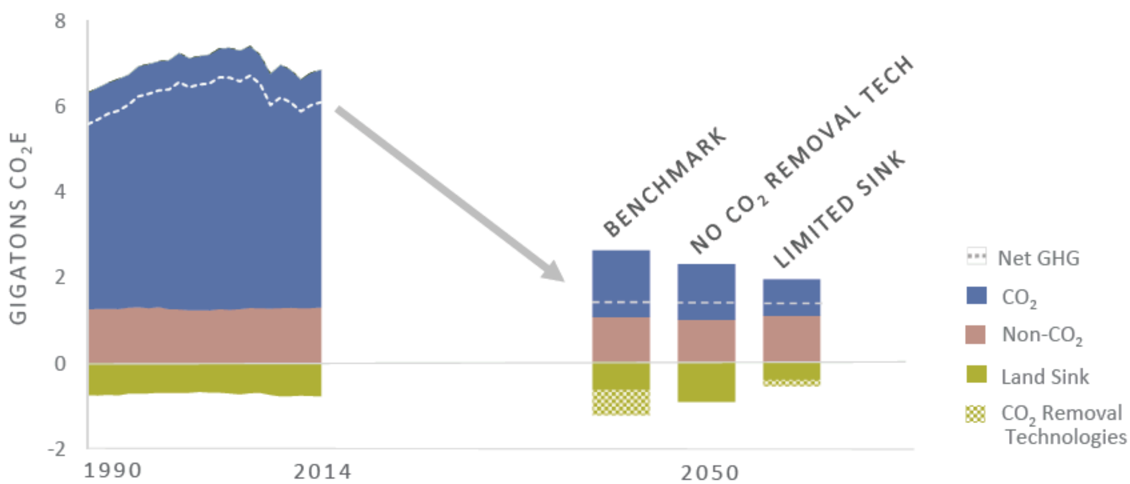

Figure 3. Multiple pathways to 80 percent GHG reductions by 2050 are achievable through large reductions in energy CO_2 emissions, smaller reductions in non-CO_2 emissions, and delivering negative emissions from land and CO_2 removal technologies.[25]

The MCS involves scenarios with numerous pathways to an 80% reduction below 2005 levels in 2050, including one called the MCS Benchmark. The emissions budget for the Benchmark scenario in 2050 is approximately 1.5 gigatons of CO_2. This would represent a reduction in net emissions from 2005 levels of approximately 6 gigatons of CO_2.

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[23] United States of America, "U.S.A. First NDC Submission" (United Nations Framework Convention on Climate Change, 2015), https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/United%20States%20of%20America%20First/U.S.A.%20First%20NDC%20Submission.pdf.
[24] White House, "United States Mid-Century Strategy for Deep Decarbonization," in *United Nations Framework Convention on Climate Change,* Washington, DC, 2016.
[25] White House.

ENERGY SECTOR. The emissions budget for the US energy sector in 2050 is 0.963 gigatons net emissions of CO_2. To achieve these emissions levels, the electricity generation mix in 2050 should be approximately: renewables (55 percent), nuclear (17 percent), and fossil fuels with carbon capture, utilization, and storage (CCUS) (20 percent).[26]

TRANSPORTATION. About one-third of all US CO_2 emissions come from the transportation sector. And about three-fourths of oil used in the US is consumed within this sector. With a continuation of trends in improved fuel economy and GHG emissions standards, fleet-wide emissions intensity would decline 76% by 2050. The MCS Benchmark scenario is that emissions intensity will decline by 86% by 2050.[27] A key part of the transition to lower emissions in the transportation sector is the adoption of electric vehicles, wherein about 32% of the world's passenger vehicles may be electric by 2040.[28]

1.2. Task Force on Climate-related Financial Disclosures

In 2017, the Task Force on Climate-related Financial Disclosures (TCFD), an international consortium, produced a report with a set of recommendations on how to "appropriately assess and price climate-related risks and opportunities."[29] The report aimed to identify the information needed by investors, lenders, and insurance underwriters to understand a company's material risks. Its ultimate goal is to have the effects of climate change routinely considered in business and investment decisions. By having companies voluntarily and consistently disclose climate-related financial risks and opportunities, the report argues that capital can be more efficiently allocated as economies transition to a more sustainable, low-carbon state.

RISKS. The TCFD report divides climate-related risks into two categories: (a) risks from the transition to a lower-carbon economy; and (b) risks from the physical impacts of climate change.

A. Transition risks
    (i) Policy and legal risks involve the financial impact of policy changes, such as implementing carbon-pricing mechanisms to reduce GHG emissions, and they involve the possibilities of litigation arising from organizations' failures to adequately mitigate climate change or adapt to its impacts.
    (ii) Technology risk involves the impact that emerging technologies such as renewable energy will have on organizations relative to their competition.

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[26] White House, page 8.

[27] White House.
[28] Bloomberg New Energy Finance, "Electric Vehicle Outlook 2019", 2019, https://about.bnef.com/electric-vehicle-outlook/
[29] Task Force on Climate-related Financial Disclosures, "Final Report: Recommendations of the Task Force on Climate-Related Financial Disclosures," 2017, https://www.fsb-tcfd.org/publications/final-recommendations-report/.

(iii) Market risk involves climate-change-induced shifts in supply and demand for certain commodities, products, and services.

(iv) Reputation risk involves the perceptions of an organization's positive or negative role in transitioning to a lower-carbon economy.

B. Physical risks

(i) Acute risk involves the impact of hazards like hurricanes, or floods.

(ii) Chronic risk involves longer-term shifts in climate patterns, like higher temperatures, which result in sea-level rise, among other impacts.

OPPORTUNITIES. As organizations attempt to mitigate and adapt to climate change, there are particular opportunities.

(i) *Resource efficiency*: Organizations can reduce operating costs by increasing efficiencies in energy, water, and waste management.

(ii) *Energy source*: Given the continuing fall in the price of renewable energy, organizations that shift their energy use toward low-carbon sources can save on energy costs.

(iii) *Products and services*: Organizations that take advantage of consumer desire for low-emission products and services can improve their competitiveness.

(iv) *Markets*: Organizations can better position themselves for the transition to a low-carbon economy by seeking opportunities in new markets.

(v) *Resilience*: Organizations that have adaptive capacity are better able to better manage the associated risks of climate change and seize the abovementioned opportunities.

RECOMMENDATIONS. The Task Force organized its recommendations on climate-related financial disclosures around four thematic areas: governance, strategy, risk management, and metrics and targets.

A. Governance	i) Describe the board's oversight of climate- related risks and opportunities. ii) Describe management's role in assessing and managing climate-related risks and opportunities.
B. Strategy	i) Describe the climate-related risks and opportunities the organization has identified over the short, medium, and long term. ii) Describe the impact of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning. iii) Describe the resilience of the organization's strategy, taking into consideration different climate-related scenarios, including a 2 °C or lower scenario.

C. Risk Management	i) Describe the organization's processes for identifying and assessing climate-related risks. ii) Describe the organization's processes for managing climate-related risks. iii) Describe how processes for identifying, assessing, and managing climate-related risks are integrated into the organization's overall risk management.
D. Metrics and Targets	i) Disclose the metrics used by the organization to assess climate-related risks and opportunities in line with its strategy and risk management process. ii) Disclose Scope 1, Scope 2, and, if appropriate, Scope 3 GHG emissions, and the related risks.[30] iii) Describe the targets used by the organization to manage climate-related risks and opportunities and performance against targets.

Table 1. The TCFD's recommendations for financial disclosure.[31]

1.3. Science Based Targets Initiative (SBTi)

The Science Based Targets Initiative, a joint initiative by CDP, the UN Global Compact, the World Resources Institute, and WWF, has produced a target-setting methodology for reducing companies' GHG emissions. SBTi considers a GHG emissions reduction target to be "science-based" if it is in line with the level of decarbonization necessary to keep warming below 2 °C (3.6 °F) compared to pre-industrial levels.

The Initiative has four goals:[32]

1. Showcase companies that set science-based targets through case studies, events and media to highlight the increased innovation, reduced regulatory uncertainty, strengthened investor confidence and improved profitability and competitiveness generated by science-based target setting;

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[30] Scope 1 refers to all direct GHG emissions. Scope 2 refers to indirect GHG emissions from consumption of purchased electricity, heat, or steam. Scope 3 refers to other indirect emissions not covered in Scope 2 that occur in the value chain of the reporting company, including both upstream and downstream emissions.
[31] Task Force on Climate-related Financial Disclosures, "Final Report: Recommendations of the Task Force on Climate-Related Financial Disclosures," 14.
[32] Science Based Targets, "Frequently Asked Questions," *Science Based Targets Initiative* (blog), accessed June 10, 2019, https://sciencebasedtargets.org/faq/.

2. Define and promote best practice in science-based target setting with the support of a Technical Advisory Group;
3. Offer resources, workshops and guidance to reduce barriers to adoption; and
4. Independently assess and approve companies' targets.

SBTi has created a set of documents to assist the creation of science-based targets, including the "SBTi Criteria and Recommendations",[33] which provides the guidelines that the targets must meet to be approved as science-based; and the "Science-Based Target Setting Manual",[34] which details the various approaches and methodologies available to help establish a science-based target. (See Appendix 2 for the "Conclusions and Recommendations" of the Target Setting Manual.)

SBTi's "Science-Based Target Setting Manual" states that "ambitious action by power companies will be vital to keep global warming within the well-below 2°C limit" because they contribute approximately one third of global GHG emissions. Decarbonization in this sector should occur through shifting electricity generation from centralized to decentralized production and from fossil fuels to renewables.[35]

According to the SBTi report "Sectoral Decarbonization Approach: A method for setting corporate emission reduction targets in line with climate science," the power generation sector's global emission total in 2010 was approximately 13 gigatons (Gt) of CO_2, while SBTi's 2050 target is to reduce CO_2 emissions by about 91% to 1 Gt. Because the amount of generated electricity is expected to almost double from 2010 to 2050, the carbon intensity of electricity (i.e. GHG per kWh) needs to decline by more than 95% compared with 2010 levels in 2050 to achieve this goal.[36]

1.4. Electric Power Research Institute (EPRI) Report

The Electric Power Research Institute produced the 2018 report *Grounding Decisions: A Scientific Foundation for Companies Considering Global Climate Scenarios and Greenhouse Gas Goals* to serve as a technical resource for making scientifically-informed climate scenario

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[33] Science Based Targets Initiative, "SBTi Criteria and Recommendations, Version 4.0" (Science Based Targets, April 2019), https://sciencebasedtargets.org/wp-content/uploads/2019/03/SBTi-criteria.pdf.
[34] Science Based Targets Initiative, "Science-Based Target Setting Manual, Version 4.0" (Science Based Targets, April 2019), https://sciencebasedtargets.org/wp-content/uploads/2017/04/SBTi-manual.pdf.
[35] Science Based Targets Initiative, 10.
[36] Science Based Targets Initiative, "Sectoral Decarbonization Approach: A Method for Setting Corporate Emission Reduction Targets in Line with Climate Science" (Science Based Targets, May 2015).

planning and emission reduction targets.[37] The report analyzes and characterizes the current state of scientific understanding on the climate and identifies observations from the literature that are relevant to a variety of stakeholders, with a particular emphasis on power companies.

Following a thorough assessment of the current scientific understanding of climate change, the report derives four particular insights from the assessment that are applicable for the creation of emissions reductions targets: a) companies need to use their individual perspectives to identify the relevant uncertainties and define the company-specific context; b) companies should base their climate strategies on scientific understanding of climate goals and the companies' relationship to these goals; c) in choosing a cost-effective target, there is considerable uncertainty, and what is a cost-effective emissions pathway for one company will likely be different from what is cost-effective for others; and d) robust strategies are those that are flexible and that make sense in different future contexts.

While the above four insights are technical principles for developing targets, there is still the need to actually carry out the process of constructing the targets. The report provides the following eight steps to operationalize these insights (reproduced verbatim below):[38]

1. *Utilize existing science*: Consider scientific understanding in the peer-reviewed literature to objectively inform subsequent steps and ground decisions, such as ranges of plausible emissions pathways consistent with a temperature goal. In this process, technical considerations should be distinct from other considerations, such as policy preferences.

2. *Develop emissions ranges*: Consider both uncertainty about temperature-emissions relationships and the attainability of global emissions pathways associated with climate goals. The emissions ranges resulting from these two uncertainties represent potential aggregate emissions boundaries within which a company might operate, with underlying assumptions informing thinking about the plausibility of different emissions outcomes.

3. *Specify alternative policy designs*: Consider uncertainty about policy design features, including allocation of target levels across sectors as well as coordination within and across sectors, which will define company and societal opportunities, incentives, and costs.

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[37] Electric Power Research Institute, "Grounding Decisions: A Scientific Foundation for Companies Considering Global Climate Scenarios and Greenhouse Gas Goals," 2018, https://www.epri.com/#/pages/product/000000003002014510/?lang=en.
[38] Electric Power Research Institute, "Grounding Decisions: A Scientific Foundation for Companies Considering Global Climate Scenarios and Greenhouse Gas Goals," 2018, 3-3, https://www.epri.com/ -/pages/product/000000003002014510/?lang=en.

4. *Overlay company-specific context*: Consider company-specific elements such as current assets, markets, systems, customers, and current policy and strategy.

5. *Run preliminary analysis*: Define and analyze preliminary scenarios based on the previous steps to identify the key climate policy and non-climate-policy related uncertainties for company operations and investments.

6. *Implement a scenario design*: Develop and evaluate potential futures defined by company key uncertainties. Quantitatively compare the resulting potential futures in terms of compliance cost (to companies, customers, society), environmental effectiveness, the cost risk of potential outcomes, and the sensitivity of outcomes to alternative assumptions.

7. *Identify risk management alternatives*: Identify potential strategies for managing the futures and the risks represented, considering consequences and likelihood.

8. *Develop a robust strategy*: Develop a robust overall strategy based on risk management that provides flexibility to manage different possible futures.

According to EPRI, in all the work that companies do in constructing emissions reductions targets and pathways, it is necessary to be aware of uncertainties. First, the scientific literature on climate scenarios contains multiple possible future scenarios, and companies may wish to define a range of 2050 CO_2 percentage reduction levels to reflect these different plausible pathways. Second, it is important to consider the design of climate policy where there are alternative emissions target levels within and across sectors, and reductions with and without coordination. Third, utilities might want to take into account risks and opportunities, such as lower vs. higher projected electricity load, lower vs. higher projected natural gas prices, and differences in technology cost and availability for renewables, carbon capture and storage, and nuclear.

2. Review of US Utilities' Existing Emission Reductions Protocols

2.1. Overview of review

Our study began by collecting a dataset on 29 US energy utilities that set targets for achieving lower carbon emissions by a particular date. (See Figure 4 for the locations.) While this dataset does not include all utilities with such targets, it does likely represent the majority of those with targets that state a specific percentage reduction in carbon emissions, compared to a baseline, by a future date. The 29 US utilities also represent a diversity of sizes, locations, and energy mixes in their generating portfolios (See Appendix 1 for a table of the 29 utilities, plus TEP, and their characteristics).

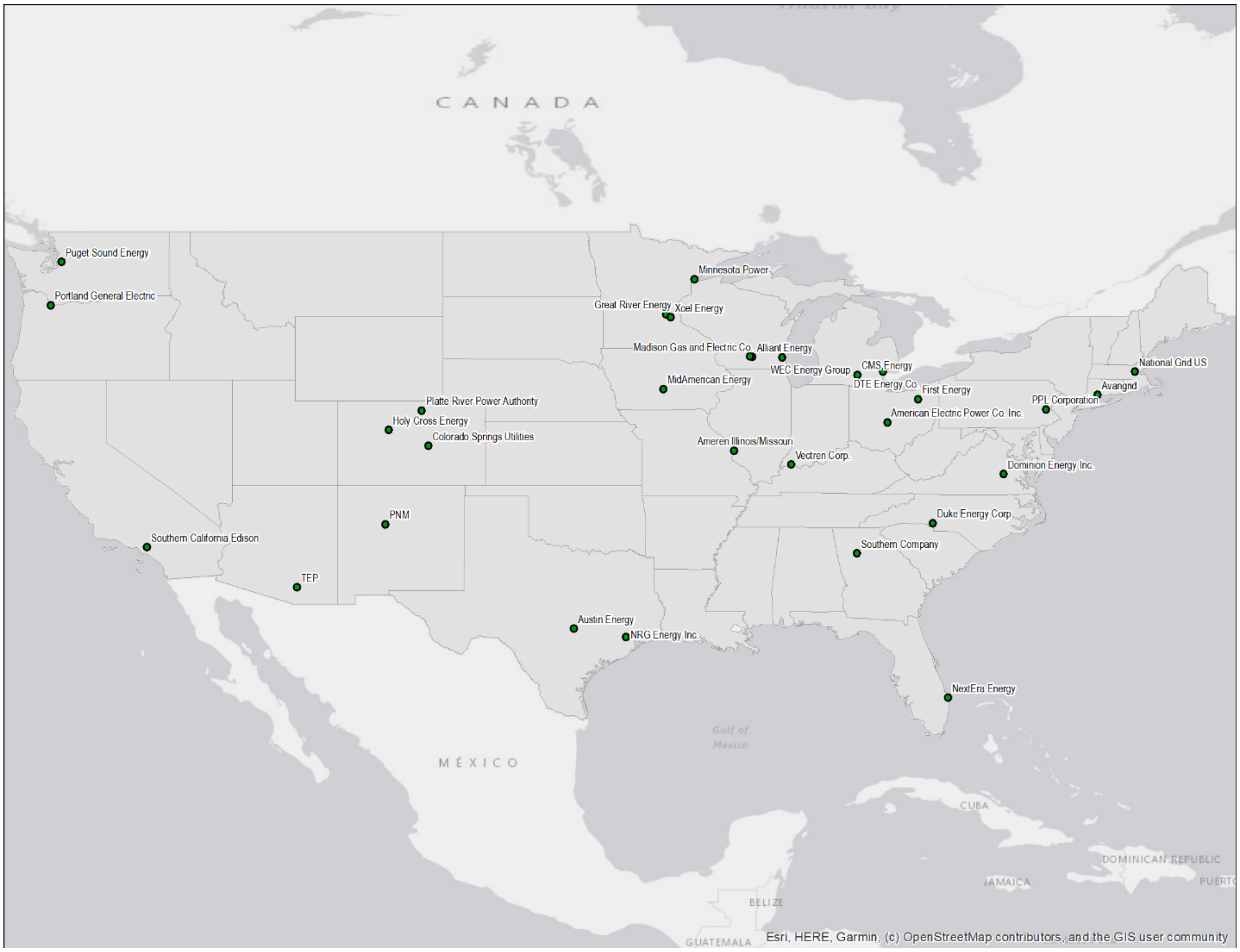

Figure 4. Map of the 29 utilities in the data set, plus TEP.

In the group of 29 utilities, we included five that instead of stating their emissions will be a particular percentage lower by a later date compared to a beginning date, instead target a particular share of their energy portfolios to be renewable by a future date, for example, that renewables will be 50% of their energy mix by 2030.

The difference between these two kinds of targets is significant because, of the five utilities with renewable portfolio targets, only one is investor-owned (MidAmerican Energy) and the others are either cooperatives or municipal utilities. This is in contrast to the 24 utilities with emissions targets more akin to the US's NDC formulation (80% fewer emissions compared to 2005 levels by 2050), of which 23 are investor-owned and only one is a cooperative (Holy Cross Energy, which also has a renewable energy goal). Among the 24 investor-owned utilities,[39] most have

[39] This includes MidAmerican Energy, which has a renewable portfolio target, and the 23 utilities with emissions targets.

their shares principally owned by institutional investors, such the Vanguard Group, SSgA Funds Management, and BlackRock Fund Advisors.

2.2. Summary of US utilities' reports on carbon emissions reduction targets and planning

Before we look in depth at the specific targets that US utilities have set for themselves, we will first examine the motivations and explanations for such goal setting as found in their company reports. (See Appendix 3 for links to the reports by each of the 29 utilities in our dataset on their targets and their wider environmental strategies.)

One reason that utilities have set targets is in response to government regulation. There are both state-level emissions reduction targets and state-level targets for renewables as a share of the energy mix, known as renewable portfolio standards (RPS). Twenty-nine states and the District of Columbia have an RPS.[40] There are also mandatory market-based programs, like the Regional Greenhouse Gas Initiative (RGGI), which was established as the first of its kind in the US in 2009. RGGI mandates compliance for utilities with fossil-fueled power plants 25MW and larger within ten states.[41] National Grid US is subject to RGGI and state-level RPS, but has also set the goal of exceeding these requirements in emissions reductions.

There are also market forces that are guiding utilities toward lower emissions. Pension funds, for example, have been asking utilities to accelerate their work in reducing carbon emissions. Investors in electric utilities, like the New York City Comptroller who controls retirement funds and leaders of the California Public Employees' Retirement System, have asked the US's twenty largest publicly traded electric generators for plans to be carbon-free by 2050.[42]

Additional market forces in the form of the declining cost of alternative energy sources also are driving utilities' long-term planning. According to Lazard's latest annual Levelized Cost of Energy Analysis, the declining cost of natural gas and utility-scale solar and wind has brought them "at or below the marginal cost of existing conventional [that is, coal and nuclear] generation technologies."[43] An example of this phenomenon is American Electric Power, which

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[40] US Energy Information Administration, "Updated Renewable Portfolio Standards Will Lead to More Renewable Electricity Generation," *Today in Energy* (blog), accessed June 10, 2019, https://www.eia.gov/todayinenergy/detail.php?id=38492#.

[41] Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont.

[42] "Big U.S. pension funds ask electric utilities for decarbonization plans", *Reuters*, February 28, 2019. https://www.reuters.com/article/us-usa-utilities-investors/big-u-s-pension-funds-ask-electric-utilities-for-decarbonization-plans-idUSKCN1QH27D

[43] Lazard, "Lazard's Levelized Cost of Energy Analysis, Version 12.0" (Lazard, 2018), https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf.

from 2000 to 2016 reduced its CO_2 emissions by 44%, in part because low natural gas prices resulted in less frequent operation of coal-fueled generating units.[44]

Finally, being seen as leaders in reducing carbon emissions can be an important part of a utility's branding. Avangrid, for example, positions itself as "a leading sustainable energy company," stating prominently in their emissions planning report that "Demand for clean energy solutions represents more than business opportunities; it is a driver of a potentially disruptive shift that requires us to act—right now—to remain at the vanguard of our industry."[45] In addition to Avangrid (with 80% wind generation), other utilities positioning themselves as leaders in renewable energy include MidAmerican Energy (60% wind), and NextEra Energy (80% renewable).

2.3. Emissions reductions targets

To help visualize the range of the emission reduction targets for the 29 utilities in our dataset, Figure 5 below represents the baseline date (the starting date for the line), the final target date (the endpoint of the line), and the percentage reduction target (the bolded percentage number aligned with the associated target date). Where there is both an intermediate and final target date, for example, National Grid, the first percentage is the intermediate date. (For simplicity, the starting and final target dates are rounded to the nearest year that is a multiple of five; for example, a baseline of 2001 is represented as a baseline of 2000.)

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[44] American Electric Power, "Strategic Vision for a Clean Energy Future 2018" (American Electric Power, 2018), https://www.aep.com/Assets/docs/AEP2018CleanEnergyFutureReport.pdf.

[45] Avangrid, "A New Generation of Energy: 2018 Sustainability Report". https://www.avangrid.com/wps/wcm/connect/4e0bd62b-a04c-4af1-a2fe-cddbc0930c59/SustainabilityReport_R11.pdf?MOD=AJPERES&CVID=mF5MHtx

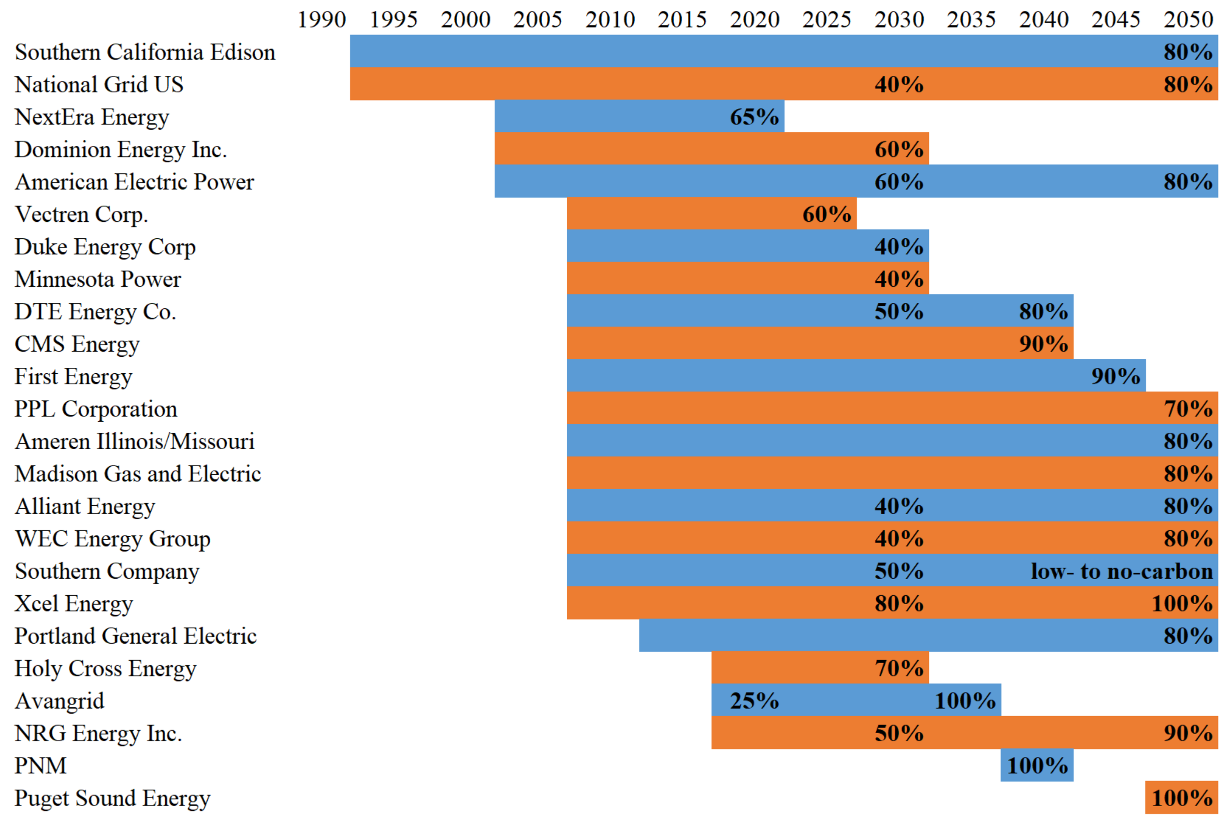

Figure 5. The 24 US utilities studied and their emissions reductions targets.

BASELINE. As we can see from Figure 5, among the 24 utilities there are eight distinct baseline years, from 1990 to 2015. Two years do not have a baseline because they aim for zero emissions by a particular end date.[46]

EMISSIONS REDUCTIONS PERCENTAGES. The 24 utilities have 10 distinct carbon reduction target amounts, from 40% to 100%, with 80% being the most common.[47] Nine of the 24 utilities have two targets: an intermediate and a final target.[48]

END DATE TARGET. The 24 utilities have eight distinct carbon reduction targets dates, from 2021 to 2050, with the latter date accounting for a little over half of the utilities' targets.[49]

HIGH DIVERSITY OF REDUCTIONS TARGETS. As we can see from Figure 5 above, there is considerable diversity across the targets. If we consider each unique combination of a baseline, a

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[46] 1900 (2), 2000 (2), 2001 (1), 2005 (11), 2007 (1), 2010 (2), 2014 (2), 2015 (1).

[47] 25% (1), 40% (5), 50% (3), 60% (3), 65% (1), 70% (2), 80% (10), 90% (3), 100% (4), "low- to-no-carbon" (1).

[48] The 2030/2050 pair occurs 6 times (out of the 9 total pairs of intermediate and final target dates).

[49] 2020 (1), 2021 (1), 2024 (1), 2030 (12), 2035 (1), 2040 (3), 2045 (1), 2050 (13).

reduction percentage, an intermediate date (if it exists), and a final date, there are 21 distinct targets. This means that only 3 utilities share targets, with each of (a), (b), and (c) occurring twice in the dataset. The duplicated targets are:

(a) 2005 baseline, 40% reduction by 2030;

(b) 2005 baseline, 40% reduction by 2030 and 80% reduction by 2050; and

(c) 2005 baseline, 80% reduction by 2050.

Note that these formulations are highly similar to each other. (And that (c) is the target that is the extension to the US's NDC.) We consider these three targets to be the core of the diverse dataset because they share fundamental elements with most of the other 24 utilities' targets: 80% is the most common reduction target; 54% of the utilities have 2005 as the baseline; 54% of the utilities have 2050 as the end date; and of those with intermediate dates, 89% of the utilities have 2030 as the intermediate date.

3. Typology of Utilities and Their Emission Reduction Targets

3.1. Overview

To categorize the diversity of the utilities we chose two variables—energy capacity and energy mix—to create a four-part typology (see Appendix 1 for the precise values of the variables). We chose these variables for two reasons. First, these variables are the characteristics that had the most variety across the utilities. Second, the variables center on two important characteristics of utilities that concern their emissions reduction pathways.

A utility's energy capacity, measured in MW, is a proxy for its size. As such, energy capacity is implicated in the scope and complexity of the transition toward lower carbon emissions. A smaller utility would have fewer changes to make within its system, although a larger one may have greater resources—including investments—to draw on to make these changes.

A utility's energy mix is the portfolio of resources that it draws on to generate energy. It is thus the starting point from which a utility will make reductions. One with a high coal mix, for example, will have more scope to reduce carbon emissions, as it tackles the low-hanging fruit first. But one that is very low in coal and high in renewables may find diminishing returns as it moves toward ever higher shares of renewables, though it may also have considerable expertise in renewable energy as well. In addition, a utility with access to renewables, such as hydropower and wind, will also find the transitions to renewable energy easier.

3.2. Utilities' energy capacity

The 24 utilities ranged in energy capacity from 300 MW (Madison Gas and Electric Company) to 49,500 MW (Duke Energy Corporation), with an average of 12,500 MW. We created two groups, "Small"[50] and "Large"[51] utilities, with the former set of 14 utilities being less than 10,000 MW, and the latter set of 10 utilities being greater than or equal to 10,000 MW. We chose this distinction so as to divide the utilities into two groups at the order of magnitude closest to the average size. The energy capacity data for this analysis was obtained from the utilities' reports listed in Appendix 3.

3.3. Utilities' energy mix

The 24 utilities have an average energy mix similar to the US average. Our set is a little higher in both coal and renewable and lower in nuclear than the US average. (See Table 2 below for a comparison of this dataset, the US average, and TEP. Also see Appendix 1 for the specific energy mix for each utility in our dataset). The energy mix data for this analysis was obtained from the utilities' reports listed in Appendix 3.

	Coal	Oil	Natural Gas	Nuclear	Hydro-electric	Renewable	Purchased	Other
Our Dataset	39%	2%	20%	10%	4%	20%	3%	2%
2018 Average	27%	0%	35%	19%	7%	12%	0%	0%
TEP	55%	0%	29%	0%	0%	8%	2%	5%

Table 2. Comparison of the energy mix of the average of the 24 utilities in this dataset, the 2018 US average, and TEP.

In order to further distinguish the 24 utilities by energy mix, we divided the utilities into a "Low-carbon" group,[52] consisting of the 13 utilities with less than 50% coal in their energy portfolio,

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[50] This includes: Alliant Energy, Avangrid, CMS Energy, First Energy, Holy Cross Energy, Madison Gas and Electric Co., Minnesota Power, PNM, Portland General Electric, PPL Corporation, Puget Sound Energy, Vectren Corp., WEC Energy Group, and Xcel Energy.
[51] This includes: American Electric Power Co. Inc., Ameren Illinois/Missouri, Dominion Energy Inc., DTE Energy Co., Duke Energy Corp, National Grid US, NextEra Energy, NRG Energy Inc., Southern California Edison, and Southern Company.
[52] This includes: Alliant Energy, Avangrid, CMS Energy, Dominion Energy Inc., Duke Energy Corp, National Grid US, NextEra Energy, NRG Energy Inc., Portland General Electric, Puget Sound Energy, Southern California Edison, Southern Company, and Xcel Energy.

and a "High-carbon" group,[53] consisting of the 11 utilities with greater than or equal to 50% coal in their energy portfolio. We chose to use coal as the sole variable to create the two groups because of the key role that it plays in carbon emissions. We did not include the share of renewables in constructing the two groups because there was not a clear connection between low coal and high renewables; some utilities had energy portfolios with both high coal and renewables, or both low coal and renewables.

3.4. Size/energy mix typology

The resulting typology based on size and energy mix divides the 24 utilities roughly equally across the 4 types. Large/High-carbon type is the least common (13%), and Small/High-carbon type is the most common (33%). TEP is a Small/High-carbon utility. (See Table 3 for the placement of each utility in the dataset within the four-part typology.)

	Small	Large
Low carbon	<u>25% of all utilities</u> Alliant Energy, Avangrid, CMS Energy, Portland General Electric, Puget Sound Energy, Xcel Energy	<u>29% of all utilities</u> Dominion Energy Inc., Duke Energy Corp, National Grid US, NextEra Energy, NRG Energy Inc., Southern California Edison, Southern Company
High carbon	<u>33% of all utilities</u> First Energy, Holy Cross Energy, Madison Gas and Electric Co., Minnesota Power, PNM, PPL Corporation, Vectren Corp., WEC Energy Group	<u>13% of all utilities</u> American Electric Power Co. Inc., Ameren Illinois/Missouri, DTE Energy Co.

Table 3. Four-part typology of utility size (energy capacity) and use of coal (energy mix).

[53] This includes: American Electric Power Co. Inc., Ameren Illinois/Missouri, DTE Energy Co., First Energy, Holy Cross Energy, Madison Gas and Electric Co., Minnesota Power, PNM, PPL Corporation, Vectren Corp., and WEC Energy Group.

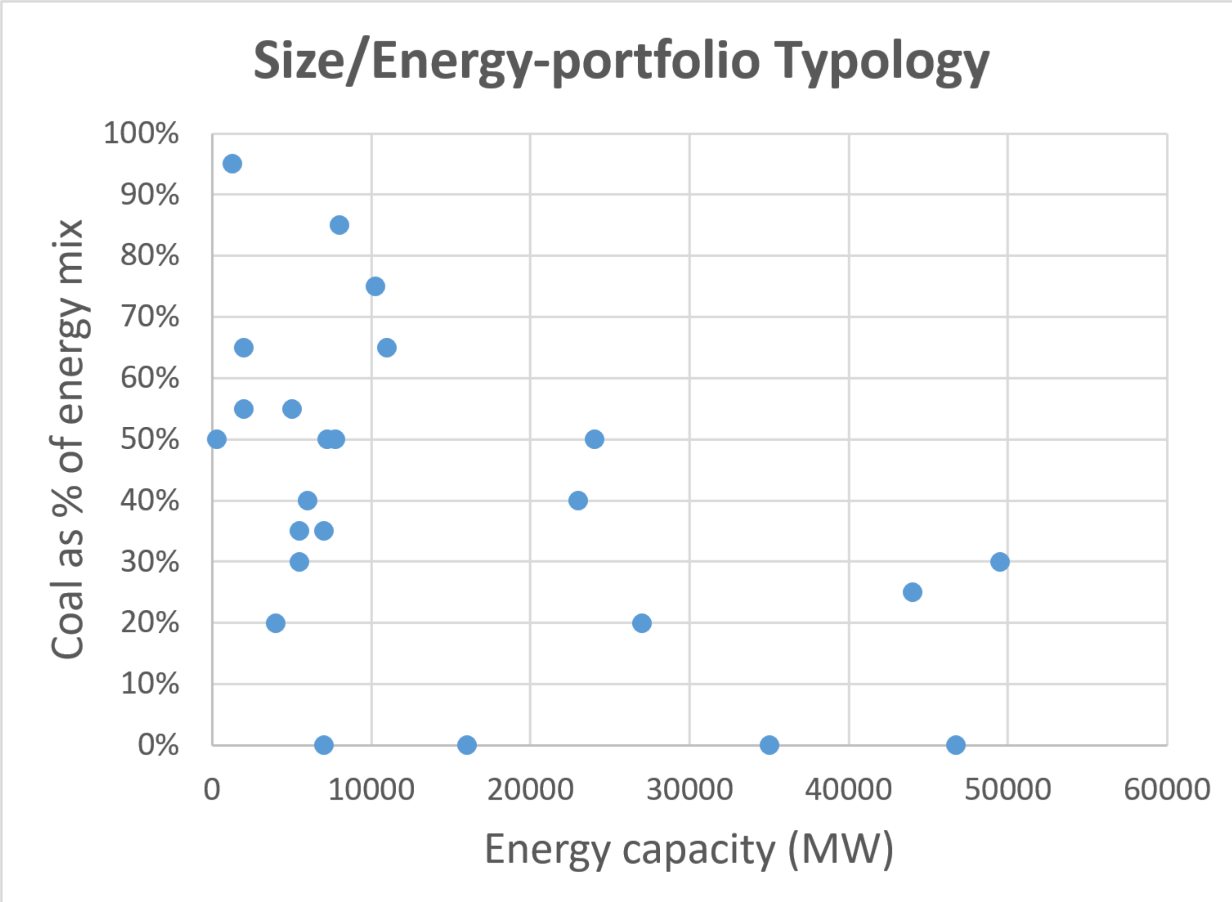

Figure 6. Scatterplot of the energy capacity and portfolio of each utility (represented as a point).

Figure 6 represents the distribution of the 29 utilities in our dataset as a scatterplot of our two variables: energy mix (represented as "coal as a % of energy mix") and energy capacity (in MW). Note that smaller utilities (below 10,000 MW) have a wider range of values of coal as a share of the energy mix compared to the larger utilities. Only three large utilities have half or more of their energy mix as coal, with only one of these three utilities being larger than 11,000 MW. Thus the level of targeted carbon reduction of large utilities, which is relatively low compared to smaller utilities, is to some degree based on already lower carbon emissions compared to smaller utilities.

3.5. Targeted level of carbon emissions reductions

The next step in the analysis was to divide the 24 utilities in the dataset according to their level of targeted carbon reductions. This allowed us to describe how typical the targeted levels of carbon reductions were among the four types of utilities. For example, what are the typical targets of the Small/Low-carbon utilities? Or, to compare TEP to its peer utilities, what are the typical targets of the Small/High-carbon group? In order to do this, though, the 24 emission reduction targets had to be assessed relative to each other.

DIFFICULTIES WITH STANDARDIZING. The great diversity of different baseline dates made it difficult to compare the targets, especially absent data about utilities' past emissions. We could have chosen a standard baseline, for example 2005, then converted all the percentage reductions to this baseline. But this would have required knowing the emissions for the original baseline to be converted -- for example 1990, and the emissions for the standard baseline, 2005.[54] Only then could we have translated, say, Southern California Edison's target of 80% reductions under 1990 emissions by 2050 to, say, Madison Gas and Electric's target of 80% reductions under 2005 emissions by 2050. The former is likely a higher reduction target because presumably Southern California Edison's emissions were smaller in 1990 than in 2005. But what higher percentage reduction is its target when we convert it to the 2005 baseline? Is it equivalent to reducing emissions by 98% by 2050 compared to their 2005 baseline? (This would be correct if their 2005 emissions were 10 times greater than their 1990 emissions). Additional conversions would also have been needed for different end date targets, for example 2030 instead of 2050.

There is also the subtler problem of comparing the degree of reductions for two utilities that share the same target, for example Madison Gas and Electric Company and Ameren, which share a target of 80% reductions from 2005 emissions by 2050. Madison is the smallest utility in our dataset at 300 MW and Ameren is a medium-sized utility. If Ameren has grown considerably more than Madison has since 2005, the size of its required cuts will be proportionally more, and thus Ameren has set itself a higher carbon reduction target, even though its target formulation is the same as Madison's. In addition, there are other factors that differ across utilities that may be considered when comparing two targets, including a utility's contractual and financial make-up of existing resources, its access to low-cost renewable resources, and the rate impacts associated with lower-carbon energy.

For all these reasons, there is considerable opacity in framing reduction targets in the common form of baseline, target year, and percentage reduction. The alterative formulation of setting a target for percentage of the energy mix consisting of renewable or zero-carbon resources is easier to compare, and may be easier to understand; however, it misses the key element of pledging absolute reductions on emissions.

THREE CATEGORIES OF TARGETED LEVELS OF CARBON REDUCTION. In creating these three target categories, we used the three variables: baseline, percentage reduction, and target end date. All

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[54] The converted percentage reduction = 1 – ("emissions at non-standard baseline"/"emissions at standard baseline") * (1 – % reduction). For example, using the example in the text, the converted percent reduction = 1 – ("1990 emissions"/"2005 emissions"*0.2).

things being equal, we rated targets as being at a higher level if they had earlier baselines, higher percentage reductions, and earlier end dates. The resulting groups of low, medium, and high targeted levels of carbon reduction were based on some subjective decisions, as the standardization difficulties described above precluded a formula or algorithm.

The nine utilities in the Low target group[55] had, compared to the other two groups, both relatively late target dates (2050) with middling percentage reductions, or they had a relatively early target date (2030) paired with a relatively low percentage reduction (40%).

Significantly, all the targets that occur more than once, including the formulation of "80% reductions under 2005 emissions by 2050" were rated as Low. This is because compared to the targets in the other two groups, for each equivalent baseline, the target date and/or percentage reduction were earlier or higher, respectively. For example, utilities would alternatively use a 2005 baseline aiming for an 80% reduction by 2040, or a 90% reduction by 2050.

The nine utilities in the Medium target group[56] were defined in relation to the Low and High target groups.

The six utilities in the High target group[57] had targets that aimed for either 90% or 100% reduction no later than 2050.

PATTERNS IN TARGET LEVELS. All of the High target utilities were classified as small (forming 58% of the total). And 67% of High target utilities were of the Small/Low-carbon type, even though this represents only 25% of the total utilities. The Low and Medium target utilities have mixed results without a clear pattern. (See Table 4 for the distribution of target levels for each of the four types of utilities.)

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[55] This includes: Alliant Energy, Ameren Illinois/Missouri, Duke Energy Corp., Holy Cross Energy, Madison Gas and Electric Co., Minnesota Power, NRG Energy Inc., Portland General Electric, PPL Corporation, Southern Company, and WEC Energy Group.
[56] This includes: American Electric Power Co. Inc., Dominion Energy Inc., DTE Energy Co., National Grid US, NextEra Energy, Southern California Edison, and Vectren Corp.
[57] This includes: Avangrid, CMS Energy, First Energy, PNM, Puget Sound Energy, and Xcel Energy.

	Small	Large
Low carbon	33% Low target level Alliant Energy, Portland General Electric 0% Medium target level 67% High target level Avangrid, CMS Energy, Puget Sound Energy, Xcel Energy	43% Low target level Duke Energy Corp, NRG Energy Inc., Southern Company 57% Medium target level Dominion Energy Inc., National Grid US, NextEra Energy, Southern California Edison 0% High target level
High carbon	63% Low target level Holy Cross Energy, Madison Gas and Electric Co., Minnesota Power, PPL Corporation, WEC Energy Group 13% Medium target level Vectren Corp. 25% High target level First Energy, PNM	33% Low target level Ameren Illinois/Missouri 67% Medium target level American Electric Power Co. Inc., DTE Energy Co. 0% High target level

Table 4. The proportion of target levels among the 4 types of utilities.

4. Science Priority Targets for Further Inquiry

In considering which science-based GHG emission reduction targets should be adopted, we propose the four following questions to help TEP situate itself in the landscape of US utilities and the diverse targets.

4.1. What are the common emission reduction targets?

Among the utilities that are investor-owned, reduction targets are commonly formulated as a certain percentage reduction below a baseline before an end date. This is in contrast to municipal and cooperative utilities, which tend to have goals for minimum renewable energy shares of their portfolios.

There is great diversity of reductions targets across the US utility landscape making comparisons difficult. Particular baselines may be chosen so as to predate the closure of a coal plant, for example, or an emissions reduction target may be chosen so it has a catchy form, as Holy Cross energy calls its target “seventy70thirty”, aiming for 70% reduced emissions, and 70%

renewables, by 2030. Despite the great diversity, though, the anchor among all the targets is the formulation of “80% reductions under 2005 emissions by 2050”.

4.2. What are the highest targeted levels of carbon reduction?

It is important to recognize, however, that this anchor formulation -- “80% reductions under 2005 emissions by 2050” -- is within the Low target group. Despite this, it is common for utilities to take elements of this formulation and create a target that places them in the Medium and High target groups. One-third of the utilities in our dataset used the formulation but changed just one element, for example, making the baseline 1990, the end target date 2040, or the percentage reduction 90%. This allows one to readily compare the target to other utilities, a task that we saw was difficult with many targets.

4.3. What kind of utilities have the highest targeted levels of carbon reduction?

The larger and more high-carbon utilities tend to be in the Low target group, though the targets’ exact formulations varied across the utilities. The most pronounced pattern among the utilities is that small utilities with low-carbon portfolios tend to be in the High target group. (See Table 5 for the correspondence of the reduction targets’ level with the 4 utility types.)

	Small/Low-Carbon	Small/High-Carbon	Large/Low-Carbon	Large/High-Carbon
Low Target Level	-Alliant Energy -Portland General Electric	-Holy Cross Energy -Madison Gas and Electric Co. -Minnesota Power -PPL Corp. -WEC Energy Group	-Duke Energy -NRG Energy -Southern Company	-Ameren Illinois/Missouri
Medium Target Level		-Vectren Corp.	-Dominion Energy Inc. -National Grid -NextEra Energy -Southern California Edison	-American Electric Power -DTE Energy
High Target Level	-Avangrid -CMS Energy -Puget Sound Energy -Xcel Energy	-First Energy -PNM		

Table 5. Correspondence of level of reduction targets with the 4 utility types: Small/Low-Carbon, Small/High-Carbon, Large/Low-Carbon, and Large/High-Carbon.

4.4. How does TEP compare to other US utilities with reduction targets?

We classify TEP as a Small/High-carbon utility, which has the greatest proportion of Low targets among its members: 50% of the targets are Low target, compared to 43% for Large/Low-Carbon, 33% for Large/High-Carbon, and 20% for Small/Low-carbon.

In contrast, TEP has the opportunity to set both a high targeted level of carbon reduction and an easily comparable target. For example, TEP could set a target with a 2005 baseline—which recognizes the industry norm—but that also sets a higher percentage goal than 80% reductions and/or sets a date earlier than 2050. This would have the effect of creating a transparent target.

Appendix 1: Table of US utilities with carbon emissions targets, and their characteristics

Utility name	Headquarters	Baseline	Emissions reduction (final %)	Emissions target date (final)	Non-carbon emissions target	Utility ownership	Capacity (MW)	Energy portfolio
Alliant Energy	Madison, Wisconsin	2005	80%	2050	Renewables 30% of energy mix (2030) Eliminate all coal from energy mix (2050)	Investor-owned	5,500	2017 Portfolio: Coal 33% Renewable 16% Natural Gas 44% Oil 1% Nuclear 6%
Ameren Illinois/Missouri	St. Louis, Missouri	2005	80%	2050	N/A	Investor-owned	10,250	2017 Portfolio: Coal 75% Renewable 4% Natural Gas 1% Nuclear 20%
American Electric Power Co. Inc.	Columbus, Ohio	2000	80%	2050	N/A	Investor-owned	24,000	2017 Portfolio: Coal 47% Renewable (hydro, wind, solar) 13% Natural Gas 27% Nuclear 7% Other 6%
Austin Energy	Austin, Texas	N/A	N/A	N/A	Renewables 55% of energy mix (2025) Renewables 65% of energy mix (2027)	Cooperative	3,000	2017 Portfolio: Coal 28.2% Renewable 36.4% Natural Gas & Oil 12.9% Nuclear 23.5%
Avangrid	Orange, Connecticut	2015	100%	2035	N/A	Investor-owned	7,000	2017 Portfolio: Wind 80% Natural Gas 11% Cogeneration 9%

CMS Energy	Jackson, Michigan	2005	90%	2040	Eliminate all coal from energy mix (2040) Renewables 40% of energy mix (2040)	Investor-owned	5,500	2017 Portfolio: Coal 29% Renewable 9% Natural Gas 30% Nuclear 19% Other 13%
Colorado Springs Utilities	Colorado Springs, Colorado	N/A	N/A	N/A	Renewables 20% of energy mix (2020)	Municipal utility	1,000	2017 Portfolio: Coal 51% Solar 1% Natural Gas 31% Mixed market purchases % Hydro 10%
Dominion Energy Inc.	Richmond, Virginia	2000	60%	2030	N/A	Investor-owned	27,000	2017 Portfolio: Coal 18% Renewable 2% Natural Gas 32% NUGs contracted 5% Purchased power 10% Nuclear 33%
DTE Energy Co.	Detroit, Michigan	2005	80%	2040	N/A	Investor-owned	11,000	2018 Portfolio: Coal 65% Nuclear 17% Natural Gas 7% Renewables 9% Hydro 2%

Duke Energy Corp	Charlotte, North Carolina	2005	40%	2030	N/A	Investor-owned	49,500	2018 Portfolio: Coal/Oil 31% Renewable (Hydro, wind, solar) 5% Natural Gas 32% Nuclear 32%
First Energy	Akron, Ohio	2005	90%	2045	N/A	Investor-owned	5,000	2018 portfolio Coal 55% Nuclear 24% Gas/Oil 9% Renewable 11%
Great River Energy	Maple Grove, Minnesota	N/A	N/A	N/A	Renewables 50% of energy mix (2030)	Cooperative	3,500	2017 portfolio Beneficiated lignite: 50% Renewable: 25% Market: 15% Hydro: 10% Natural Gas: 1%
Holy Cross Energy	Glenwood Springs, Colorado	2014	70%	2030	Renewables 70% of energy mix (2030)	Cooperative	2,000	2017 portfolio Coal: 53% Clean/Renewable: 39% Market: 2% Natural Gas: 6%
Madison Gas and Electric Co.	Madison, Wisconsin	2005	80%	2050	Renewables 30% of energy mix (2030)	Investor-owned	300	2016 portfolio Coal: 48% Purchased power: 21% Gas/Oil: 19% Renewable: 12%

MidAmerican Energy	Des Moines, Iowa	N/A	N/A	N/A	Renewables 100% of energy mix (2020)	Investor-owned	9,750	2018 portfolio: Wind: 59% Coal: 24% Nuclear/Other: 4% Natural Gas: 13%
Minnesota Power	Duluth, Minnesota	2005	40%	2030	N/A	Investor-owned	2,000	2018 Portfolio: Coal 64% Renewables 27% Contract Purchases 9%
National Grid US	Waltham, Massachusett s	1990	80%	2050	N/A	Investor-owned	35,000	2018 Portfolio: Nuclear 28% Hydro 14% Gas 24% Oil 13% Coal 1% Renewable 20%
NextEra Energy	Juno Beach, Florida	2001	65%	2021	N/A	Investor-owned	46,750	2017 portfolio: Wind: 69% Nuclear: 14% Solar: 11% Oil: 4% Natural Gas: 2%
NRG Energy Inc.	Houston, Texas	2014	90%	2050	N/A	Investor-owned	23,000	2018 Portfolio: Coal 41% Renewable 2% Natural Gas 51% Nuclear 6%

Platte River Power Authority	Fort Collins, C	N/A	N/A	N/A	Renewables 100% of energy mix (2030)	Cooperative	1,000	2018 portfolio Coal: 62% Hydro: 19% Purchased power: 5% Wind: 11% Natural Gas: 1% Solar: 2%
PNM	Albuquerque, 1	N/A	100%	2040	N/A	Investor-owned	7,750	2017 Portfolio: Coal 17% Wind and solar 8% Natural Gas 38% Other 6% Hydro 32%
Portland General Electric	Portland, Oregon	2010	80%	2050	N/A	Investor-owned	4,000	2016 Portfolio: Coal 50.6% Wind 6.4% Natural Gas 11.1% Solar 2.3% Nuclear 29.5% Geothermal 0.1%
PPL Corporation	Allentown, Pennsylvania	2010	70%	2050	N/A	Investor-owned	8,000	2017 Portfolio: Coal 85% Renewable (hydro and solar) 1% Natural Gas 14%

Puget Sound Energy	Bellevue, Washington	N/A	100%	2050	N/A	Investor-owned	6,000	2017 Portfolio: Coal 38% Wind 6% Natural Gas 21% Other 1% Nuclear 1% Hydro 33%
Southern California Edison	Rosemead, California	1990	80%	2050	N/A	Investor-owned	16,000	2017 Portfolio: Unspecified (market bought) 34% Wind 10% Natural Gas 20% Biomass and waster 8% Solar 13% Nuclear 6% Hydro 9%
Southern Company	Atlanta, Georgia	2007	low- to-no-carbon	2050	N/A	Investor-owned	44,000	2018 Portfolio: Coal 27% Renewable/Other 11% Natural Gas 47% Nuclear 15%
TEP	Tucson, Arizona	N/A	N/A	N/A	N/A	Investor-owned	3,000	2019 Portfolio: Coal 55% Natural Gas 29% Market Purchases 2% Utility Scale Renewable Resources 8% Distributed Generation 5%

Vectren Corp.	Evansville, Indiana	2005	60%	2024	N/A	Investor-owned	1,250	2017 Portfolio: Coal 95% Wind 4% Natural Gas 1%
WEC Energy Group	Milwaukee, Wisonconsin	2005	80%	2050	N/A	Investor-owned	7,250	2018 Portfolio: Coal 48% Renewable/Natural Gas 52%
Xcel Energy	Minneapolis, Minnesota	2005	100%	2050	N/A	Investor-owned	7,000	2017 Portfolio: Coal 37% Solar 2% Biomass 1% Natural Gas 23% Wind 21% Nuclear 13% Hydro 3%

Appendix 2: Conclusions and Recommendations from SBTi's Target Setting Manual

Science-Based Target Setting Manual - Version 4.0, pp. 6-7.

Conclusions and Recommendations

SBTs offer a number of strategic advantages

SBTs are more effective than incremental emissions reduction targets at:

- Building business resilience and increasing competitiveness.
- Driving innovation and transforming business practices.
- Building credibility and reputation.
- Influencing and preparing for shifts in public policy.

SBT-setting methods are complex and should be considered in the context of each company's operations and value chains

- Generally, science-based target setting methods have three components: a carbon budget (defining the overall amount of GHGs that can be emitted to limit warming to1.5°C and well-below 2°C), an emissions scenario (defining the magnitude and timing of emissions reductions) and an allocation approach (defining how the carbon budget is allocated to individual companies).
- Three methods are currently available that are applicable to multiple sectors.
- Companies should choose the method and target that drives the greatest emissions reductions to demonstrate sector leadership.
- To calculate SBTs, companies should use a method that is based either on sector-specific decarbonization pathways (i.e., the Sectoral Decarbonization Approach) or on a percentage reduction in absolute emissions.
- Intensity targets may be set for scope 1 and 2 sources. However, an intensity target should only be set if it leads to absolute reductions in line with climate science or is modeled using a sector-specific decarbonization pathway that assures emissions reductions for the sector

To ensure their rigor and credibility, SBTs should meet a range of criteria.

Most importantly:

- An SBT should cover a minimum of 5 years and a maximum of 15 years from the date the target is publicly announced. Companies are also encouraged to develop long-term targets (e.g., up to 2050).
- The boundaries of a company's SBT should align with those of its GHG inventory.

- The emissions reductions from scope 1 and 2 sources should be aligned with well-below 2°C or 1.5°C decarbonization pathways
- SBTs should cover at least 95 percent of company-wide scope 1 and 2 emissions.
- Companies should use a single, specified scope 2 accounting approach ("location-based" or "market-based") for setting and tracking progress toward an SBT.
- If a company has significant scope 3 emissions (over 40% of total scope 1, 2 and 3emissions), it should set a scope 3 target
- Scope 3 targets generally need not be science-based, but should be ambitious, measurable and clearly demonstrate how a company is addressing the main sources of value chain GHG emissions in line with current best practice.
- The scope 3 target boundary should include the majority of value chain emissions; for example, the top three emissions source categories or two-thirds of total scope 3emissions.2
- The nature of a scope 3 target will vary depending on the emissions source category concerned, the influence a company has over its value chain partners and the quality of data available from those partners.
- SBTs should be periodically updated to reflect significant changes that would otherwise compromise their relevance and consistency.
- Offsets and avoided emissions should not count toward SBTs.

Getting internal stakeholders on board through all stages of the target-setting process requires careful planning

- Staff responsible for setting an SBT should partner closely with all levels of the company during the target-setting process to socialize goals, assess feasibility and co-create practical implementation plans.
- Staff should anticipate the issues that commonly create internal push-back and formulate ready-made responses.
- For scope 3 targets, companies should work closely with and support suppliers during the target-setting process to increase buy-in and enable implementation.

Appendix 3: List of US utilities' most recent carbon emission reduction reports, with links

Alliant Energy	Energy Vision
Ameren	Building a Cleaner Energy Future
American Electric Power	Strategic Vision for a Clean Energy Future 2018
Austin Energy	Resource, Generation and Climate Protection Plan to 2027
Avangrid	A New Generation of Energy: 2018 Sustainability Report
CMS Energy	2018 Sustainability Report
Colorado Springs Utilities	2017 Environmental Report
Dominion Energy Inc.	Working Toward a Sustainable Future
DTE Energy Co.	Clean, Reliable Solutions to Power Michigan's Future
Duke Energy Corp	Transforming the Future
First Energy	Energy for a Brighter Future
Great River Energy	50% by 2030 Renewable Energy Fact Sheet
Holy Cross Energy	CO2 Emission Report
Madison Gas and Electric Co.	Environmental and Sustainability Report 2018
MidAmerican Energy	100% Renewable Energy Vision
Minnesota Power	Discover how we are moving EnergyForward
National Grid US	Clean Energy, Efficiency, and Electrification: National Grid's Northeast 80x50 Pathway
NextEra Energy	Corporate Responsibility Executive Digest
NRG Energy Inc.	2018 Sustainability Report
Platte River Power Authority	2018 Strategic Plan
Portland General Electric	2017 Sustainability Report
PNM	Our Sustainability Mission

PPL Corporation	PPL Corporation Climate Assessment: Assessing the Long-term Impact of Climate Policies on PPL
Puget Sound Energy	2018 Integrated Resource Plan
Southern California Edison	2017 Sustainability Report
Southern Company	Planning for a Low-Carbon Future
Vectren Corp.	Next Generation Sustainability
WEC Energy Group	Pathway to a Cleaner Energy Future
Xcel Energy	Building a Carbon-free Future