Decarbonizing Electricity in the United States: A Review of Goals and Effectiveness

Decarbonizing Electricity in the United States: A Review of Goals and Effectiveness

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Abstract

In 2022 alone, U.S. reliance on natural gas to meet peak demand electrical generation needs prevented the global use of fossil fuels to decrease, clearly signifying the link between the country's energy dependence on fossil fuels and the global emissions profile (CO_2 emissions in 2022, 2023).

The United States has committed to decarbonizing as part of the Paris Accords, stating that by 2030 the United States will reduce total economy CO_2e emissions 50-52% below 2005 levels, and by 2035 will have a 100% carbon pollution free electrical grid (President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target, 2021). It is unclear how these goals will be met. There is no public tracking to demonstrate where the United States is on its decarbonization journey, and no public pathway to delineate how the administration intends to move the needle. A confounding factor is that power generation companies have set their own decarbonization targets that may not align with federal targets.

The research focused on power companies in the United States with publicly stated decarbonization goals as well as those states that have set goals. I hypothesized that the United States will not reach its stated goals based on current trends, and power generation companies collectively have not divested from emissions intense operations to reach their own decarbonization goals. I also hypothesized that the western United States is decarbonizing faster than other regions. Leveraging data from self-published company reports sources as well as the EPA and EIA, I analyzed how the rate of decarbonization, both for a single company and then for the cohort of identified companies, as well as a

single state, moved across the ten-year period. The average rate of decarbonization was applied to forecast the electric emissions for the United States through 2035 to determine if the 100% carbon pollution free electrical grid goal can be attained. A secondary analysis to determine if particular regions and types of companies are decarbonizing faster was also completed.

The analysis of the U.S. electric consumption related emissions over the last ten years revealed that after the NDCs were published, emissions continued to increase. Power generation company emissions are volatile, and reflect that actions taken may not be enough to meet stated goals. Similarly, state emission trends over the 2012-2022 period for states with emission reduction goals and states without emission reduction goals are not statistically different.

This research demonstrated that while setting goals is a good first step to decarbonizing electricity, there must be intentional and immediate next steps to ensure those goals are met and decarbonization actions are taken. In a country as large and complex as the United States it is not enough to set a goal without interim targets or mandatory requirements for the sectors that contribute most to emission outputs. Leaders must set subsequent policies in place with appropriate administrative support to ensure that policies can be enacted on time.

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Introduction

Electricity is the lifeblood of the industrialized world, lighting up the smallest provinces to the largest cities and powering all types of connections. Despite being a driving force behind complex industrialization to this point, electrical generation is a process that has not significantly changed since its discovery. The difference between now and when electricity was first discovered is that now electricity is used to power millions of homes and businesses rather than the odd street lamp or small community, requiring careful management and planning of resources.

Now, with electricity powering every day activities of all kinds across the globe, there is an urgency for countries to transition energy sources from more carbon dioxide emissions intense sources to those that do not generate any emissions. An undertaking of this size and breadth requires intentional goal-setting and planning, and clear, regular communication to all involved on status of those goals, including regular citizens.

The US has committed to decarbonizing as part of the Paris Accords, stating that by 2030 the US will reduce total economy CO_2e emissions 50-52% below 2005 levels, and by 2035 the US will have a 100% carbon pollution free electrical grid (President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target, 2021). It is unclear how the US will meet these goals. There is no public tracking to demonstrate where the US is on its decarbonization journey, and no public pathway to delineate how the administration intends to move the needle.

Research Significance and Objectives

My research examined the current state of electricity generation in the United States and how it has shifted over the last 10 years of available emissions data. It also outlined how electricity generation is managed at a high level, and how that impacts decarbonization efforts at the company, state and federal levels. Lastly, my research modeled how effective decarbonization goals are in the United States, both at the federal and state levels, and how the country is tracking against its decarbonization goals based on historical rates of decarbonization and future industry models based on announced closures of high intensity carbon emitting power plants. From this modeling and comprehensive timeline, trends by region and company type were identified to better inform policy makers and other key stakeholders on how to realign planning actions to meet the stated decarbonization goals.

My research objectives were to:

- Describe the current state of electrical generation in the United States and trends in energy sources over the last 10 years
- Analyze publicly stated decarbonization targets by power generation companies, individual states and the United States, and calculate their decarbonization rate over time based on their decarbonization goals and annual reported CO_2 or CO_2e emissions
- Evaluate if actions taken by power companies, individual states and the United States are significant enough to meet their stated targets or decarbonization goals, assessing rates of decarbonization and industry models

- Identify challenges of decarbonization on a national scale based on these analyses, and identify potential thresholds or interim goals for consideration to meet publicly stated goals and timelines nationally

Background

The most famous form of electricity is lightning: dangerous, erratic, and unpredictable. The same three words can describe modern life across the globe when electricity lapses. All aspects of life in post-Industrial Revolution societies are inextricably dependent on electricity. As technology evolves, life in industrialized societies is increasingly tied to a continuous and dependable, predictable stream of electricity. Transportation, the internet, heating and cooling sources, light, nearly all forms of communication, the list of electricity dependent systems consistently grows. Despite the evolution of technology over time, electricity generation and transmission in the US has happened the same way for over 100 years (Lazar, 2016).

Electrical Generation and Transmission in the United States

To understand decarbonization, one has to understand electrical generation and transmission first. There are three major steps to get electricity from the point of production to the usage point (a home or business), as visualized in Figure 1 (Lazar, 2016). The first step is generation. At a high level, generation is the combustion or consumption of a fuel, whether that be a fossil or renewable fuel source (Lazar, 2016). Once that fuel is consumed, the electricity is transported through a series of step up (increase in voltage) transformers to high voltage power lines, where it is then pushed through a step down (decrease in voltage) transformer to be distributed (Lazar, 2016).

Once the voltage is decreased, the energy is distributed to the user through their grid connection. For users with on-site generation (e.g., a home with a solar panel) the set-up can vary, but often involves a converter that changes the energy generated from direct-current to alternating-current energy, which is used in residential and in commercial facilities (US Department of Energy, 2020). Again, at a high level, the technology behind energy generation, transmission and distribution system in the United States has not meaningfully changed in many years (Lazar, 2016).

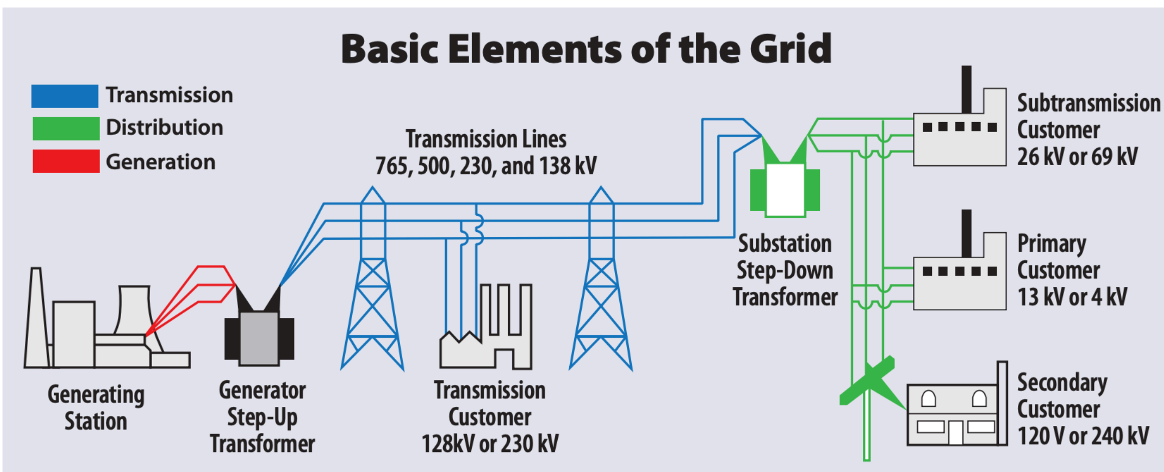

Figure 1. Electricity distribution elements (Lazar, 2016).

Current State of Electricity Generation in the United States

There are roughly 3,000 utilities in the United States, with the majority of consumers paying for electricity through one of the 189 investor-owned utilities (Bakke, 2017; Lazar, 2016). These utilities are part of the three main power grids in the lower 48 states: The Eastern Interconnection, The Western Interconnection and the Electric Reliability Council of Texas (How electricity is delivered to consumers, 2019; Willrich, 2017). In a global world, the US power grid remains state-centric and segmented (Willrich, 2017). Not only is transmission segmented into states but in many areas power transmission is managed by for-profit companies, adding a layer of complexity and conflicting obligations to the management of power distribution and reliance planning.

Power generation companies take various forms, and power is a sector that changes often and quickly. Seventy-five percent of customers in the United States are serviced by power companies that are investor owned, are considered 'large' companies, and often have many fuel sources in their portfolio (e.g., Dominion, Duke, Entergy, Southern Energy, NRG) (Lazar, 2016). The remaining 25% of U.S. energy customers are serviced by municipality owned utilities, non-profit and privately managed co-ops or public utility districts (Lazar, 2016). Electricity is a dynamic industry and companies have taken many forms. In the past, many companies have been what is termed a 'vertically integrated' utility, meaning the company (or co-op, or other service provider) owns the power plant that generates the electricity in addition to the power lines, and manages the entire process (e.g., Exelon prior to the sale of Constellation in 2022) (Lazar, 2016; *About Constellation*, 2024). There are still a number of vertically integrated utilities present, but there are also 'distribution only' utilities, that have sold their generation business units and are solely responsible for the transmission and distribution of electricity (e.g., Consolidated Edison in New York state) (Lazar, 2016; *Managing our Emissions*, 2022).

In 2022, the predominant fuel source for electrical generation in the United States was natural gas, followed by coal and then nuclear, with renewables (excluding hydroelectric and solar) slotting in as the fourth largest energy source (Figure 2) (Total

Electric Power Industry Summary Statistics, 2022 and 2021, 2023). Coal is at about half its use in 2022 compared to 2013, while natural gas has fluctuated over that time, with year over year change rates ranging from -6% to 15% (Total Electric Power Industry Summary Statistics, 2022 and 2021, 2023). Meanwhile, solar has increased steadily over that time, increasing 94% from 2013-2022, and other renewables (wind) have increased 54% over that same time period (Total Electric Power Industry Summary Statistics, 2022 and 2021, 2023). Sources for energy production in the US have changed dramatically in the last 10 years, and will continue to shift as decarbonization of electricity accelerates.

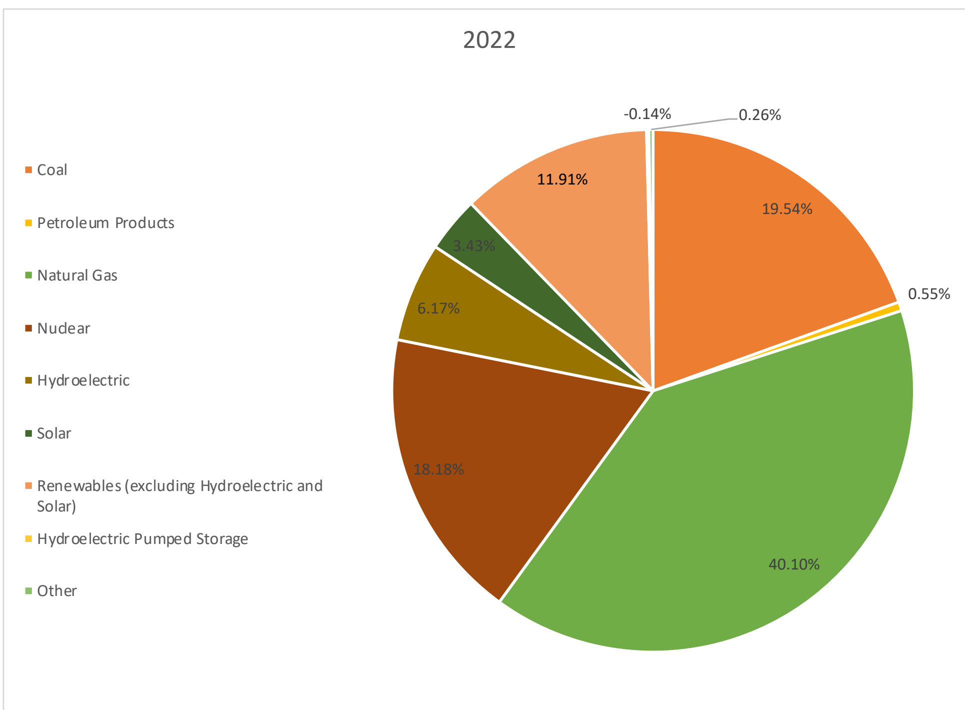

Figure 2. Fuel source breakdown in the US in 2022 (Total Electric Power Industry Summary Statistics, 2022 and 2021, 2023).

In addition to the segmented nature of the grid, electricity is generally produced and consumed simultaneously (unless battery storage is involved), which requires careful management. To complicate things further, power generation and distribution in the US sits at the intersection of many regulatory and management agencies. Several types of these agencies with their regulatory roles are listed and briefly described below (Lazar, 2016; Shen et al., 2021):

- Electric Cooperative (Co-op) – local; non-profit, consumer-owned electric cooperatives service primarily serving rural communities in the US
- Environmental Protection Agency (EPA) – federal; can be promulgated to the state level; sets environmental regulations that affect power generation operations and facility siting
- Federal Energy Regulatory Commission (FERC) – federal; regulates interstate transmission and distribution services
- Independent System Operators (ISOs) – regional; manages a reliability planning area under guidance of NERC
- North America Electric Reliability Council (NERC) – multinational (Canada, Mexico, US); manages the eight reliability planning areas in the three nations and oversight of flow of power in those areas
- Public Utility Commission (PUC) – state; manages investor-owned utilities in a region (usually a state); charged with assuring that utilities provide reasonable, adequate and efficient service to customers at just and reasonable prices
- Regional Transmission Organizations (RTOs) – regional; manages a reliability planning area under guidance of NERC
- US Securities & Exchange Commission (SEC) – federal; enforces regulations to prevent market manipulation

Planning, Resilience and Reliance

As described above, management of the electrical ecosystem in the US is segmented into several groups, and is a variable that can affect decarbonization. The RTOs and ISOs in North America cover approximately two thirds of the region (ISO RTO Council, 2023). The areas that are not covered by an ISO or RTO are generally served by a cooperative (ISO RTO Council, 2023). These organizations are responsible for a variety of tasks for their region, including planning and resilience.

FERC regulations stipulate that NERC is the not-for-profit responsible for managing guidance and rules around grid reliability (Federal Energy Regulatory Commission, 2016). Reliability is the term that encompasses and describes (at a high level) how organizations that manage electrical generation and transmission ensure that the electricity is "on" when a customer turns on their light switch. NERC maintains 117 separate standards as part of its reliability management program, demonstrating its complexity, despite how simple it may sound (Federal Energy Regulatory Commission, 2016). These standards encompass topics like balancing the load of energy (energy being generated and transmitted through the grid), communications, facility design and maintenance, personnel training and management, and infrastructure and interconnection (facility to grid connection) management and maintenance (Federal Energy Regulatory Commission, 2016). While NERC maintains the guidance around these topics, the ISOs and RTOs themselves set their own reliability standards and thresholds, that must be approved by NERC (Federal Energy Regulatory Commission, 2016).

Decarbonization of electricity incorporates a number of different technologies, not only solar and wind generation, but energy storage, hydro power, and things like microgrids that control the flow of energy in smaller areas than an ISO or RTO. Those types of energy generation and storage systems interact differently with the grid technology than what the greater grid was originally constructed for, and those differences in technology, if not managed, could result in reliability issues. NERC creates standards to manage grid risks, and is currently building a set of standards that speak specifically to incorporating additional renewable energy sources, including solar photovoltaics, wind and storage (Howland, 2024b).

When new facilities are cited, they are required to undergo an approval process with that ISO or RTO, and the various standards from NERC are employed in the review of the project (*Reliability standards: Development and compliance*, 2024). Additionally, as generating companies prepare to decommission facilities, the ISOs and RTOs typically require shutdowns and decommissions to undergo an approval process, and can (and do) veto those closures depending on how comfortable the agency feels the state of their grid segments and load capacity (Howland, 2022). As companies plan for decarbonization and publicize goals with stakeholders, consideration of how the respective ISOs or RTOs will approach reliability is a factor they consider, and affects how those goals are communicated publicly.

Availability of electric generating sources are not the only risk to reliability ISOs and RTOs consider. Physical risks driven by extreme weather events are already affecting grid performance and management, with the blackout events in Texas and California clearly demonstrating that in recent years for two very different climate related events (Svitek, 2022; Rodriguez, 2022). In 2021 after winter storm Uri knocked out the ERCOT grid system in Texas, 246 people were reported by the Texas Department of State Health services to have died directly or indirectly because of the storm impacts to the grid, clearly demonstrating the deadly impacts of inconsistent electricity on the community (Svitek, 2022). Causes of death from the storm ranged from hypothermia (two thirds of deaths) to motor vehicle accidents to exacerbation of pre-existing medical conditions (Svitek, 2022). Wildfires have taken place across nearly all of the state of California in recent years, with major fires in 2021 being attributed to electricity provider Pacific Gas & Electric (PG&E) (Rodriguez, 2022). Since 2017, more than 30 wildfires have been attributed to PG&E due to the utility's management of vegetation near transmission lines, resulting in 100 deaths and destruction of 23,000 homes in California (Rodriguez, 2022).

The United States has reached a critical point in its journey to fully decarbonized electricity, as more renewable energy sources come online, which can make the transition all the more difficult to manage as physical risks to the grid are realized. If electricity is already lapsing because of impacts to the grid, shifts in the energy sources and subsequent updates to the grid to align new generation technology to the transmission and distribution technology could leave room for additional lapses or other impacts to electricity in the US. Decarbonization of electricity is a critical climate mitigation strategy, and while there are several potential pathways, execution is not optional (Luderer et. al., 2019).

Decarbonizing Energy

Growing pains is an accurate, if not colloquial, description of where the United States is in its transition to decarbonized energy. The term "mid-transition" perhaps more clearly describes where the United States is in its pathway to decarbonizing its electrical grid. Grubert and Hastings-Simon (2022) define the mid-transition as the period between new technology entering the system and placing meaningful operational constraints on the system, and new infrastructure being put in place to reduce those operational constraints. For the electrical supply system of generating assets (facilities that generate electricity) in the United States, the authors define this quantitatively as roughly between 20-80% implementation of renewable energy sources within the grid system being evaluated (Grubert & Hastings-Simon, 2022).

The 2022 energy sources breakdown (Figure 2) places the United States on the cusp on entering the mid-transition phase. If nuclear is included as a renewable source, then the United States is squarely in the middle of the previously defined mid-transition, with 39% of the energy being sourced from renewables (Total Electric Power Industry Summary Statistics, 2022 and 2021, 2023). If nuclear is not included, which is sometimes the case in renewable energy studies, then the United States has just hit the threshold to be considered in mid-transition of its electricity sources (19%). Nuclear energy has seen a 1-2% fluctuation in use in the United States over the last 10 years, and despite mixed public opinion, new nuclear facilities are being approved and constructed, including the Vogtle facility units 3 and 4 in Georgia (US Energy Information Administration, n.d.; Southern Company, 2024).

One of the defining hurdles for the transition to renewable energy is building technological solutions that can handle variable or changing energy loads (Grubert & Hastings-Simon, 2022). The grid today was originally built to support energy sources that operated 24 hours a day, 7 days a week, 365 days per year (Bakke, 2017). Fossil fuel sources historically burned consistently and power generation facilities were massive, typically hundreds and sometimes even thousands of megawatts (Bakke, 2017). Shifting an electrical network as large as the United States, that has also been implemented for several decades, is no simple feat even if the new energy sources were the same size and could be “dragged and dropped” into the current grid system.

Rebuilding and transforming a system that accounts for variable energy inputs at utility scale is a massive undertaking. Identifying the pain points and potential pathways to implementation is the start and first step, and the United States (both government and corporations alike) has begun implementing regulations and plans to work through this step. Renewable sources annually account for greater shares of installations and capacity additions in the US (Fasching, 2023). The country and industry are now in the mid-transition point, with renewables (including hydroelectric, but excluding nuclear) accounting for 20.4% of the net generated energy (Total Electric Power Industry Summary Statistics, 2022 and 2021, 2023). However, without clear next steps to accelerate implementation, the United States is in danger of languishing in the mid-transition. Identifying a mechanism to track and chart out how the grid will decarbonize at a national level is a key next step, and setting clear interim targets is a way to accomplish this.

Regional Differences

Part of the reason energy is challenging to decarbonize in the United States is regional differences in energy needs and capacity for new energy development. The Northeast is characterized by large cities and densely populated suburbs. The Midwest and Southeast are characterized by agriculture and smaller cities, and heavy industry. The West is less populated in many areas, but has large swathes of dense population and desert. These differences make for varied energy needs, and abilities to support different types of energy sources.

Utility-scale solar fields require large open spaces and enough sunlight, and wind farms similarly require large open spaces. Both of these requirements make the Northeast a difficult region to cite utility-scale renewable energy in, though it is possible with offshore capacities. The western and southern United States have more open space that could more easily support utility-scale wind and solar, but the southern United States has a well-documented economic relationship with fossil fuels, resulting in a difficult cultural discussion on renewables, while the western United States is known for moving away from fossil fuels more quickly than other regions (O'Boyle, 2019).

Decarbonization Goals and Tracking

At the federal level, the administration has set a series of goals to reach a decarbonized economy, summarized below with emissions added by the author for additional context (*President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target*, 2021):

- 2030: the United States will reduce emissions 50-52% below 2005 levels (for the entire economy; 2005: 6.6 billion metric tons of carbon dioxide emitted; goal: 3.3 billion metric tons of carbon dioxide emitted)
- 2035: the United States will have a 100% carbon pollution-free electrical grid
- 2050: the United States will be a net zero economy

Accountability is essential for any transition, but especially for one that impacts 331 million people. Under the Paris Accord, participating Parties were not required to set public plans or interim targets when setting their nationally determined contributions (NDCs), although there are options to provide details on specific projects planned to be implemented by the Party to meet the NDC in the submittal form (*United States NDC April 21, 2021*). It is common knowledge that setting a goal without getting buy in from key stakeholders, and setting a clear plan with small steps will be more difficult to achieve. The US has put itself in a difficult position by setting these decarbonization goals without a clear plan.

In addition to not setting a clear plan, what the administration did not do, and what has been repeatedly called for (Behr, 2022) is set additional regulations and/or interim targets to plan for decarbonizing the grid, which would further enhance accountability and transparency in the transition. The goals go from reducing overall emissions for the U.S. economy, with no additional requirements or goals for electric generation emission reductions or minimum generation requirements from renewable energy sources, to a net-zero grid five years later. This means that power generation companies, which are beholden to a number of stakeholders with conflicting interests, are left to set their own goals and timelines without sign off from at the federal level to confirm alignment. To complicate things further, a number of states have set their own decarbonization goals that now need to be overlaid the federal goals.

A goal in the context of this thesis is a commitment, whether voluntary or legally binding, that a state government (either the state legislature or state governor) has set to reduce emissions from the state economy. Those emission reductions could be from the overall economy or a specific industry, including electric related emissions. A goal does not include a renewable portfolio standard (RPS). An RPS is a tool that can be leveraged at any level of government, but is most often used at the state level in the US (*Renewable energy explained*, 2022). The structure and enforcement of an RPS varies from state to state, but typically the RPS sets a minimum required amount of electricity to come from renewable sources by a particular time, set by the governing body (*Renewable energy explained*, 2022). In June 2023, 29 of the 50 U.S. states and the District of Columbia had an RPS in place that call for varying degrees of renewable energy implementation (Barbose, 2023). RPSs are often used in tandem with emission reduction goals and are also used where emission reduction goals are not in place (e.g., Maine), but are separate mechanisms from goals.

States Without Goals

To that end, 29 of the 50 states do not currently maintain a decarbonization or emissions reduction goal, including some states with the highest electric related emissions, like Texas and Florida. Texas has no history of a decarbonization or emissions reduction goal, but Florida previously maintained an emissions reduction goal that was later repealed. In 2007, through Executive Order 07-127 the governor of Florida at that time enacted legally binding electric utility emission reduction targets. The executive order required the state to reduce electric utility emissions to 1990 level emissions in 2025 (86.6 MMT CO_2 of electric utility emissions in 1990) and 80% below 1990 levels (17.32 MMT CO_2 of electric utility emissions emissions) by 2050 (Executive Order 07-127; *State-Level Energy-Related Carbon Dioxide Emissions*, 2019). The executive order required the Department of Environmental Protection (DEP) to enact a cap-and-trade program for carbon emissions to reach the reduction goals, which was done with legislative approval. While originally the 2007 legislature in Florida agreed that DEP had the authority to set up and run that program, and passed legislation promulgating authority to the DEP to do so, in 2012, through HB 4001, the Florida legislators at the time repealed the original ruling and effectively nullifying the original executive order (HB 4001, 2012).

Nebraska does not have a state electricity emissions reduction goal at the time of writing. However, the boards of three major public power districts in the state (Lincoln, Nebraska and Omaha) have set non-binding emission reduction goals (Harpel, 2021). The non-binding goals hold Lincoln to a 2040 carbon pollution free generation goal while holding Nebraska and Omaha to a 2050 carbon pollution free generation goal. The board of directors for all three public power districts voted (in 2020, 2020 and 2019 respectively) (Harpel, 2021). Combined, these three public power districts provide electricity to over half of the state's population (Harpel, 2021). None of the three power districts have published public updates on progress towards achieving those non-binding goals at the time of writing.

Kansas does not have any active emissions reductions goals, specific to electric or more broadly. Previously, the state did have a voluntary target, through the Kansas Corporation Commission, that stated that 20% of electric supply to meet peak demand would be from renewable sources (*Kansas Renewable Energy Standard,* n.d.). This goal was achieved, and at the time of writing the Commission reported that 46% of the state's electricity is from wind (*Kansas Electric Generation Sources by Total Megawatt hours*, n.d.). While there is no active goal, the state is in the middle of drafting a comprehensive action plan, through funding from the IRA, called the Emissions Reduction and

Mitigation Plan (E-RAMP) (*Emissions Reduction & Mitigation Plan*, n.d.). The plan is set to be delivered and finalized in 2025, and will include emission reduction targets, greenhouse gas inventory for the state, workforce planning analysis and several other components as defined by the EPA (*Emissions Reduction & Mitigation Plan*, n.d.).

The remaining states without any type of emission reduction goals are Alabama, Alaska, Arizona, Arkansas, Delaware, Georgia, Idaho, Indiana, Iowa, Maine, Mississippi, Montana, New Hampshire, North Dakota, Oklahoma, South Carolina, South Dakota, Tennessee, Utah, Vermont and Wyoming. Of these states, only Mississippi and Idaho increased their electricity related CO_2e emissions from 2012 to 2021, 8% and 174% respectively. It is important to note that Idaho emitted 2 MMT of electricity related CO_2e in 2021, up from 0.73 MMT in 2012 (EIA, 2023).

States With Goals

There are 22 states with active emission reduction goals, some of which specially require electric emission reductions, but many do not have this specificity and just set net zero overall economy goals. Not all state goals will be described in detail, but those with specifics around electric carbon emissions reductions or renewable energy development will be discussed below.

2035 goals consistent with federal goals. Of the 22 states that do maintain carbon emission reduction goals, only New Jersey, Maryland and Rhode Island are consistent with the federal 2035 goal for a carbon pollution free grid. Rhode Island's 100% renewable energy goal is set for 2030, setting the state ahead of the national goal for a carbon pollution free grid in 2035. Both New Jersey and Rhode Island's goals are legally binding and were set through executive order by state governors (Executive Order (EO) 315 and 20-01 respectively) (Executive Order 315, 2023; Executive Order 20-01, 2020). Neither goal calls out a specific utility provider, or include specifics on the pathway to achieving the goals. Maryland's 2035 goal was published in December 2023 through the state's comprehensive Climate Pollution Reduction Plan, which is part of the 2022 Climate Solutions Now Act actions; however, the 2035 goal itself is not currently legally binding (Maryland's Climate Pollution Reduction Plan, 2023).

New Jersey recently updated its clean energy goal via a 2023 EO (Executive Order 315, 2023). Previously, in 2007 the state had committed to a clean energy by 2050 goal alongside a goal to reduce all state emissions to 80% below 2006 levels by 2050 (Executive Order 315, 2023). The EO does not define clean energy, but a review of the state's Department of Environmental Protection web publications around the EO confirmed that the clean energy technologies included are bioenergy, hydrogen, solar and wind (*Clean Energy Technologies*, 2023). The updated 2023 EO mandates that in 2024, the Board of Public Utilities (BPU) for the state will publish a plan to meet the 2035 goal as part of the state's overall Energy Master Plan that would include short- and long-term actions for implementation (Executive Order 315, 2023). At the time of writing, no notice or timeline from the BPU on when the Energy Master Plan would be published was found to be publicly available.

Executive Order 20-01 dictates that all electric demand shall be met with renewable energy sources by 2030 in Rhode Island (Murphy et al., 2020). Rhode Island commissioned a report from the state's Office of Energy Resources and the energy consulting firm, the Brattle Group. The *Road to 100% Renewable Energy by 2030 in*

Rhode Island, was published at the end of 2020 and outlines potential forecasts in for increases in demand, policy suggestions for renewable energy standards, regional planning considerations for collaborations with NE-ISO alongside several other items to demonstrate how the state may meet the 2030 goal (Murphy et al., 2020). Based on a 2024 update, Rhode Island set a schedule to implement a Renewable Energy Standard in 2023 that would continue through 2033 while also developing the Primary Climate Action Plan that would open discussions for the final 2025 Climate Action Plan, all of which is projected to be in line with the updated timeline for 100% renewable energy (*2025 Climate Action Strategy,* 2024).

Maryland currently has a legally binding goal that requires the state to source 50% of its electricity from renewable sources by 2030 (Maryland's Climate Pollution Reduction Plan, 2023). That goal is part of a larger piece of legislation titled Maryland's 2030 Greenhouse Gas Emissions Reduction Act (GGRA). The legislation includes portions that have not been enacted, including something titled the Clean and Renewable Energy Standard (CARES), that would have set a 2040 100% clean energy goal (Maryland's Climate Pollution Reduction Plan, 2023). As part of the recent Climate Pollution Reduction Plan published by the Department of the Environment, the state wrote that it is not currently on track to meet the 2030 legally binding goal, or the not-yet-active 2040 goal due to lower than anticipated deployment of wind and solar energy sources and supply chain issues (Maryland's Climate Pollution Reduction Plan, 2023).

As a way to course correct, the department is suggesting the 2035 goal be made legally binding and developed with a number of state agencies, including the Maryland Department of Natural Resources (DNR) Power Plant Research Program (PPRP), the

Maryland Public Service Commission (PSC), and the Office of People's Counsel (OPC) (Maryland's Climate Pollution Reduction Plan, 2023). As this suggested 2035 goal is developed, the Department hopes that the proposed legislation will include things like milestones for implementation, complimentary policy or policies and impacts to ratepayers (Maryland's Climate Pollution Reduction Plan, 2023). Maryland is the only state to publicly state that they are not on track to meet their goals at the time of writing (Maryland's Climate Pollution Reduction Plan, 2023). In 2021, the state emitted 11.23 MMT of CO_2e related to electricity, putting it in the bottom third of absolute electric related carbon emissions among the states, meaning the state has one of the lowest absolute electric related emissions rates (EIA, 2023).

2040 goals. The states with the next closest carbon pollution free grid goals are Connecticut (set in 2022), Minnesota (set in 2023) & New York (set in 2019). All three goals are set for 2040, and all four goals arose from legislation (Public Act 22-5, House File 7 and Senate Bill S6599). Similar to New Jersey and Rhode Island, none of the three goals specify if any utility provider is beholden to any interim targets or goals.

Connecticut's Public Act 22-5 is a brief piece of legislation, coming in under two pages. The bill does not speak to pathways, or any specifics around how the emission reduction targets will be met, stating only that by 2030, carbon emissions for the state (not electric specific) be 45% below a 2001 baseline, and by 2040, electric related carbon emissions will be eliminated (Public Act 22-5, 2022). The bill does state that the Commissioner of Energy and Environmental Protection will have jurisdiction, but does not specify anything else relating to achieving the goals (Public Act 22-5, 2022).

The Minnesota regulation similarly requires all electric utility providers, both public and private, to submit utility plans to the public utility commission that outlines the organization's pathway to complying with the regulation (House File 7, 2023). The regulation also requires that by 2035 the fleets for electric utility providers will be made up of at least 90% carbon-free energy (House File 7, 2023). The state defines carbon-free energy as wind, solar, hydroelectric (less than 100 MW capacity) or biomass (House File 7, 2023). Minnesota specifically excludes a waste to energy or energy recovery facility that burns municipal solid waste in populated areas (greater than 1,500 persons per square mile but less than 2,500 persons per square mile) (House File 7, 2023).

New York, the third and final state with an active 2040 zero electric carbon emissions goal, passed what is commonly called the CLCPA, or Climate Leadership and Community Protection Act, or the Climate Act, in 2019 (Senate Bill S6599, 2019). The bill is expansive, and includes standards for building heating and cooling efficiencies, as well electrification of public and private transportation and requirements for a just transition to attempt to ensure that Disadvantaged communities are not disproportionately impacted during the transition (Senate Bill S6599, 2019). Regarding electric carbon emissions, the CLCPA specifies that the state will source 70% of its electricity from renewable sources (offshore wind, solar) by 2030 and source all electricity from renewable sources by 2040 (*Progress to our Goals*, 2023). Other interim goals regarding electric carbon emissions include the development of 6,000 MW of distributed solar by 2025 and 9,000 MW of offshore wind by 2035 (Senate Bill S6599, 2019).

NYSERDA (New York State Energy Research and Development Authority) maintains an active "Clean Energy Dashboard" that tracks various metrics, including renewable energy capacity, avoided CO_2e emissions, electricity demand and many others (*Clean Energy Dashboard*, 2023). At the time of writing, the dashboard had been updated through the third quarter of calendar year 2023. The dashboard is unique to New York and presents a level of transparency and accountability to state stakeholders on progress towards the stated decarbonization goals not seen at the federal level or in other states reviewed for this analysis. Given that NY enacted the goal in 2019 and has been implementing for close to five years at the time of writing, it is not surprising that tracking mechanisms and overall transparency standards and practices are better developed than other states, or even the federal goals, that were enacted within the last two to three years.

Goals that call out specific companies. Two states with legally binding goals, Colorado and Virginia, have called out their largest utility providers as part of their goal. Colorado does not name Xcel Energy specifically in the bill text (House Bill 19-1261) that sets the emission reduction goal, citing only that public electric utilities should create and submit clean energy plans, and will not be required to plan for emission reductions greater than 80% below 2005 levels (House Bill 19-261, 2019). Xcel then published in its 2019 Sustainability Report (note: the report was published in 2020, but covers reporting year January 1, 2019 – December 31, 2019) that the company worked closely with stakeholders in the state government to codify the company's 80% reduction goal as part of the legislation, demonstrating commitment to the reduction (*2020 Corporate Responsibility Report*, n.d.).

Virginia does name AEP and Dominion Energy specifically in the 2020 bill (HB 1526) for its emission reduction goals to reach carbon-pollution free energy by 2050 and 2045, respectively from the two providers. Virginia not only calls out the two electric companies, but goes several steps further and states in the bill (HB 1526, 2020) that:

- any provider that does not meet the stipulations in the bill will be forced to pay energy deficiency payments or purchase renewable energy credits to cover the deficit;
- by 2035, the two providers will acquire or build 400 and 2,700 MW capacity energy storage projects respectively; and,
- Dominion Energy will have at least 5,200 MW of offshore wind by 2034.

The Virginia bill, commonly referred to as the Virginia Climate Plan, also specifies that all coal fired facilities, except for those operated by a Phase II utility (Dominion) that co-fire with biomass or operate with a capacity greater than 500 MW, must close by December 31, 2024 (HB 1526, 2020). At the time of writing, based on fleet information published on the Projects and Facilities section of their corporate webpage, Dominion maintains two active coal power generation stations in Virginia that (Clover and Mt. Storm), due to the exemption explained in the previous sentence, do not have firm closure or decommissioning timelines (*Coal and Oil Facilities*, n.d.). Additionally, AEP currently owns 4,270 MW of coal, as part of its subsidiary Appalachian Power Company (*AEP 2023 Factbook*, 2023). The two facilities however, Amos and Mountaineer, are both located in West Virginia (*AEP 2023 Factbook*, 2023).

Other goals. Through its 2023 regulation with a 2024 activation, Michigan requires electric providers that are subject to rate case submissions to the public utility commission to submit renewable energy plans by 2028 that specify the provider's forecast to construct or acquire renewable resources to comply with the specified timelines in the regulation (Act No. 235, 2023). The regulation requires that in 2035 electric providers' portfolios will be made up of at least 80% clean energy sources, and will be made up of 100% by 204, but does not align with the federal non-binding 2035 carbon pollution free goal (Act No. 235, 2023). For this regulation, Michigan has defined clean energy as:

- the generation of steam without greenhouse gas emissions (including nuclear generation);
- if the facility combusts natural gas to generate steam, carbon capture and storage with 90% effectiveness is also used at the facility; or,
- if the facility is a combined cycle facility, there is some other type of carbon sequestration or removal technology used at the facility (Act No. 235, 2023).

Pennsylvania, the state with the third highest absolute electric carbon emissions in 2021, has set overall (not electric specific) emissions reduction targets via executive order in 2019 (EO 2019-01, 2019). The goals, that the state shall "strive" for a 26% reduction of net greenhouse gas emissions statewide by 2025 from 2005 levels; 80% reduction of net greenhouse gas emissions by 2050 from 2005 levels, are considered legally binding (EO 2019-01, 2019). Net in this scenario means the state takes into account the estimated quantities of sequestered carbon from forests and other land use types to determine the final emissions for the time period being quantified (EO 2019-01, 2019). The EO mandated that a "voluntary GHG inventory" would be built for the state and revisited annually, and this inventory serves as the basis for the state determining progress towards meeting the previously mentioned targets (EO 2019-01, 2019). Similar to the other states mentioned, Pennsylvania does not call out specific utility providers in the 2025 or 2050 targets.

California, notably one of the most influential and proactive states when it comes to climate action, enacted their carbon emissions reduction goals in 2018 through legislation. The legislation, AB 32, required the state to reduce carbon emissions to 1990 levels in 2020 (*AB 32 Global Warming Solutions Act of 2006*, 2018). The state did achieve this goal. In addition to AB 32 being passed in 2018, the state also passed SB 100, which mandated all electricity be from renewable sources by 2045, and that 60% of electricity for the state be sourced from renewable sources by 2030 (SB 100, 2018). In 2021, as required under SB 100 the first joint agency report between the state level Energy Commission, Public Utilities Commission and Air Resources Board was published, and demonstrated through various models that the SB 100 mandates were in fact achievable (*SB 100 Joint Agency Report*, n.d.).

After the 2021 joint agency report, the state of California published the 2022 Scoping Plan, which went into greater detail and laid out pathways to achieve the targets set in AB 1279, which include GHG emissions being reduced to 85% below 1990 levels (*SB 100 Joint Agency Report*, n.d.). The reporting and planning are akin to how New York publishes regular data driven updates through the Clean Energy Dashboard for public viewing. Both states achieved carbon emissions reductions from 2012 through 2016, but for 2017 through 2021 electric emissions increased (7% for California, 13% for

New York). Overall, both states have decreased emission from 2012 to 2021, but given that both states implemented ambitious emissions reduction goals during the latter half, the increase in that five-year period is an interesting contrast. New York has not provided much public commentary on this trend, but in the 2022 Scoping Plan, California acknowledged the impact of weather on reliability and the increased use of fossil fuel electric during severe weather events (*SB 100 Joint Agency Report*, n.d.).

A short description of the remaining state goals not listed here, whether voluntary or legally binding, can be found in the Results chapter.

Company goals. At the company level, decarbonization goals are sometimes managed solely by the company, but can also be submitted for external verification and approval to an organization. There are a select few companies (Dominion, AEP, Xcel) with goals tied into legally binding state goals.

The majority of power generation companies do not set externally verified goals that require regular public disclosure of progress, and track their progress privately and publish on an ad-hoc basis. When goals are tracked privately, it gives the power generation company license over what information is published, and how often. External verification of progress towards goals can enhance public trust and overall accountability. While private tracking may make sense for the goal-setting power generation company when it is first starting the goal-setting process, it does not lend itself well to accountability to stakeholders (e.g., customers).

The earliest goal of the companies included here was set by Southern Company in 2018 (Planning for a low carbon future, 2018). The voluntary goal calls for the company to reduce emissions 50% from a 2007 baseline (156 MMT CO_2e), and to reach net zero emissions by 2050 (*Planning for a low carbon future*, 2018). Three companies set goals in 2019: Xcel, Berkshire Hathaway Energy and Entergy. Xcel, as part of the larger legally binding goal set by Colorado for carbon pollution free energy by 2050, set a voluntary interim goal of an 80% reduction in emission from a 2005 baseline (64 MMT CO_2e) by 2030 (*2021 Sustainability Report*. n.d.-a). Berkshire Hathaway Energy set a net zero by 2050 goal with an interim goal of a 50% reduction by 2030 from a 2005 baseline (Berkshire Hathaway Energy, n.d.). The last voluntary goal set in 2019 was set by Entergy, committing to a 50% reduction from 2000 base-year levels by 2030, 50% carbon-free energy capacity by 2030, and net zero emissions by 2050 (*Entergy's path to net-zero emissions*, 2022).

Nine companies set emissions reduction goals in 2020, including Dominion and AEP's respective legally binding goals set by the state of Virginia. The other seven companies include Ameren, Exelon, FirstEnergy, PG&E, SCE, TVA and Vistra. All the voluntary goals include a net zero component, as well as interim 2025 or 2030 reduction goals from an earlier baseline.

Eight other companies set goals in 2021, two of which (Evergy and NRG) included an interim target for 2025 or 2030, and net zero emissions by 2045 or 2050 respectively. Brookfield set a Scope 1 & 2 net zero goal for 2030, as the company only operates renewable energy, making a more comprehensive emissions reduction goal less impactful for their operations. Consumers Energy, as previously noted, set a coal-free goal for 2025 and a net zero emissions goal for 2040. Energy Harbor set out to be a carbon free baseline energy producer by 2023, which the company achieved through divestment of its coal operations, and also set a net zero operations goal for 2050. Lastly, the three public power districts in Nebraska, LES, NPPD and OPPD all set net zero goals for 2040, 2050 and 2050 respectively. The last three companies (DTE, Duke & NextEra) included in the analysis set their goals in 2022. All three companies set interim targets for 2025, 2035 or 2040 as well as net zero targets for 2050 (DTE and Duke) or 2045 (NextEra).

Notably, the only company included in the analysis that does not maintain any type of emissions reduction goal, voluntary or otherwise, is Calpine. The company was included because of its geographic spread (22 states) and variation in types of operation and pursuit of carbon capture technology (*2021 Sustainability Report*, n.d.-b). Including a company without a goal that pursues electricity generation with lower carbon emissions and carbon capture technology seems an appropriate alternative to review against companies that have voluntary and/or legally binding goals.

Rate of Decarbonization

The rate of decarbonization for electric generation related emissions can be calculated as the ratio of renewable or carbon free energy to carbon producing energy, in MW or by calculating the rate of percentage change in carbon emissions. This rate of percent change can be calculated at a variety of levels, including the country or federal level, a single state or region, or at the individual company level. In 2022, PwC found that the rate of decarbonization within the global Net Zero Economy Index had fallen to 0.5%, the lowest rate in a decade (Plasschaert, 2022). The Net Zero Economy Index (NZEMI) measures the progress of G20 nations in reducing carbon emissions (Plasschaert, 2022).

In the previous decade, the United States had maintained a rate of decarbonization of approximately 3%, (Figure 3) by the Center for Climate Change and Energy Solutions, based on data published by the Energy Information Administration, or EIA (Lawson, 2018). In parallel, the rate of emission reductions over a set time period can also be referenced as a measurement of decarbonization, and depending on the level (e.g., state) can be more straightforward to calculate and evaluate. This demonstrates that while the United States is making small strides to decarbonizing, small contributions are not enough to lead or encourage other nations to follow similar pathways. This does not foster confidence that decarbonization globally will happen quickly enough or that the federal targets will be met on time.

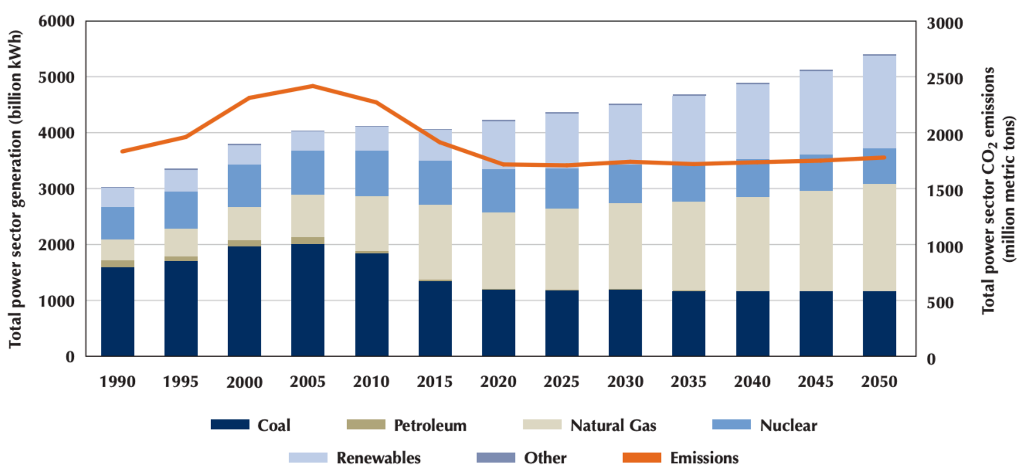

Figure 3. Total past and projected U.S. electricity generation by energy source and total sector emissions. (Lawson, 2018).

The federal administration has not set a public method of tracking for the U.S. decarbonization goals. Data that covers emissions from any permitted source and energy source breakdown at various time intervals is available from the EPA and EIA at regular frequencies, but that information is tracked at the facility or asset level and held in specific holding companies, so cannot be easily tracked back to the owner without a significant investment of effort by the researcher. With a rise in electrical generation still expected to meet increased demand, a lower rate of decarbonization paired with difficult tracking of emissions does not build confidence in the goal-setting in the United States.

Tracking the rate of decarbonization at the company and regional level would allow for a closer level of analysis, and the identification of different trends. Eberle and Heath (2020) evaluated and characterized the differences between eight different sources and forecasts of emissions in the US, and their methodology provides a strong framework to draw from. They began their analysis with documentation reviews and informal stakeholder interviews with staff at each of the data publishers, and confirmed the relevance of their approach with each. The team then identified trending energy sources (e.g., biomass) and estimated the source's potential influence on the energy system's emissions (Eberle & Heath, 2020). From that estimation, the team built two models, Low and High, projecting to 2040. Leveraging capacity factors published and utilized by the California Public Utility Commission, Eberle and Heath (2020) then estimated emissions by source for each scenario. To close their analysis, they evaluated the ability of the federal government to effectively capture emissions information as the grid modernizes.

Rebuilding a system is one thing, and understanding how the rebuild is progressing is another entirely. Currently, the United States has no publicly stated method to determine how the decarbonized reconstruction of the electrical grid is progressing, and with the global rate of decarbonization decreasing in a time where it should be increasing to meet demand, as one of the largest emitters of GHG emissions, the lack of

U.S. monitoring is concerning. Without a method in place or at least planned, it can be difficult or near impossible to track progress, which makes meeting goals unnecessarily difficult and nearly impossible.

Research Questions, Hypotheses and Specific Aims

I broke out my research into three main questions and hypotheses:

1) Will the US meet its publicly stated decarbonization goals for 2030 and 2035?
    - H1: The United States will not meet its publicly stated decarbonization goals for 2030 or 2035.
2) Are utilities in the US divesting from fossil fuel sources in line with their publicly stated decarbonization goals?
    - H2: For the years 2012-2022, power generation companies in the United States with publicly stated decarbonization goals did not divest from fossil fuels at a high enough rate to meet their goals.
3) Are there particular grid regions in the United States that are decarbonizing at a faster rate than others, based on the previous 10 years?
    - H3: The western United States is decarbonizing at a faster rate than the rest of the country.

Specific Aims

To test my hypotheses, I:

1. Defined the US federal decarbonization goals, individual state decarbonization goals and a selection of power company decarbonization goals and determined alignment on an overall timeline to 2035.

2. Estimated the rate of decarbonization for a stratified sample of power companies in the United States, as well as the states themselves from 2012-2022 and extrapolated this to grid regions and the entire country.
3. Analyzed the relationship between publicly stated decarbonization goals for a selection of power companies in the United States to their actual rate of decarbonization from 2012-2022 and identify trends.
4. Built a forecasting model (decarbonization timeline) extending to 2035 using the estimated rate of decarbonization and associated emissions with low and high emission scenarios for the United States.
5. Identified those companies successfully decarbonizing, so that the United States can leverage their strategies to uplift the rest of the industry.

Chapter II

Methods

To answer the research questions and address the various hypotheses on whether or not the US will reach its 2030 and 2035 decarbonization goals, I utilized a number of publicly available data sources and statistical analyses of the data to determine the rate of decarbonization (the rate of change for emissions from electrical generation for residential and industrial consumption) from 2012-2022 for a selection of power companies across the United States, as well as for individual states and the country as a whole. The rate of decarbonization for this analysis is calculated as the percent change in CO_2e year over year over the full ten-year (2012-2022) period, with subsequent analyses completed for the two successive 5-year periods (2012-2016 and 2017-2022) to better understand any trends in how emission rates shifted.

Data Sources

The research focused on private and publicly owned utilities in the United States with publicly stated decarbonization goals (e.g., published in a sustainability or corporate responsibility report). The analysis then went a step up, and brought in all the states, and compared those with decarbonization or electric emissions goals and those without. There are also a select number of utilities with legally binding decarbonization goals that are tied directly to state determined decarbonization targets, and the impact of the state set target was reviewed for those specific companies.

I analyzed how the rate of decarbonization has changed across two five-year periods for a sample of individual utilities, states and then the country as a whole. The mean rate of decarbonization was applied against the generation capacity for the US through 2035 to determine if the 100% carbon pollution-free electrical grid goal can be attained at the historical rate of decarbonization. A secondary qualitative analysis to determine if particular regions and types of companies are decarbonizing faster was also completed. A Pearson correlation coefficient was calculated to assess the linear relationship of emissions against time at the company, state and country level. This coefficient was used because of its ability to describe the strength of a relationship between two variables.

The federal goals were reviewed and pulled from the NDC submittal form, published by the administration in 2021 and held on the United Nations Framework Convention on Climate Change webpage (2021). The emissions data for the national analysis were pulled from the United States Energy Information Agency (EIA), which serves as the independent, impartial energy data gatherer for the nation (EIA, n.d.). The agency publishes a variety of data summaries and raw data files, including annual reports on electric emissions at the federal level.

State level emission reduction goals, decarbonization goals or renewable energy standards were sourced from state government online publications and legislative trackers. The states publish data in a variety of ways, and the sources cited will reflect this. The emissions data for the state analysis were also pulled from the EIA annual reports on emissions (EIA, n.d.).

A complete list of utilities and independent power producers participating in the six ISOs and RTOs and one major co-op in the United States was generated by pulling the list of participants from each of the organizations' website. The seven organizations are:

- California Independent System Operator (CAISO)
- Electric Reliability Council of Texas (ERCOT)
- Independent System Operator of New England (ISONE)
- Midcontinent Independent System Operator (MISO)
- New York Independent System Operator (NYISO)
- PJM Interconnection Regional Transmission Operator (PJM)
- Southwest Power Pool Regional Transmission Operator (SPP)

The lists from each organization were current as of August 30, 2023. The Alberta Electric System Operator (AESO) and the Independent Electricity System Operator (IESO, for Toronto) were excluded from analysis as they do not serve energy consumers in the US.

The list was compiled in Microsoft Excel and was categorized by organization, type of company and location. The combined list was filtered for duplicates, and only those companies that are categorized as "generation" were used as the final listing for selection of companies. Companies with legally binding emission reduction or decarbonization targets were immediately selected, and from the remaining companies, those with publicly stated decarbonization goals and were found to cover at least two ISO or RTOs were selected.

While reviewing the list of generating companies from each ISO and RTO, I was also searching for "ultimate parent companies" for the operating entities. In energy, it is common that each asset (power generation facility) will have its own legal entity, and that entity is used on permit applications, and to register for the power market. Some lists, including PJM, provided this information up front and allowed for a simpler sorting. For the other organizations where the ultimate parent company was not provided or immediately obvious, I searched the entity name through Google and confirmed ultimate ownership through press releases and financial filings. There are also several large utility companies (e.g., Exelon, Southern Energy) that own several state-specific utilities (e.g., ComEd, Georgia Power), so understanding those roll-ups was essential to making company selections. Where those parent companies were selected or if there were financial transactions that substantially affected (e.g., the sell-off of an entire fleet of facilities), those relationships are explained in the results section. The 2021 GHG emissions (Scope 1) in MT of CO_2e are included from each company, sourced from each company's published emissions in their financial statements or corporate responsibility reports. The determination of largest utilities was based on a 2022 report generated by the 2022 Emissions Benchmarking report from ERM's SustainAbility Institute (2022). While 2021 emissions are used in this analysis, the 2022 report from ERM was leveraged to confirm the most current grouping of large utilities was used in the analysis as the analysis was published in 2022 and based on 2021 data and utility activities.

In several cases a larger company will own a state-specific utility (e.g., AEP owns Appalachian Power), and this is indicated in the table through parentheticals. In these cases, the ultimate parent company's emissions will be listed. In the case of AEP and

Appalachian Power, because Appalachian Power is named in Virginia's legally binding goal, Appalachian Power is named first and AEP is listed in parentheses to call out the ultimate owner and operator and decision maker. AEP also maintains a voluntary interim decarbonization goal that is listed secondarily in the table due to the voluntary nature. In the case of NextEra, Florida Power & Light (FP&L) is the state-specific utility and NextEra is the ultimate parent company. NextEra maintains a voluntary decarbonization goal that encompasses FP&L, so NextEra is the primary listed company with FP&L included in parentheticals for transparency and reference. Where abbreviations or shortened versions of the company name will be used, those are also listed in parentheticals.

Following my review of the ISO and RTO listings alongside the list of power generation companies and utilities legally obligated to decarbonize due to state set targets, I compiled a list of 25 electric generation companies and utilities. Once these power companies were selected, I pulled the sustainability report and financial report directly from each company's website. The information regarding goals was compiled in a Microsoft Excel workbook that included the terms of the goal(s), including the base year, the reduction goal (e.g., percent change or net zero emissions) and the year the goal was set. One company (Calpine) was selected that does not currently have a decarbonization target, but does publish sustainability reports that include greenhouse gas data.

In this analysis, a legally binding goal for a company is defined as when a state (e.g., Colorado) sets a goal and calls out a specific power company or utility that services the state to reduce emissions by a certain percent by a particular year. States with goals that do not call out a particular company, are not considered legally binding for companies that operate in those states for the sake of this analysis. Depending on how the state set its goal, through legislation or through an executive order, or through a statement by a state leader, the goal can be considered legally binding or not. For this analysis, goals set by executive order or legislation will be referred to as legally binding.

The three Nebraska public power districts do not publish these types of reports, so the facilities listings were pulled from each district's webpages and then data for 2021 from each facility was pulled from EPA GHGRPA FLIGHT. To be in alignment with emissions available at the state level, 2021 data was used here instead of 2022 data. Given uncertainty in ownership, and in an attempt to not misstate or misattribute emissions if sites have been sold or closed between 2012 to 2021, only 2021 emissions were pulled from FLIGHT.

Decarbonization Rate Calculation

The rate of decarbonization was based on comparing published CO_2e emissions over the 2012-2022 time period sourced from company published reports and from the EPA's public emissions dashboard, FLIGHT or published sustainability report values for companies, and from EIA's annual emission reports for individual states. Where emissions data was not available (e.g., if a company published reports with CO_2e data starting in 2015) the period of analysis was shortened to match the available data. For all states and each power company selected as a sample, I took the following steps:

- identified the decarbonization goal, including start and end date and % reduction (if applicable);

- identified CO_2e emissions for the power company for the duration of the time period and calculated the rate of change year over year (decarbonization rate) for the selected time period; and,
- determined what trends exist for each power company and state over the two consecutive five-year periods (2012-2016; 2017-2022) and the entire ten-year period (2012-2022).

Decarbonization Timeline

I leveraged existing data for 2012-2022 to calculate rates of decarbonization, and then to map the decarbonization timing for the United States. The goals for the United States are that: by 2030 the country will reduce emissions 50-52% below 2005 levels, and in 2035 have a 100% carbon pollution-free electrical grid (*President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target*, 2021). By using the decarbonization rate I calculated for the sample of power companies in the United States, I projected CO2e emissions to 2030 and 2035 to determine whether the goals will be met (or in the case of 2030, whether the allocated emissions for electrical generation will be met).

The National Renewable Energy Laboratory (NREL) is in the middle of a series of publications called the Electrification Future Studies (EFS) centered on electrification rates in the US, and has published several papers to date discussing the history of electrification, demand and supply side scenarios, grid scenarios and consumption patterns. For this thesis, the supply side scenarios were used as a guide for the projected timeline through 2035. These projections were similar in scope and magnitude to those published by the EIA as part of the 2023 Annual Energy Outlook, which is specific to the US (EIA 2023).

I also followed precedent set by Eberle and Heath (2020) and utilized capacity factors (based on population projections) to incorporate planned or anticipated changes in energy sources between 2023 and 2035, and build a more informed timeline under different scenarios. I calculated the emissions anticipated in a low and decarbonization scenario based on the historical rates of decarbonization and insights from NREL, and then applied the capacity factors against both scenarios.

Chapter III

Results

The overarching goal of the analysis was to evaluate how the United States, individual states and electric generation companies publicly represent their decarbonization actions against what the actual decarbonization actions being taken are. The analysis was intentionally designed to be straightforward, to expose what complexities are present based on publicly available information.

Hypotheses 1 & 2 were set up to test the effectiveness of various types of decarbonization goals across different stakeholder groups, ranging from investor owned and public utility companies to the country at large. Specific aims 1 & 4 supported testing of hypothesis 1 by testing how publicly stated goals from utilities and states (both voluntary and legally binding) support the 2030 and 2035 federal decarbonization goals, and what the forecasted decarbonization timeline based on EIA data looks like. Specific aims 2, 3 and 5 helped evaluate hypothesis 2 by splicing utility specific data across regions and years to determine alignment with their own goals, and identify those utilities that are decarbonizing successfully. Hypothesis 3 examined if there were any regional differences across the country, and is supported by specific aim 3.

Specific Aim 1 – Define the Goals

There are three categories of goals that will be discussed. One, are the voluntary federal goals set by the administration as part of the nationally determined contributions for the United States as part of the Paris Agreement and EO 14008. The second are the legally binding state set goals from various state governor set executive orders. The last are the mix of voluntary and legally binding goals associated with a selection of utility companies and independent power producers in the United States.

Federal Goals

The U.S. decarbonization goals are delineated in Table 1 (President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target, 2021). The 2050 net zero economy goal and 40% of benefits from federal investments being directed to disadvantaged communities are included in the below table for completeness but are not the focus of this thesis and will not be included in the analysis.

Table 1. The US decarbonization goals.

Year	Goal	Type of Goal
2030	The US will reduce emissions 50-52% below 2005 CO_2e levels (2005: 6,635 million metric tons of CO_2e total; goal: 3,317 million metric tons of CO_2e)	Nationally Determined Contribution (NDC) as part of the Paris Agreement
2035	The US will have a 100% carbon pollution-free electrical grid (a 3317 million metric ton reduction from 2030)	Part of Executive Order 14008
2050	The US will be a net zero economy	Part of Executive Order 14008
N/A	Delivering 40% of the benefits from federal investments in climate and clean energy to disadvantaged communities	Part of Executive Order 14008

The United States cites a 2005 baseline year as a reference for reductions for the 2030 goal. In 2005, the United States emitted (gross) 6,635 MMT of CO_2e overall, with 2,400 MMT of those emissions coming from electrical generation, or roughly 36% of the emissions (*President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target*, 2021;

EIA, 2023b). It is important to note that the 50% reduction goal is for all emissions from US-based activity, not just electrical generation. If the proportion of electrical generation emissions to overall emissions remains at roughly 36% in 2030, then the industry would be "allocated" 1,200 MMT of emissions in 2030 to remain in line with the 2030 goal. However, emitting 1,200 MMT CO_2e in 2030 would not align with the 2035 carbon free pollution goal, and would indicate a slow emissions reduction trend, indicating that the 2035 goal may not be achieved.

Figure 4 visualizes the trend in EIA reported emissions from electrical generation in the United States from 2005 through 2021. At the time of writing, 2022 data from EIA was not available for review. However, per the EPA Greenhouse gas reporting program (GHGRPA) tool, Facility Level Information on GHG Tool (FLIGHT) R.151, approximately 1,585 MMT of CO_2e were emitted from electrical generation facilities in 2022 (2023). The FLIGHT tool, in alignment with all EPA reporting, utilizes the global warming potential (GWP) values from the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (2023). The two databases release data on different schedules due to the respective agency review schedules, but are typically aligned on emissions data, which corroborates the assertion that the United States did in fact have a minor increase in GHG emissions related to electrical generation. As mentioned above, although the electrical generation industry would have an "allotted" 1,200 MMT of CO_2e (300 MMT less than what was emitted in 2021) under the 2030 goal scenario, maintaining that level of emissions would indicate that CO_2e emissions reductions slowed and the 2035 carbon pollution-free grid goal would likely not be achievable under that rate of emissions reduction.

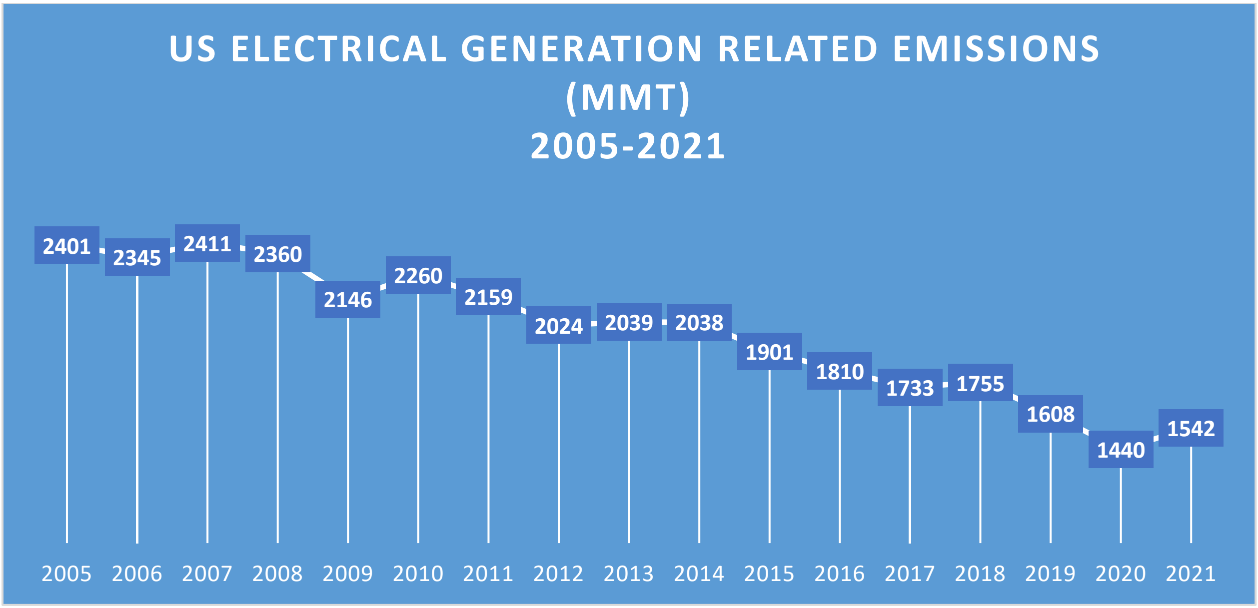

Figure 4. U.S. electrical generation related emissions in MMT of CO_2e, 2005-2021 (EIA, 2023b).

The 10% reduction in emission from 2019-2021, and subsequent 7% rise in emissions from 2020-2021, can be attributed to the impacts of COVID-19 on standard activity in the United States. The approximate 2022 emissions from electrical generation, 1,585 MMT of CO_2e, would indicate a 3% rise. Given the overall trend towards electrification of heat in commercial buildings and homes to reduce reliance on natural gas, electrification of vehicles for personal and commercial transportation to reduce reliance on gasoline and other fossil fuels and in turn reduce overall emissions, the need for electricity will only increase in the future.

State Goals

Table 2 includes all states (and the District of Columbia), whether or not there is a goal, and if there is a goal, the terms. Some states include other types of decarbonization activities in their goals (e.g., decarbonizing fleet vehicles) and if that is the case that portion of the goal has been intentionally excluded from this listing. The 2021 GHG electric related emissions by state, from consumption of electricity by state residents, are also listed alongside the goals (EIA, 2023b). 2021 data are presented in this table for consistency, because at the time of writing the 2021 dataset was the most recently available from EIA.

Table 2. State decarbonization goals and terms, and 2021 electric related CO_2e emissions.

State	Goal	2021 Electric CO_2e emissions (MMT) (EIA, 2023b)	Reference
Alabama	No goal	47.20	
Alaska	No goal	2.80	
Arizona	No goal	34.33	
Arkansas	No goal	28.54	
California	40% below 1990 emissions by 2030; 100% carbon-free electricity by 2045; reduce all emissions to 85% below 1990 levels by 2045	35.35	SB 100, 2018
Colorado	Reduce 2025 greenhouse gas emissions by at least 26% from 2005 baseline, 2030 greenhouse gas emissions by at least 50%, and 2050 greenhouse gas emissions by at least 90%; 100% carbon-free electricity by 2040 for Xcel Energy	30.58	House Bill 19-261, 2019
Connecticut	100% carbon-free electricity by 2040	9.23	Public Act No. 22-5, 2022
Delaware	No goal	1.77	
District of Columbia	Reduce greenhouse gas emissions by no less than 60% relative to 2006 levels by 2030 and to reach carbon neutrality by 2045; 100% renewable energy by 2032 through the RPS	0.00	DC Law 24-176, 2022

Florida	No goal	91.23	
Georgia	No goal	40.87	
Hawaii	Reduce all emissions 50-52% below 2005 baseline by 2030; 100% renewable energy by 2045 through the RPS	5.77	HB 1800, 2022
Idaho	No goal	2.00	
Illinois	40% renewable energy by 2030; 50% renewable energy by 2040; 100% clean energy by 2050	52.43	Public Act 102-0662, 2021
Indiana	No goal	68.84	
Iowa	No goal	24.12	
Kansas	No goal	22.25	
Kentucky	No goal	56.90	
Louisiana	Reduce GHG emissions 26-28% below 2005 levels by 2025; Reduce GHG emissions 40-50% below 2005 levels by 2035; Net zero greenhouse gas emissions by 2050	30.40	Executive Order Number JBE 2020 – 18, 2020
Maine	No goal	1.26	
Maryland	60% GHG reductions from 2006 levels by 2031; 50% renewable energy by 2030; 100% renewable energy by 2035; Net-zero greenhouse gas emissions by 2045	11.23	Maryland's Climate Pollution Reduction Plan, 2023
Massachusetts	Net-zero greenhouse gas emissions by 2050	6.14	Bill S.9, 2021
Michigan	Grid will have to be 50% renewable by 2034, 60% by 2035, with a clean energy standard of 100% by 2040	52.91	Act No. 235, 2023
Minnesota	30% GHG reductions from 2005 by 2025; 50% reductions from 2005 by 2030; 100% carbon-free electricity by 2040; 80% reductions from 2005 by 2050	21.21	Minnesota Statute §61.216H.02.01, 2023
Mississippi	No goal	25.19	
Missouri	No goal	60.21	
Montana	No goal	12.46	
Nebraska	No goal	19.79	

Nevada	28% GHG reductions from 2005 level by 2025; 45% GHG reduction from 2005 level by 2040; near-zero or zero economy emissions by 2050	13.70	SB No. 254, 2019
New Hampshire	No goal	2.10	
New Jersey	50% GHG reductions from 2006 level by 2030; 100% carbon-free electricity by 2035; 80% GHG reductions below 2006 by 2050	13.33	Executive Order 274, 2021; Executive Order 315, 2023
New Mexico	45% GHG reductions from 2005 level by 2030; 100% carbon-free electricity by 2045	17.13	Executive Order 2019-003, 2019
New York	40% GHG reduction from 1990 levels by 2030; 70% electricity from carbon-free sources; 100% carbon-free electricity by 2040; 85% GHG reduction from 1990 levels by 2050	25.00	Senate Bill S6599, 2019
North Carolina	70% reduction in emission from 2005 levels by electricity sector by 2030; Carbon neutrality in the electricity sector by 2050	40.13	House Bill 951, 2021
North Dakota	No goal	27.42	
Ohio	No goal	68.45	
Oklahoma	No goal	26.74	
Oregon	45% GHG reduction from 1990 levels by 2035; 80% GHG reduction from 1990 levels by 2050	8.23	Executive Order 20-04, 2020
Pennsylvania	26% reduction of net greenhouse gas emissions statewide by 2025 from 2005 levels; 80% reduction of net greenhouse gas emissions by 2050 from 2005 levels	77.48	EO 2019-01, 2019
Rhode Island	100% renewable energy electricity by 2030	3.38	Executive Order 20-01, 2020
South Carolina	No goal	25.03	
South Dakota	No goal	2.40	
Tennessee	No goal	24.03	

Texas	No goal	180.30	
Utah	No goal	29.94	
Vermont	No goal	0.00	
Virginia	By 2035, American Electric Power and Dominion Energy Virginia to construct or acquire 400 and 2,700 megawatts of energy storage capacity, respectively; 100% carbon-free electricity by 2045 for Dominion Energy and 2050 for Appalachian Power Company	24.36	HB 1526, 2020
Washington	45% GHG emission reduction below 1990 levels by 2040; 100% zero-emissions electricity by 2045; 95% GHG emission reduction below 1990 levels by 2050	9.85	RCW 70A.45.020, 2020; SB 5116, 2019
West Virginia	No goal	58.97	
Wisconsin	100% carbon-free electricity by 2050	35.00	Executive Order 38, 2019
Wyoming	No goal	34.08	

Figure 5 presents the year over year changes in CO_2e emissions by state and DC from 2012-2021 based on data from EIA in a sparklines format (EIA, 2023b). The table highlights the general, albeit slight, downward trend emissions related to electrical generation are taking, as shown previously in Figure 1. The actual percent changes can be found in the Appendix.

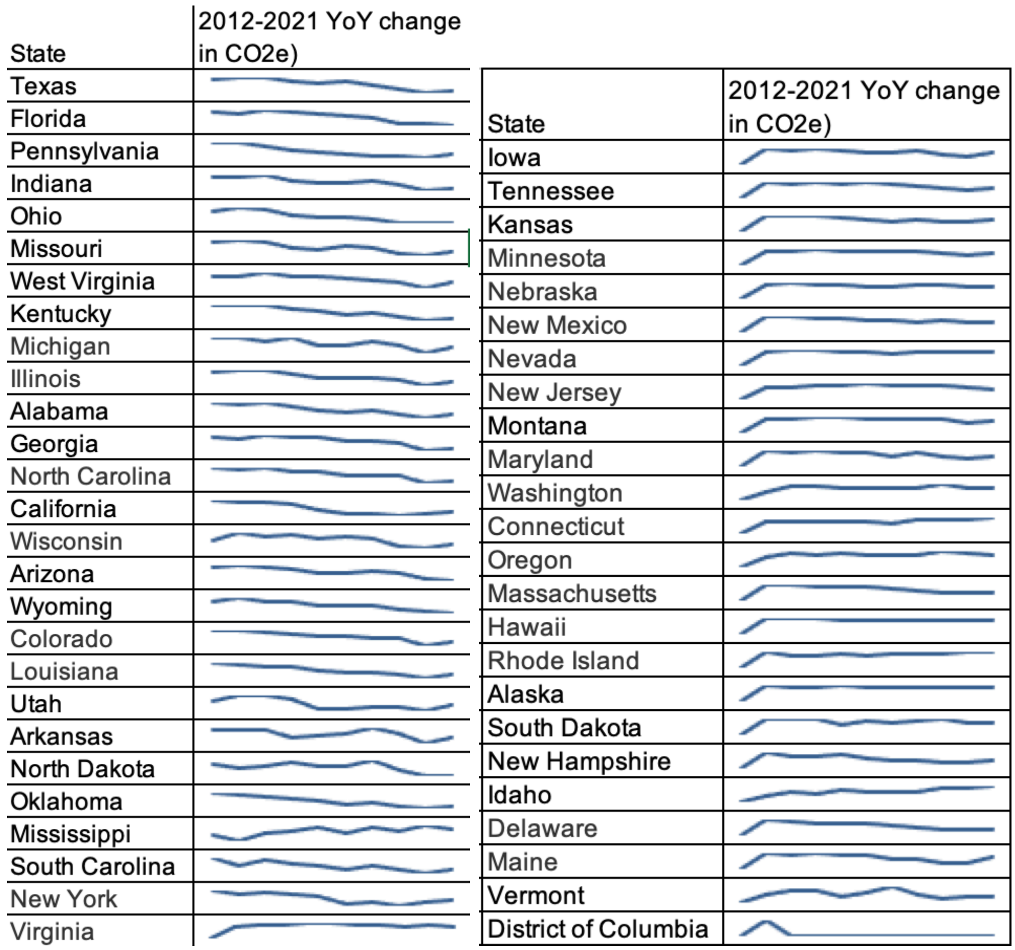

Figure 5. 2012-2021 year over year CO_2e emissions by state (EIA, 2023b).

Company Goals

The selection of 25 power company decarbonization goals, the type of goals (voluntary or legally binding) and the terms of the goals are outlined in Table 3. The utilities are presented alphabetically by type of goal (legally binding or voluntary). All companies with legally binding goals are included in this table. A selection of 19 of the largest power companies with decarbonization goals in the US were selected, and one company without a decarbonization goal.

Table 3. Table of companies selected with goals.

Company	Goal	Base year	Goal Set	2021 Scope 1 (MMT CO_2e)	Reference
AEP*	100% carbon-free electricity by 2050 for Appalachian Power Company; AEP: 80% reduction in GHG by 2030; net zero 2045	2005	2020	51	*2022 Corporate Accountability Report*, 2022
Dominion*	100% carbon-free electricity by 2045 for Dominion Energy; Dominion: 55% reduction in GHG by 2030 based on 2005	2005	2020	31	*Climate Report 2022*, 2022
Xcel*	100% carbon-free electricity by 2050 for Xcel Energy; Xcel: 80% reduction in GHG by 2030	2005	2019	39	*Sustainability Report Data Summary*, 2022
Ameren	Reduce carbon emissions 60% by 2030; 85% by 2040; net zero by 2045	2005	2020	28	*2023 EEI AGA Sustainability Report*, 2023
Berkshire	Net zero by 2050	2019	2019	39	*2021 ESG/Sustainability Quantitative Information, 2022*
Brookfield	Net zero by 2030 for Scope 1 & 2 in renewables profile	2020	2021	0	*Accelerating the net-zero transition*, n.d.
Calpine	N/A	N/A	N/A	44	*2021 Sustainability Report*, n.d.-b
Consumers Energy	Coal free 2025; net-zero 2040	2020	2021	143	*CMS Energy to Combat Climate Change*, 2022
DTE	90% CO_2 emissions reduced by 2040; net-zero 2050	2005	2022	27	*DTE Energy Company—Climate*

					Change 2021, n.d.
Duke	Exit coal by 2035; 80% reduction Scope 1 2040; net-zero 2050	2005	2022	77	*Duke Energy details clean energy transition in impact report*, 2023
Energy Harbor	Carbon free base load power producer by 2023; net zero operations by 2050	2021	2021	Not published	*Building a Sustainable Future*, n.d.
FirstEnergy	Carbon neutral operations by 2050; interim 30% reduction in GHGs by 2030 based on 2019 levels.	2019	2019	16	*Climate Report*, 2022
Entergy	50% reduction from 2000 base-year levels by 2030; 50% carbon-free energy capacity by 2030; net zero by 2050	2000	2019	36	*Entergy's path to net-zero emissions*, 2022
Evergy	70% reduction from 2005 base-year levels by 2030; net zero by 2045	2005	2021	26	*2021 Sustainable Transformation*, 2022
Exelon	50% carbon reductions by 2025; net zero by 2050	2015	2020	5	*Exelon Sustainability Report 2022*, n.d.
LES	Net-zero carbon emissions from generation resources by 2040 for Lincoln Electric System	2018	2021	1	Harpel, 2021; *EPA Facility Level Information on Greenhouse gases Tool,* 2023
NPPD	Net-zero carbon emissions from generation resources by 2050 for Nebraska Public Power District	2021	2021	8	Harpel, 2021; *EPA Facility Level Information on Greenhouse gases Tool,* 2023

NextEra	67% reduction in Scope 1 by 2025; 100% carbon-free electricity by 2045	2005	2022	42	*2022 Environmental Social & Governance Report*, 2023
NRG	50% carbon reductions by 2025; net zero by 2050	2014	2021	37	*2022 Sustainability Report*, 2023
OPPD	Net-zero carbon emissions from generation resources by 2050 for Omaha Public Power District	2021	2021	9	Harpel, 2021; *EPA Facility Level Information on Greenhouse gases Tool, 2023*
PG&E	2030 50% reduction Scope 1, 2 & 25% reduction Scope 3; 2040 net zero energy system	2015	2020	2	*Our Commitment,* n.d.; *Electric Company ESG/Sustainability Quantitative Information*, 2022.
SCE	100% carbon-free electricity by 2045	2020	2020	1	*Countdown to 2045,* 2023; *Electric Company ESG/Sustainability Quantitative Information*, 2023.
Southern	50% reduction in emissions by 2025; net zero 2050	2007	2018	83	*Planning for a low carbon future*, 2018; *2021 CDP Climate Change Disclosure*, n.d.
Tennessee Valley Authority (TVA)	70% reduction of carbon emissions by 2030; approximate	2005	2020	38	*FY 2022 Sustainability Report,* 2022; *2021 EEI*

	80% reduction by 2035; net-zero by 2050				*ESG/Sustainability Reporting Template*, 2022b.
Vistra	60% reduction in Scope 1 and Scope 2 emissions by 2030; net zero by 2050	2010	2020	95	*Sustainability Report 2022*, n.d.

Legally binding goals are noted with an asterisk beside the company name, otherwise goals included in Table 3 are voluntary. Note that the Exelon companies include: Atlantic City Electric (ACE), BGE, ComEd, Delmarva Power, PECO & PEPCO. In 2024, Exelon primarily functions as a transmission and distribution company, after divesting from its generation businesses in 2022 with the sale of Constellation Energy (About Constellation, 2023). The emissions reported for 2021 include emissions from generation that in 2024 is associated solely with Constellation.

Notably, Calpine does not maintain a decarbonization goal of any type, but does publicize carbon capture technology and decarbonization activities as a key pillar of the company's sustainability profile (2022 Sustainability Data Supplement, 2023). Calpine is included as a reference point, given the geographic spread of the operations across the United States.

Energy Harbor, a former subsidiary of FirstEnergy Corporation, emerged as a standalone company in 2020. Its fleet was comprised of nuclear and coal, and through divestment of the coal facilities to a brownfield asset manager, has successfully decarbonized its energy generation and achieved its goal (*W.H. Sammis Plant*, 2023). It was also announced in 202 that Vistra Energy was approved to acquire Energy Harbor (*Vistra receives approval*, 2024).

The total 2021 emissions from the companies listed above sum to about 878 MMT of CO_2e. This total is about 56% of the total electric emission (1,542 MMT of CO_2e) for the US in 2021.

Specific Aim 2 – Estimated Rate of Decarbonization by Company

Table 4 lists the self-reported emissions per year, from 2012-2021 in MT of CO_2 or CO_2e, depending on how data is published by the power company. The emissions data was sourced from either the power company's self-published sustainability report, or from a CDP submission and is rounded to the nearest tenth. Where data was not available in a consolidated format (e.g., published by the power company in a sustainability report or on CDP) a dash is listed. When a zero is listed that indicates that the power company is reporting zero emissions from electrical generation that year. For ease of reading only 2012 and 2021 are listed, but a table with each year's data can be found in the Appendix.

Table 4. Emissions by year and power company, in millions of metric tons of CO_2.

Company / MMT	2012	2021	Reference
AEP	122	50.8	*2013 Corporate Accountability Report*, 2013; *2022 Corporate Accountability Report*, 2022
Dominion	-	31.3	*Climate Report 2022*, 2022
LES	-	1.4	*EPA Facility Level Information on Greenhouse gases Tool,* 2023
NPPD	-	7.8	*EPA Facility Level Information on Greenhouse gases Tool,* 2023
OPPD	-	8.8	*EPA Facility Level Information on Greenhouse gases Tool,* 2023
Xcel	54.5	39	*Corporate Responsibility Overview 2013,* n.d.; *Sustainability Report Data Summary*, 2022
Ameren	55.2	28.2	CDP, n.d.; *2023 Climate Report*. n.d.
Berkshire	-	39	*2021 ESG/Sustainability Quantitative Information,* 2022
Brookfield	-	0	*Accelerating the net-zero transition*, n.d.
Calpine	-	43.6	*2021 Sustainability Report*, n.d.-b
Consumers Energy	-	14.3	*CMS Energy to Combat Climate Change*, 2022
DTE	38.1	26.5	*DTE Energy Company—Climate Change 2021*, n.d.
Duke	-	77.4	*Duke Energy details clean energy transition in impact report*, 2023
Energy Harbor	-	-	*Building a Sustainable Future*, n.d.
FirstEnergy	-	16	*Climate Report*, 2022
Entergy	34	35.5	*2012 GHG Inventory*, 2013; *Entergy's path to net-zero emissions*, 2022
Evergy	-	26.1	*2021 Sustainable Transformation*, 2022
Exelon	-	8.3	*Exelon Sustainability Report 2022*, n.d.

NextEra	-	42.4	*2022 Environmental Social & Governance Report*, 2023
NRG	-	36.6	*2022 Sustainability Report*, 2023
PG&E	-	2.5	*Our Commitment,* n.d.; *Electric Company ESG/Sustainability Quantitative Information*, 2022.
SCE	-	1	*Countdown to 2045,* 2023; *Electric Company ESG/Sustainability Quantitative Information*, 2023.
Southern	100	82.5	*Planning for a low carbon future*, 2018; *2021 CDP Climate Change Disclosure*, n.d.
TVA	81.2	38.4	Tennessee Valley Authority, n.d.; *2021 EEI ESG/Sustainability Reporting Template*, 2022b.
Vistra	-	94.8	*Sustainability Report 2022*, n.d.

Table 5 lists the annual rate of change in emissions for years of available data from power companies first listed in Table 3. Where data was not available in a consolidated format, the calculation was not performed and a dash is listed in the table.

Regarding the absence of data for certain companies and time periods:

- The three public power districts in Nebraska (LES, NPPD, OPPD) do not self-publish consolidated emissions for their operated assets. The data for 2021 was pulled from FLIGHT, and is based on current ownership.
- Brookfield, an independent power producer that is a subsidiary of the larger investment firm, primarily invests in and provides renewable energy (e.g., solar, wind). Emissions data was not published publicly until 2020.
- Energy Harbor represents a segment of FirstEnergy Corporation, another power company, that was divested into bankruptcy and emerged as the standalone company, Energy Harbor in 2020.

Table 5. Rate of change in emissions 2012-2021 by company.

Company	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021
AEP	-6%	7%	-16%	-9%	-23%	-5%	-15%	-24%	14%
Dominion	-	-	-	9%	-19%	-8%	15%	4%	-6%
LES	-	-	-	-	-	-	-	-	-
NPPD	-	-	-	-	-	-	-	-	-
OPPD	-	-	-	-	-	-	-	-	-
Xcel	-4%	2%	-2%	-7%	-3%	0%	3%	-14%	-7%
Ameren	-40%	-7%	-7%	-6%	13%	-2%	-17%	6%	9%
Berkshire	-	-	-	-	-	-36%	-2%	-9%	1%
Brookfield	-	-	-	-	-	-	-	-	-21%
Calpine	-	-	-	-	-	-	3%	10%	-4%
Consumers Energy	-	-	-	-	-	-	-26%	-16%	26%
DTE	3%	-7%	-1%	-12%	0%	7%	-10%	-20%	8%
Duke	-	-	-	-1%	-3%	0%	-11%	-21%	5%
Energy Harbor	-	-	-	-	-	-	-	-	-
Entergy	-2%	0%	-6%	12%	-6%	10%	-6%	-5%	10%
Evergy	-	-	-	-	-	-	-	-	-
Exelon	-	-	-	-	-	-	-1%	-10%	-3%

NextEra	-	-	-	-	-	-	19%	-13%	-2%
NRG	-	-	-13%	-23%	-3%	0%	-13%	-26%	46%
PG&E	-	-	-	-	-	10%	-1%	3%	-3%
SCE	-	-	-	-11%	-21%	-42%	27%	7%	-33%
Southern	0%	17%	-15%	0%	-2%	5%	-14%	-15%	10%
TVA	-11%	7%	-9%	-1%	-10%	-2%	-6%	-28%	-6%
Vistra	-	-	-	-	-	-17%	-11%	-6%	-4%

- Exelon has undergone a change in operations, due to a sale of the generation business (now known as Constellation) in 2022, and is now functioning primarily as a transmission and distribution company. Constellation is excluded from this dataset given that the company's standup took place in 2022 and that is outside the time period being reviewed.
- Similar to Exelon, FirstEnergy has undergone changes in operations, primarily the spin-off of Energy Harbor (mentioned above) in 2020, which eliminated several coal-fired and nuclear power stations from FirstEnergy's fleet of operations.
- Many utilities publish lists of their current fleet as part of overall corporate governance and transparency measures, though obtaining verified listings of historical fleets and ownership is discernible through reviews of owners listed in EPA filings which are found through EPA FLIGHT. The ownership percentages are not listed in the EPA filings, however. Depending on calculation methodologies for non-EPA filings, companies can exclude facilities based on the

ownership percentage. To eliminate uncertainty in ownership and as a result uncertainty in emissions, where published data was not made available for certain years by the company itself, no values were included.

- SCE & PG&E noted a change in methodology for calculating emissions beginning in 2019, associated with requirements in the state of California (SCE, 2019). This resulted in roughly a 2% reduction in reported emissions.

Specific Aim 3 – Relationship Between Goals and Action

To analyze the relationship between goals and action set in aims 1 and 2, a series of analytical tests were performed to determine statistical significance.

Federal

A Pearson correlation coefficient was calculated for the U.S. annual emissions from 2012-2022 to assess the linear relationship, and a strong negative correlation was noted, with $r(9) = -.94$, $p = .165$. The strong negative correlation indicates that as the years pass, emissions from electrical generation decrease, although it is not statistically significant. Figure 5 visualizes emissions over time with a trend line.

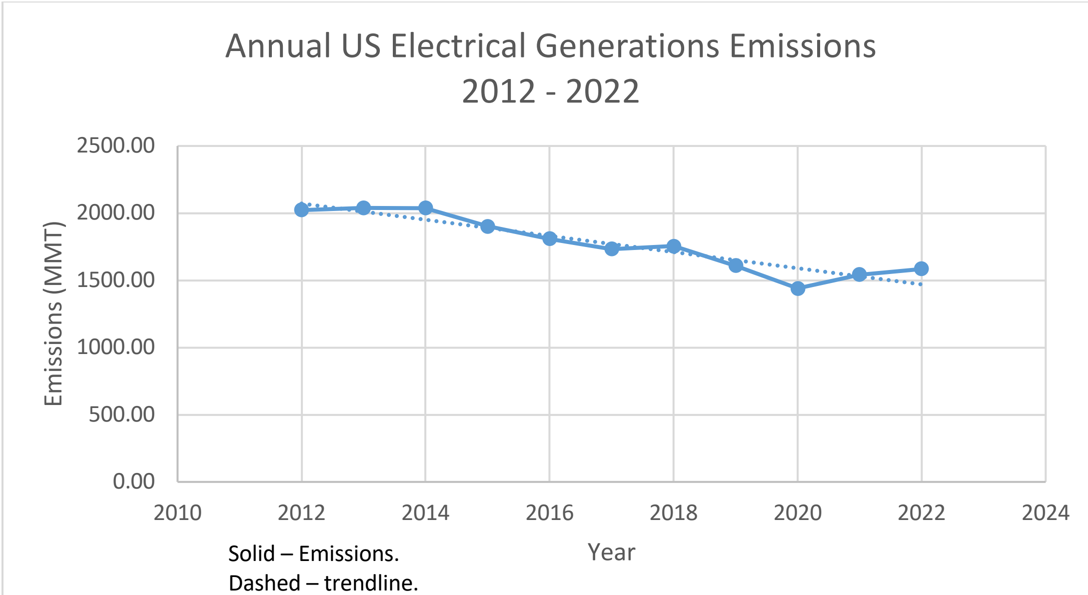

Figure 6. Annual U.S. electrical generation emissions from 2012-2022.

The U.S. goals were announced in 2021, and in 2022 emissions rose approximately 3%, per EPA FLIGHT datasets. Given that at the time of writing, only one year of data was available post-goal setting, it is unlikely that any statistical test of the year over year emission changes will be of any value.

States

A two-tailed t-test with an unequal variance was performed to analyze the difference in emissions for states with goals and states without. The actual percent change in emissions from 2005-2021 was calculated for each state, with the two populations being states with goals ($n = 22$), and states without ($n = 28$). Note that the District of Columbia, while included for qualitative purposes, was excluded from this statistical analysis as it is not a state. These populations are not paired, because the rate of change is being measured for states (and one city) that have chosen to enact emission reduction goals and those that have not. 2005 was selected as the starting year in alignment with the overarching federal goal (the base year for emissions reductions is 2005).

States with goals had an average 15% decrease in total CO_2e emissions from 2005 to 2021, while states without goals had an average 17% decrease in total CO_2e emissions over that same time period. The median decrease in total emissions for states with goals was 20%, while 26% for states without goals. The two-tailed t-test with an unequal variance returned a value of $p=0.394$, indicating there is not a statistical difference between the emissions reductions of the two populations.

Given that there were only three companies with legally binding goals (AEP, Dominion & Xcel), the originally planned statistical test comparing voluntary and legally binding goals could not be performed.

Specific Aim 4 – Decarbonization Forecasting

In 2021 the US voluntarily committed to the public that the country would have a carbon pollution free grid by 2035, in parallel with setting the NDC target of a 50-52% reduction in total economy CO_2e emissions by 2030 (*President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target*, 2021). At the end of 2021, the emissions associated solely with electrical generation totaled 1,542 MMT of CO_2e (EIA, 2022). This means to reach a carbon pollution free grid in 2035, the US would need to steadily decrease electrical generation related emissions by approximately 7% (110 MMT CO_2) each year to reach zero emissions.

In 2022, the US electrical generation related emissions increased by 3% from 2021 emission levels, to 1,585 MMT of CO_2e due to an increase in demand for electricity and a higher proportion of that electricity coming from coal (*EPA Facility Level*

Information, 2023). 2021 to 2022 was the first rise in coal generation since 2014 (EIA Monthly Review January 2022). Given the recency of the implementation of the 2035 goal, the immediate rise in emissions, however small, is cause for concern.

Figure 7 demonstrates the anticipated emissions reductions based on planned closures (as published by EIA in December 2023, as part of a summary of Form 860s) of major fossil fuel emitting sources (primarily coal facilities) alongside the projected average reductions to meet the carbon free grid goal for 2035.

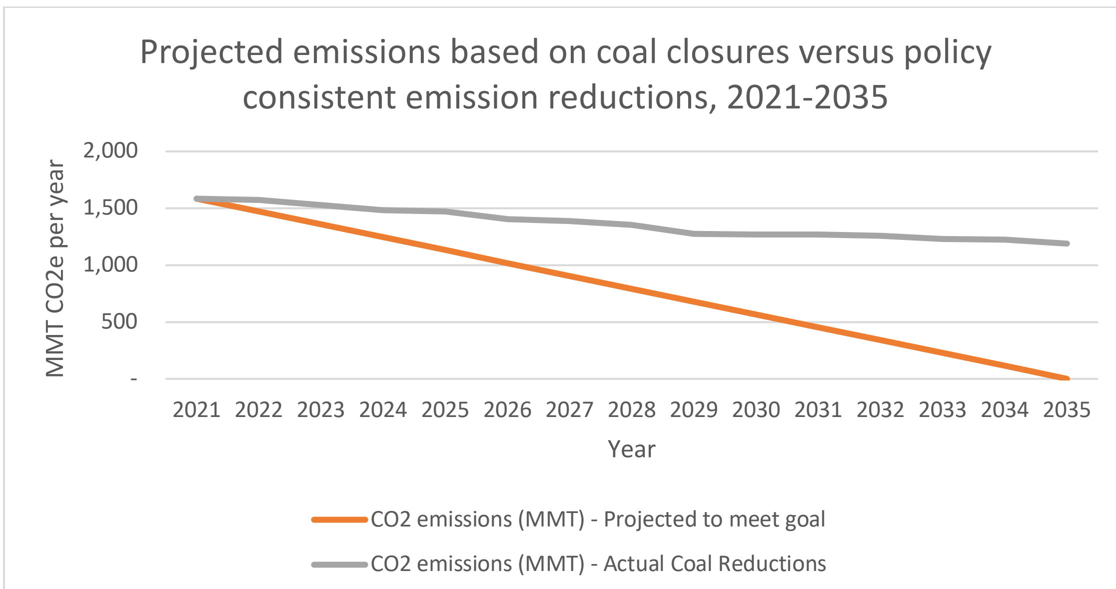

Figure 7. Projected emissions based on coal emission elimination versus policy consistent emission reductions.

The focus on coal closures in Figure 6 is due to the general emissions intensity of coal operations. At the time of analysis, based on data published in October 2023 by EIA, there are 63 natural gas facilities scheduled to close by 2035, (EIA, 2023d). In comparison there are 102 coal facilities scheduled to close by 2035 (EIA, 2023d). There are also 132 projects with varying natural gas powered technologies slated to be built between 2023 and 2027 with no new coal facilities slated to be built in that time (EIA, 2023d). The lack of natural gas facility closures and continued new natural gas fired generation facilities results in a projected gap of 1,189 MMT of CO_2 which would prevent the US from reaching the 2035 carbon free grid goal.

The projections above assume no increase in demand for electricity over the forecasted period. However, it is not reasonable to assume that demand will not increase, given the increased focus on retrofitting commercial and residential buildings for electric heat and water heating, and incorporating electric vehicles for both commercial and personal use (EIA, 2023c). Population growth in the US has slowed in recent years, but any future increases in population would lead to increased demand for electricity (Jarosz, 2023). In its 2023 International Energy Outlook, the EIA stated that continued population growth and gross domestic product (GDP) growth will both offset any decreases in energy and carbon intensity emissions; that is, while emissions intensity will continue to decrease, because of the overall increase in demand, emissions will continue to rise (*International Energy Outlook 2023*, 2023).

Figure 8 visualizes potential emission pathways for a low-, high- and standard emissions pathway. The starting point for all three pathways was the 2021 emissions figure (1,542 MMT CO_2e), converted to metric tons. The pathway that approached the US' 2035 carbon pollution free grid goal is the low emissions pathway, with an estimated 120 million metric tons of CO_2e. The standard emissions pathway, which attempted to forecast emissions in line with current trends, landed at 436 million metric tons, while the high emissions pathway, which demonstrated a potential pathway if emissions are reduced more slowly, forecasted 834 million metric tons in 2035.

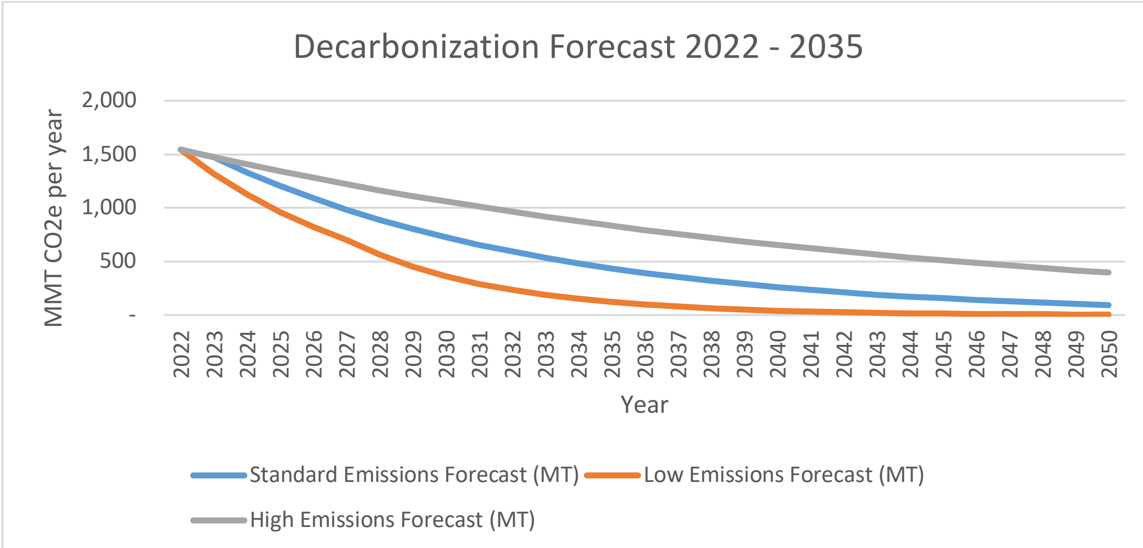

Figure 8. Decarbonization forecast 2022-2035.

Chapter IV

Discussion

The primary question driving the hypotheses I proposed was whether or not the US will meet its decarbonization goals for 2030 and 2035. The answer should be straightforward, but understanding the reason behind the answer is complex at best. Understanding how electricity is generated, and the overlapping jurisdictions of regulators and reporting requirements for electrical generation, both voluntary and legally required is really just the start. Electricity is a layered and nuanced business, and setting goals to reduce emissions from electrical generation is complex as a result.

Goals

Several sets of goals are in place in the United States, and nearly all of them conflict. In addition to the conflict, it is unclear how effective these goals are in spurring emission reductions.

Federal Goals

As outlined previously, the US has set a series of emission reduction goals at the federal level, two of which are the focus for this analysis (emission counts added by author for context):

1. The US will reduce CO_2e emissions 50-52% below 2005 levels by 2030 for the entire economy (2005: 6.6 billion metric tons of CO_2e total economy, 2.4 billion

metric tons from electrical generation; goal: 3.3 billion metric tons of CO_2e total economy, 1.2 billion metric tons from electrical generation).

2. The US will have a 100% carbon pollution-free electrical grid by 2035.

However, the federal goals set by the US do not have an active tracking mechanism or public plan to transition out electrical generation facilities with high emissions or phase in carbon free generation facilities to replace them. The administration states that these goals are ambitious, but does not provide context as to why the goals are described as such (*The Long Term Strategy of the US*, 2021). Based on the internationally accepted science, the 2035 goal is in line with the net zero 2050 goal, and is stated to be in line with domestic policy (based on scenario analyses) to meet both the 2030 and 2050 goals, which would indicate the goals are reasonably planned (*The Long Term Strategy of the US*, 2021). It could be that because there is not a defined step-by-step plan at the federal level (e.g., an RPS that requires CO_2e intensive electricity generation activities be closed by some year prior to 2030 to spur immediate emission reductions) that sets out specific timelines with stakeholders engaged and given appropriate buy-in that the goals feel lofty to achieve.

At the time of writing, the EIA and EPA have continued to publish annual emissions summaries. While there have been regular policy updates and funding releases to further emission reductions in residential and industrial operations, there has not been a formal update from the administration on where the country stands in meeting its 2030 and 2035 commitments since the publication of the goals in 2021. Regardless of any interim updates, the UNFCCC mandates updated NDCs every five years, so the US will be required to provide some sort of status and timeline on emission reductions in 2026 (five years from 2021, original submission) (*The Paris Agreement*, n.d.).

It is also important to highlight that the 2030 goal is the country's nationally determined contribution (NDC) to the Paris Agreement, while the 2035 goal is a commitment made outside the NDC framework as part of an executive order (Executive Order 14008, 2021; *The Long Term Strategy of the US*, 2021). This means that while the 2035 goal is considered legally enforceable due to its inclusion in Executive Order 14008, and the development and submittal of the NDC is, the NDC itself is not (*Enforceability of US NDC,* 2017). For the 2030 NDC however, there is an element of international tension and social pressure to meet the set contributions for each of the participating nations (*Enforceability of US NDC,* 2017; Stankovic et al., 2023). It is not clear at this time what missing the 2035 goal would mean from a legal perspective.

Based on the data published by EIA and EPA to date, it is difficult to decisively say whether or not the US will make the stated goals by 2030 and 2035 due to a short trendline. With the national goals being set in 2021, in the midst of a tumultuous and difficult global event, total economy emission trends, as well as electrical use and associated emissions are rebounding and settling into a new pattern, similar to the carbon dioxide equivalent emissions rebound after the 2008 financial crisis (Davis et al., 2022). It is reasonable to say that if this low annual rate of reduction continues and does not ramp up further, the US will likely not meet either decarbonization goal and will likely need to re-evaluate and potentially reset the NDC.

Emission trends. Prior to 2020, CO_2e emissions from electrical generation were steadily decreasing, with the only increase of 1% coming in 2017-2018. CO_2e emissions dropped 10% from 2019 to 2020, which can largely be attributed to the dramatic shift in day-to-day activity because of the impacts of COVID-19 (EIA, 2023). In 2023, the National Institute of Health (NIH) published a study that reviewed total economy CO_2e emissions trends from ten countries with the highest total economy CO_2e emissions, and found that while CO_2e emissions were reduced in the short term, and primarily during the months with highest infection rates (April 2020), total CO_2e emissions for the full 2020 year to the atmosphere were not impacted or reduced in a meaningful way (Ronaghi & Scorsone, 2023).

The United Nations (UN) Department of Economic and Social Affairs had similar findings, and the December 2020 economic analysis briefing stated that while there was a pronounced dip in total economy CO_2e emissions, again specifically citing April 2020 as the month with lowest emissions, total economy CO_2e emissions had rebounded by the second half of the year (*Monthly Briefing*, 2020). The International Energy Agency has also projected that after a dip in 2023, electricity demand will increase by 2.5% in 2024, and continue to increase an average of 1% in 2025 and 2026 (*Electricity 2024*, 2024). An increase in demand, alongside

All three of these publications readily align with CO_2e emissions from electricity rebounding in the US after the quarantine period of COVID-19 in 2020 subsided. In 2021, emissions from electricity generation increased 7% from 2020 (EIA, 2023b). In 2022, emissions from electricity increased again by 3% relative to 2021 electrical generation related emissions, which is out of line with the planned emissions trend to meet the decarbonization goals (EIA, 2023b).

Something obvious that is missing from the federal goals is a tie-in or any sort of tangible link between the subsets of state emissions and power company carbon emissions. The federal goals appear to exist in a sort of vacuum, without a clear mechanism to at least encourage, or at the most mandate, states or large utilities to reduce electrical generation related carbon emissions by 2030 and 2035. Electricity is regulated not only at the federal level by FERC, but at the regional level by each of the ISOs and RTOs, and within each state as well. Supply and demand, and while the federal government sets permitting terms for these facilities, the approval of new electrical generation facilities and retirement of old facilities are managed by each of the ISOs and RTOs, effectively stripping any federal mechanism to enact or enforce the national goals to rapidly change the generation fleets nationally. The Inflation Reduction Act (IRA), implemented in 2022, provides funding for clean energy (defined as wind and solar primarily) construction and implementation both to states and directly to companies, but there is no provision or requirement in the IRA that ties new clean energy construction to the shutdown of CO_2e intensive facilities or to limit emissions from these types of facilities (*Closing the Gap*, 2023). A potential interim goal or target the administration could consider, is phasing out coal nationally by 2030, or that electrical generation related carbon emissions in particular will be 75% below 2005 levels by 2032. An interim target in line with the original NDC and the carbon pollution free target would enhance performance and likelihood of achieving those two original goals, and give more opportunity to course-correct if operationalizing the goals has been delayed.

Additionally, EIA and EPA utilize different methodologies in their GHG calculations, and report in different units (CO_2 and CO_2e, respectively) which may seem "close enough" but represent different things (Greenhouse Gas Reporting Program, n.d.). This dissonance may seem minor, but combined with different reporting protocols circulating for voluntary carbon emissions reporting and more comprehensive and mandatory emissions reporting (GHG Protocol and EPA regulations 40 CFR Part 98, respectively) the differences between what a company publishes in relation to its own goal could look different than what is reported under mandatory permit requirements and cause confusion among data consumers. The EPA also currently recommends that reporters utilize the AR4 100-year global warming potential values (GWPs) and uses that in their own publications and calculations, which is out of sync with what is recommended by the IPCC, which is AR6 (published in 2021), which generates and publishes the GWPs (Greenhouse Gas Reporting Program, n.d.).

State-Level Goals

As stated in the results, 28 of the 50 states do not maintain any type of decarbonization or emission reductions goals. Figure 9 below visualizes the electricity CO_2 emissions over time from the eight states with the highest absolute electricity related CO_2 emissions, only one of which maintains a carbon emissions reduction goal of any kind (Pennsylvania). Per EIA from 2012 to 2021, Texas, the state with the most absolute CO_2 emissions from electricity, decreased CO_2 emissions from electricity by about 20%, but have hovered around 200 MMT of CO_2 annually in that period. Based on EPA publications, Texas carbon emissions from electricity increased to 193 MMT of CO_2e in 2023 (FLIGHT, 2023).

With only two states legally bound at the time of writing to meet the 2035 national voluntary carbon free grid goal, that means that approximately 1% of the electricity related emissions from 2021 (16.71 MMT CO_2e) are legally obligated to be eliminated before 2035. To that end, if one looks at progress towards the overall 2035 national goal based solely on how the states are progressing in electricity related carbon emissions reductions, it seems unlikely that the US will make the 2035 goal.

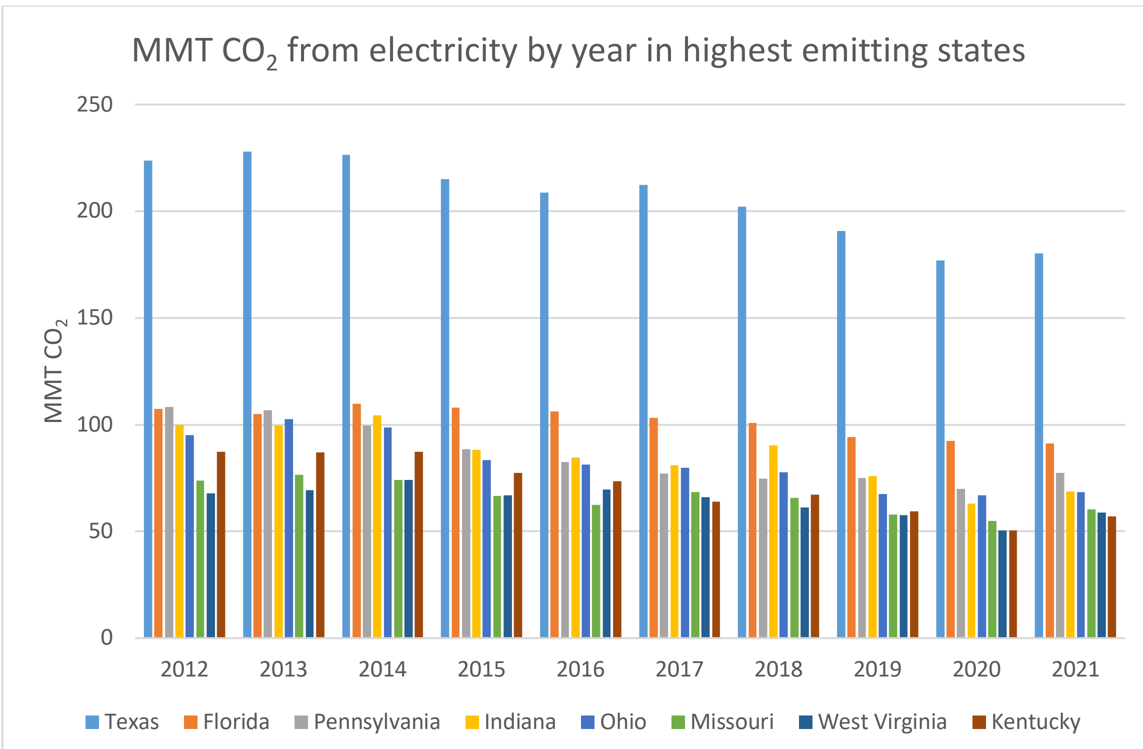

Figure 9. MMT CO_2 from electricity by year in highest emitting states (EIA, 2023b).

Additionally, the difference between the rates of decarbonization for states with goals and states without was not statistically significant. Those states without goals had a 17% reduction in CO_2e emissions from 2012 – 2021, while those states with goals had an average decarbonization rate of 15% over that same time period. Because of their larger population sizes, the 28 states without goals were responsible for two thirds of 2021 emissions (roughly 1 billion metric tons of 1.5 billion metric tons of CO_2) not being obligated in some fashion to reduce over time (EIA, 2023b). The 2030 US emissions reduction goal (50-52% below 2005 levels for the entire economy) roughly translates to 1.2 billion metric tons from electrical generation (EIA 2023b). This means that if nothing else changed in terms of electricity related CO_2 emission outputs from the states without emission reduction goals, over two thirds of the 2021 electricity related CO_2 emissions from states with goals would need to be eliminated over the next six years (EIA, 2023b). This translates to a roughly 16% decrease in electricity related CO_2 emissions year over year for those states with emission reduction goals, which is slightly higher than the 15% average found from historical emission trends. The closeness of the historical emission reduction (decarbonization rate) rate from the states with emission reduction goals to the projected policy aligned reduction rate seems lucky, rather than planned, and speaks to the need for more intentional planning by the federal government to meet these goals.

Further, the states that do not have emission reduction goals include nine of the twelve states with the highest electric related emissions, and those nine states alone represent 43% of the 2021 emissions in the US related to electricity. In contrast, the states with emission reduction goals, specifically for electricity emission reductions, in total (all 22 states) represent about 33% of the electric related emissions in 2021. When the starting population is that much smaller, the reductions will be much smaller overall. In turn, while the larger population in this scenario is not intentionally forcing change, but change is happening anyway, the reductions will make more of an impact. In many cases, utilities and power companies cross state lines, and if those companies have emission reduction goals, their emissions should reduce over time regardless of what the state the company is operating in is legislating, so the state emissions profile will change as the companies change.

Additionally, the majority of state goals were enacted between 2019 and 2022, with the earliest state goal (net zero electric emissions by 2045) being set in 2015 by Hawaii (HB 1800, 2022). In contrast, New York, which has one of the more comprehensive and transparent communication strategies around their emissions reduction goals that includes a dashboard of total economy and sector specific emissions that is updated quarterly, enacted their goal in 2019 (SB6599, 2019). California enacted their goal in 2018 and has passed subsequent legislation to reduce emissions overall in tandem to the electric emissions reductions (*SB 100 Joint Agency Report*, n.d.). With such recent goals, and with published data for 2022 and 2023 not consistently available at the time of writing, detecting the impact of the goals set in 2020 and beyond with 2021 data is likely not achievable.

This is all to say, that even though the difference in decarbonization rates between states without goals and states with goals is not statistically significant at this time, this does not mean decarbonization goals are ineffective at the state level. Repeating this analysis in a year's time, or five years' time may show something entirely different and demonstrate that states with goals are decarbonizing their energy use at a statistically significant rate compared to states without goals.

Renewable portfolio standard. The renewable portfolio standard (RPS), mentioned briefly in the introduction, is an important regulatory tool for the transformation of electrical systems globally and the United States in this case. An RPS speaks directly to the amount of renewable energy that is being constructed and put into use (EIA, 2022). While the use of renewable energy sources is intrinsically tied to the reduction of electricity related CO_2 emissions, the concept of a required minimum required amount of renewable electricity capacity in a certain regulated area (e.g., a state) is different than requiring the reduction of electricity related CO_2 emissions. Electricity related CO_2 emissions can be reduced through other means, including stricter permit limits on emissions and associated technology (e.g., a scrubber placed on a stack), or carbon capture systems (if permitted as an acceptable technology solution under the specific goal) (*Closing the Gap,* 2023). Many of the states (e.g., Pennsylvania) with decarbonization targets also have an RPS in place, which undoubtedly has hastened progress towards the decarbonization goals. However, the goal of this analysis was to gauge the effectiveness of emission reduction goals, and for that reason the RPS mechanisms in place in individual states were excluded from the analysis.

What this analysis does demonstrate though is that with the majority of state goals for carbon pollution free grid or 100% renewable energy being set for 2040 or beyond, there is a clear lack of alignment with the federal goals and perhaps a need for a federal RPS as a potential aid to meeting the federal goals. On its own, the misalignment between the 22 states with goals indicates that the federal goals may not be met on time as a result. Paired with the fact that the majority of states, particularly those with the highest electrical generation related emissions, do not maintain any type of emissions reductions goal for electricity, a stronger argument that the federal goals for 2030 and especially 2035 will not be met based on currently available data.

Companies

There are a number of layers of regulations to consider for electricity, emissions and goals. Electricity is regulated nationally, regionally, at the state level, and sometimes locally depending on the location. Electricity is not generated centrally, but by companies that span geographies, and because of this are required to mind several sets of regulations depending on the region in which their assets are located. Stakeholders, including large energy purchasers like manufacturing companies and chemical companies, are aware of the regulatory soup that electric generating companies and utilities are subject to, made clear in a survey published by PwC by stating that regulations and government policies as a key concern or roadblock to progress in meeting their own corporate sustainability goals (PwC 2023 US Large Energy User Survey, 2023).

The companies were intentionally selected to incorporate a variety of approaches to decarbonization as well as the complexity in regulatory requirements. Figure 10 visualizes the geographic coverage of the states the companies included provide power to. 80% of the states are covered by the companies selected, along with CAISO, ERCOT, NYISO, MISO, NEISO and PJM all having generation participants included in the analysis. The highlighted states indicate operations by a utility or power company selected and included in the analysis.

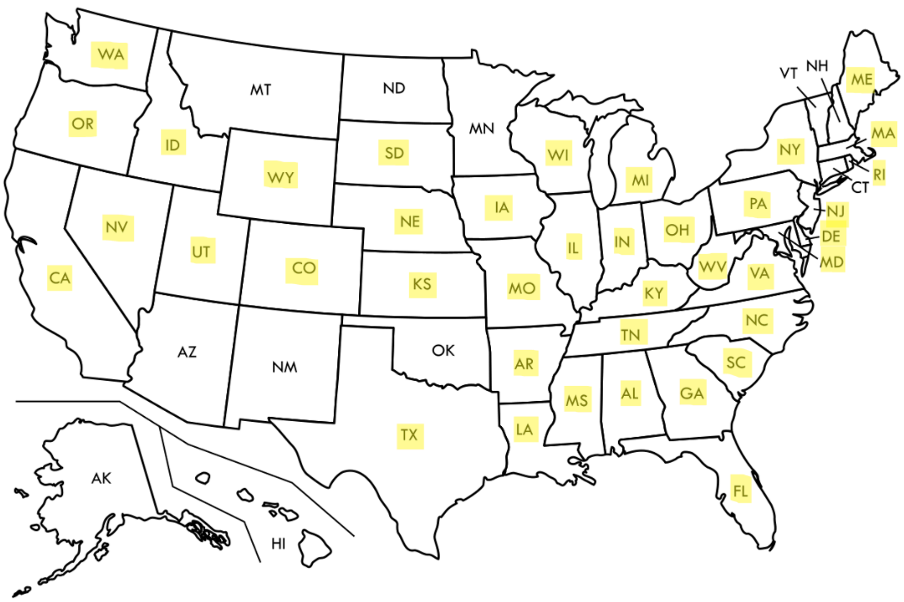

Figure 10. Operating states for selected companies.

Company Goals

As mentioned, there are two types of emission reduction goals that affect power and utility companies: legally binding and voluntary. State or federal goals are not inherently legally binding just because they are set by a state or federal leader, but as described in the previous section all the state emission reduction goals currently enacted are legally binding or enforceable, because the goals are tied specifically to legislation passed by the appropriate regulatory bodies and signed into law by governors, or by executive order and again signed by the governor and enforceable in a court of law.

In a few cases, the legislation and subsequent goal or target has called out a specific electric provider or utility, but in many cases the goal does not have this level of specificity. While outside the scope of this analysis, many states (with and without emission reduction goals) leverage an RPS with minimum requirements for portfolios to include renewable energy sources to accelerate a shift in energy production with companies.

The majority of companies included in the analysis have self-selected and voluntarily committed to reducing emissions. The majority of these companies commit to a net zero by 2040 (1 company), 2045 (6) or 2050 (12) goal, while a smaller grouping set specific 2030 or 2035 (2) emission reduction goals from a baseline. One of the more interesting goals was published by Consumers Energy. Consumers Energy has committed to be coal free by 2025, accelerating a previous commitment to close the company's coal operations by 2040 (Environment: Take a Stand for Michigan's Future, 2024). In a search of similar "coal free" type goals for power or electric companies, no other results were found. However, in Illinois, while specific power companies are not named in the state regulation to meet specific emission reduction requirements, the regulation requires that all privately owned coal and oil power generation to be "zero emissions" by 2030, and the publicly owned coal and oil power generation to be "zero emissions" by 2045 alongside interim 2035 goals (*Gov. Pritzker Signs Transformative Legislation,* 2021).

Published Data

The majority of companies included in the analysis, excluding the three public power districts in Nebraska, publish some amount of emissions data each year through a corporate sustainability report (CSR) or sustainability report. Several of the companies, including Southern, Dominion and Xcel, also publish data through CDP, as part of the annual Climate Change questionnaire companies can opt-in reporting to. All of the companies included are required to submit emissions data under their facilities Title V

Operating Permits, which is the data source the EPA utilizes for the FLIGHT dashboard referenced throughout this analysis.

Unless otherwise stated, the data for the power company analysis was pulled from self-published CSRs and other company publications. This decision was made partially due to ease of access, but largely to fully understand how the companies selected were discussing and publishing their emissions data. While this analysis is largely quantitative, having a full understanding of not only what the emissions data is, but how the companies responsible for the emissions and the goals craft the narrative around the two things is also important. For example, if a company is publishing that they are reducing emissions 10% year over year, and achieving goals in a short amount, but in the back appendices of their CSR in their data tables they disclose that they only emit 10 tons of CO_2e to start with and their goal is to get down to eight tons of CO_2e, then while that achievement is still important, knowing the numbers grounds the reaction of the reader.

Trends

For those companies with published emissions data, a graph that visualizes the emissions for 2018-2021 is presented in Figure 11. A table summarizing the values presented in Figure 11 can be found in the Appendix.

Due to the lack of available consolidated emissions data from LES, NPPD and OPPD, those three power districts have been left off the graph. Additionally, Brookfield Renewables has also been left off for two reasons: one, consolidated emissions data was not available for 2018 and 2019, and secondly, the consolidated emissions data available for 2020 and 2021 was so low in comparison to the other companies presented, that it was not easily presented and skewed the presentation of the other companies included. It is also important to note that where there years of data missing and there is not a bar included on the graph (e.g., for Evergy 2018-2019 data is not shown) the absence of data that does not indicate no emissions for that period, and only indicates that no consolidated emissions data was available at the time of writing. No inquiries about data availability were made with the companies included in the analysis, as the intent of this portion of the analysis is to primarily understand how companies are publicizing their respective decarbonization narratives and goals. A number of the companies included in the analysis either did not publish emissions data for a number of years early on in the period, making 2018 the first year the majority of companies published data and therefore the graph starts in that year (Figure 11).

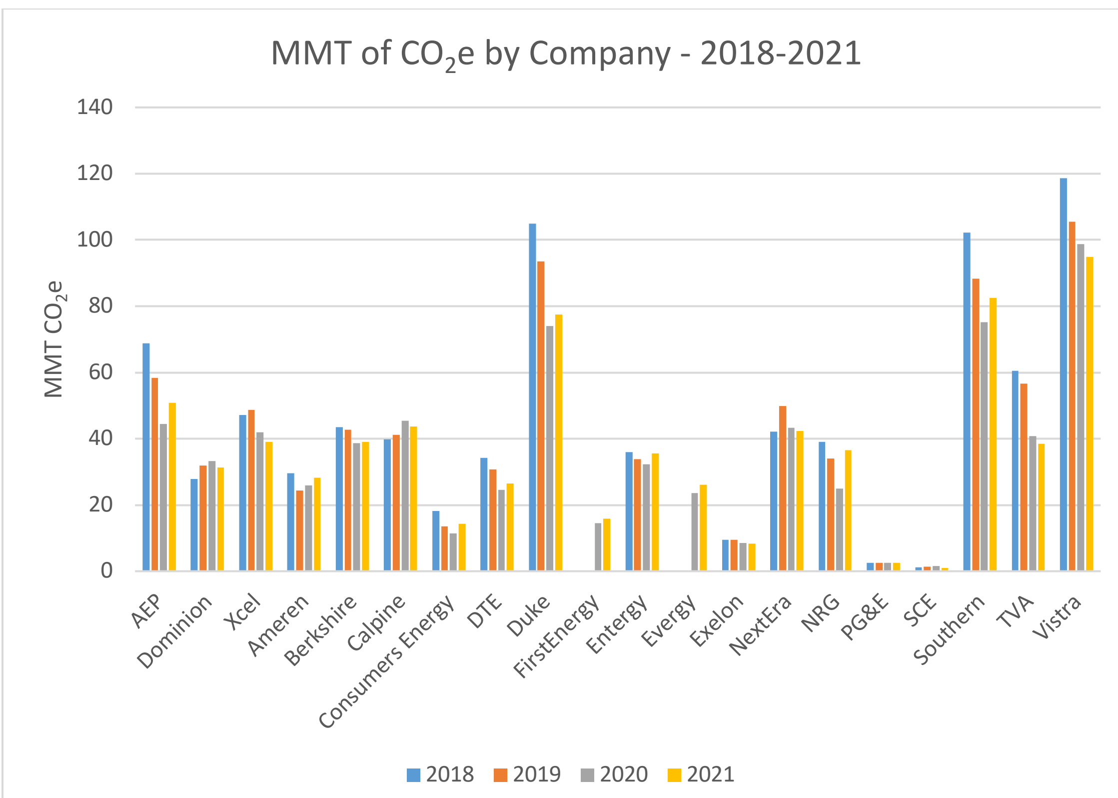

Figure 11. MMT of CO_2e by company – 2018-2021.

Figure 11 demonstrates a lack of a consistent trend for nearly all companies shown over the full four-year period. While there is a general downward trend seen in many of the individual companies over the four-year period, as with many of the state emissions, in 10 (AEP, Ameren, Consumers, DTE, Duke, FirstEnergy, Entergy, Evergy, NRG and Southern) of the 20 companies, there is an increase from 2020 to 2021 in published emissions. Given that AEP in particular has a legally binding net zero goal, any increases over time are cause for concern, but overall, the fact that half of the companies analyzed demonstrated an increase from 2020 to 2021 is cause for question of commitment and progress to those stated goals.

Dominion, another company with a legally binding net zero goal alongside a voluntary interim goal for 2030, demonstrated increases consistently in its published emissions through 2020, and then a slight decrease in 2021. Calpine exhibited the same pattern in their published emissions over the same years. Similarly, Ameren demonstrates increases steadily in 2019-2021 after a dip from 2018 to 2019.

Berkshire and Exelon both present as holding their published emissions as relatively stagnant in 2020 and 2021, as do PG&E and SCE. The companies with consistent decreases in published emissions over the four-year period are Xcel, TVA and Vistra. Based solely on this figure, one might make the conclusion that those three companies are decarbonizing successfully. A closer look at the three companies over a longer time period is presented in Figure 12. Data for Vistra were not available for years prior to 2017.

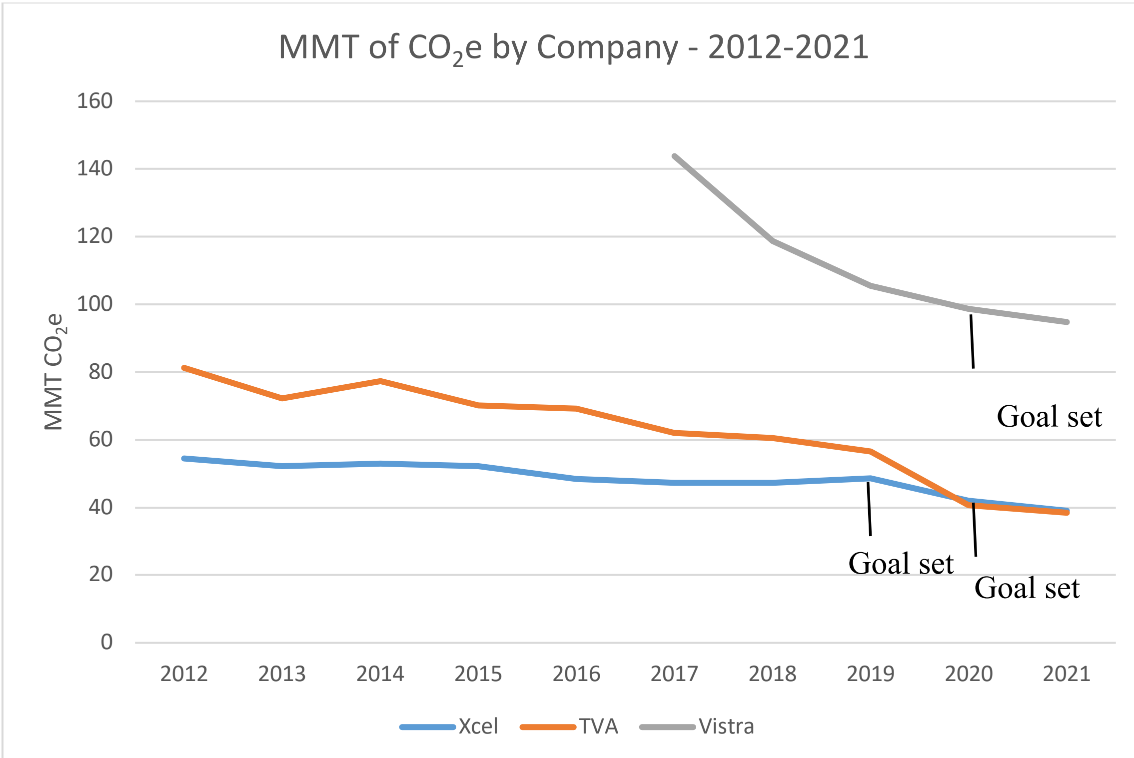

Figure 12. MMT of CO2e by company – 2012-2021.

Figure 12 is annotated with when goals were set for each company. For TVA and Vistra, based on the published emissions it is clear the companies had a strategy in place before the goals were set that set the companies on a path to reduce emissions. The Xcel published emissions have a clearer inflection point when the legally binding goal was set, indicating a potential reaction by the company to meet the moment.

After denoting where the goals came into play for each company, similar to the state emissions curves, it is not possible to definitively say whether or not the goals are effective. For two of these three companies, only one year of data is available after the goal was set. For Xcel there are two years of data, so the conclusion that the goal is driving decarbonization can be a slightly more informed, but is still not a strong conclusion. Additionally, while the year over year decrease of these companies' published emissions is encouraging, the goals set are not aligned with the overall federal goal for a carbon pollution free grid in 2035.

In all three companies' (TVA, Vistra, Xcel) recent publications that discuss their decarbonization strategies and published emissions, there is a consistent narrative that places regulation and reliability front and center. All three put forth a vision that drives innovation, decarbonizes consistently year over year and includes technological advancements that are yet to come. TVA summarizes this sentiment well in the company's 2022 sustainability report:

> "Fluctuations in year-over-year carbon emissions numbers are expected as TVA works toward its aspirational goal of net-zero by 2050. TVA recognizes the challenges and opportunities presented by the clean energy transition." (*FY 2022 Sustainability Report: Delivering Sustainable Solutions*, 2022).

Electricity does not exist in a vacuum, and electric companies, whether public or private, are reliant on technological advances and updates to regulations that allow those advances to be implemented in a reasonable timeframe, in their words. The key word in the quote from TVA's report is aspirational. It indicates a preemptive acceptance of the status quo energy system not changing in time, despite companies having the power to change their energy sources. So long as companies are compliant with applicable regulations, and meet the required reliability and other NERC standards, it does not matter what energy source is used, so long as the energy is available to be put into the grid on demand. The use of the word aspirational signals that companies are unwilling to make the jump and are relinquishing autonomy in changing their energy sources in favor of other drivers. This consistent framing exacerbates my doubt of the commitment to meeting these stated decarbonization goals by the companies included in the analysis.

Federal Regulation

The aspirational framing ties back to federal regulations and overall management of the decarbonization process in the electrical generation sector in the United States. The prior sections outlining the state and company specific emissions reduction goals, and related trends in published emissions for both groups, sheds light on a disconnect between not only the federal goals with state and company specific goals, but also between all three groupings of goals and how regulations and approvals are currently functioning, resulting in a slowed ramp up to implementing more emission reduction opportunities in electricity.

Over the last several years there have been numerous articles and published decisions on changing coal facility closure timelines in the US. In 2018, in an interview with Utility Dive, an online energy sector news publication, a consultant from energy consulting firm The Brattle Group commented not only that "plant closure decisions can vary by region" but also that the decision to close a facility can be dependent on "market dynamics and renewable penetration, as well as the characteristics of the particular power plant" (Maloney, 2018). In 2022, Ameren, Alliant Energy and WEC Energy Group, delayed closures of several of their coal plants (one, two and one respectively) in Missouri and Wisconsin due to reliability concerns from the grid operator, MISO (Howland, 2022; Gheorghiu, 2022).

In 2024, TVA announced that the closure of one of their coal plants (Cumberland), scheduled for a 2026 partial and 2028 total closure (Howland, 2024). In the FERC filing, TVA urges the regulator to expedite and complete a review and approval of a new natural gas pipeline that would kick off construction on a new natural gas plant intended to replace the Cumberland facility (*Tennessee Gas Pipeline Company, L.L.C., Docket No. CP22-493-000*). TVA states in the letter to the agency that a delay in construction would not only cause a delay in closure, but also force the federal power company to incur additional costs to keep the Cumberland facility compliant with water discharge regulations and perform necessary upgrades, as well as put the net zero and 2035 80% emissions reduction goal for TVA in jeopardy (*Tennessee Gas Pipeline Company, L.L.C., Docket No. CP22-493-000*). While natural gas is not a zero-emission energy source and will not support the federal carbon-pollution free grid goal, the delayed approval of the pipeline and eventual (likely) delayed replacement of the emissions heavy coal plant further highlights a disconnect between the overlapping regulatory requirements in place for electric generation and how power companies are approaching decarbonization at this time.

While facilities and their operators (the power companies) need to be compliant with current environmental, security and reliability regulations as various levels (state, federal and grid operators) when the plant is running, there are almost as many regulations that dictate how and when (or if, as demonstrated by the TVA Cumberland case) a plant can be closed. Recently, what appears to the most commonly cited rationale for delaying fossil plant closures is impacts to reliability. In a targeted review of 2023 publications discussing impacts of closing fossil fuel fired plants, reliability and grid stability were continuously cited by industry groups and company leaders (Baldwin, 2023; Howland, 2023a; Howland, 2023b).

To that end, NERC has published a schedule of activities and is actively working to review and update the reliability standards used across the industry (Reliability

Standards Update Plan, 2023). The updates are scheduled to be complete on a staggered schedule, with some standards complete in 2023, and others in 2024 and beyond (Reliability Standards Update Plan, 2023). The standard updates cover gaps that touch on topics like model validation; planning and operational studies; and performance requirements (Reliability Standards Update Plan, 2023). While these standards are finalized and implemented, the updates and timing of those updates (and the fact that the request for updates to the standards was requested by FERC after the publication of the federal level goals), as demonstrated by the Ameren, Alliant and WEC closure delays, emission reductions and plant closures may continue to be delayed.

The standard review and update timeline highlights a disconnect between the federal goal for a carbon-pollution free grid and how regulations are followed and actioned by grid operators and power companies. Further highlighting and underlining this disconnect is the amount of capacity for renewable energy projects sitting in the queues of the ISOs and RTOs across the country. At the time of writing, per a consolidation of active interconnection queues, there is an estimated 1.3 terawatts of energy capacity waiting for approval (State of Interconnection January 2024, 2024). To put this into context, approximately 4.1 terawatts of electricity were consumed in 2021 (EIA, 2023a). Capacity in this context refers to power that can be generated (e.g., a wind turbine) or energy storage (e.g., a lithium battery), or a facility that would contain both generation and storage. Approval and implementation of all the capacity currently in the queue would undoubtedly shift the energy supply in the US and support reaching the stated federal goals. Outside the scope of this analysis is what that mass approval and implementation would look like to execute, and if that type of shift is even feasible for the US, with assumed manufacturing, logistical and workhour constraints.

Shifting regulations are not the only puzzle piece in misalignment with federal goals. Changes and increases in electricity demand impact the reliability needs, but also impacts how companies decide what types of projects to execute and build. The IEA has projected that after a dip in 2023, electricity demand will increase by 2.5% in 2024, and continue to increase an average of 1% in 2025 and 2026 (IEA, 2024). The IEA also stated that the primary drivers of these increases and models are increases in industrial activity (IEA, 2024). Given the focus in the US on electrification of vehicles, heating and other processes, it can likely be assumed that demand will continue to rise and models may change to reflect this (*The Long Term Strategy of the US*, 2021; EIA, 2023c).

Conclusions

There is a great deal of research to be done in the electricity emission reduction tracking and goal setting space. This research did not begin to cover all the facets and nuances of the electricity sector. It does draw the following conclusions, though.

If the United States does not accelerate emission reductions in the electricity sector in the short term (2-3 years most likely), it will not meet its 2035 carbon pollution free grid goal. It is also not likely, based on the existing trend, that the electric sector will meet its allocated emissions for the 2030 NDC total economy reduction. The vast majority of state electric emission reduction goals are not aligned with the federal electric emission reduction and total economy reduction goals, making achievement of the federal goals that much more difficult. In the relatively short time (approximately 2-3 years) from when the majority of sampled electric companies have set their goals, the associated relatively flat or erratic trendline for electric emissions from these companies does not support the conclusion that the goals will be met. There is also significant and demonstrable doubt that the power companies included in the analysis display a strong commitment to meeting their published decarbonization targets and goals based on their actions and emissions trends in recent years, and no one company pulls ahead as a leader over the others. There is an overall reduction in electric emissions across the US, but due to the year over year fluctuations in each state and overall minor reductions in electric emissions, no one region is decarbonizing electricity faster than another.

Appendix

Annual Electric Emissions by Company & State (in MMT of CO_2e)

Table 6. Annual electric emissions (in MMT of CO_2e) by company.

Company	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
AEP	122	115	123	103	93	82	69	58	44	51
Dominion	-	-	-	34	37	30	28	32	33	31
Xcel	54	52	53	52	48	47	47	49	42	39
Ameren	55	33	31	29	27	20	30	24	26	28
Berkshire	-	-	-	-	-	68	44	43	39	39
Brookfield	-	-	-	-	-	-	-	-	0.1	0.1
Calpine	-	-	-	-	-	-	40	41	46	44

Consumers Energy	-	-	-	-	-	-	18	14	11	143
DTE	38	39	37	36	32	32	34	31	25	27
Duke	-	-	-	109	108	105	105	94	74	77
Energy Harbor	-	-	-	-	-	-	-	-	-	-
FirstEnergy	-	-	-	-	-	-	-	-	15	16
Entergy	34	33	33	31	35	33	36	34	32	36
Evergy	-	-	-	-	-	-	-	-	24	26
Exelon	-	-	-	-	-	-	10	94	8	8
LES	-	-	-	-	-	-	-	-	-	1
NPPD	-	-	-	-	-	-	-	-	-	8
NextEra	-	-	-	-	-	-	42	500	43	42
NRG	-	-	60	52	40	39	39	34	25	37

OPPD	-	-	-	-	-	-	-	-	-	9
PG&E	-	-	-	-	-	2	3	25	26	2
SCE	-	-	-	3	2	2	1	1	2	1
Southern	100	100	117	100	100	98	102	88	75	83
TVA	81	72	77	70	69	62	61	57	41	38
Vistra	-	-	-	-	-	144	119	106	99	95

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Table 7. Annual electric emissions (in MMT of CO_2e) by state.

State	Electricity Related CO2 emissions (million metric tons)									
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Alabama	66.99	64.73	65.55	62.36	55.57	50.99	53.86	48.47	42.69	47.20
Alaska	3.13	2.65	2.91	2.95	2.76	2.79	2.69	2.72	2.74	2.80
Arizona	51.78	55.18	53.52	50.04	44.59	43.84	46.81	43.53	35.58	34.33
Arkansas	34.88	35.87	35.81	27.27	30.47	32.07	36.98	31.22	22.57	28.54
California	48.02	45.68	46.22	44.14	36.47	32.90	33.65	31.12	33.65	35.35
Colorado	39.53	38.99	38.06	37.00	35.65	35.19	34.19	33.47	28.58	30.58
Connecticut	7.22	6.78	6.69	7.42	6.97	6.27	8.03	7.92	8.65	9.23
Delaware	4.58	4.07	3.62	3.25	3.58	2.94	2.55	1.76	1.80	1.77
District of Columbia	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Florida	107.50	105.11	109.66	107.96	106.17	103.24	100.72	94.35	92.28	91.23
Georgia	56.17	54.04	59.94	56.06	57.87	52.40	52.26	48.61	37.31	40.87
Hawaii	6.89	6.57	6.53	6.43	6.41	6.29	6.26	6.30	5.87	5.77
Idaho	0.73	1.33	0.99	1.49	1.25	1.13	1.28	1.69	1.64	2.00
Illinois	86.34	90.03	88.82	77.36	67.16	65.17	67.10	58.19	42.60	52.43
Indiana	99.88	99.51	104.40	88.29	84.53	81.01	90.24	75.81	63.18	68.84
Iowa	34.83	32.57	32.88	28.84	25.09	25.88	29.47	23.92	16.23	24.12
Kansas	30.99	32.33	30.99	26.73	25.12	21.67	23.13	20.34	19.82	22.25
Kentucky	87.44	87.03	87.37	77.56	73.39	64.05	67.14	59.51	50.47	56.90
Louisiana	43.20	41.02	39.47	39.35	36.25	33.46	33.91	30.67	27.55	30.40
Maine	1.74	1.43	1.65	1.58	1.49	1.03	1.07	0.71	0.70	1.26
Maryland	19.19	17.54	19.23	16.84	17.32	11.97	16.34	11.80	9.22	11.23
Massachusetts	12.13	12.66	10.78	11.31	10.70	10.27	7.65	6.23	5.74	6.14

Michigan	63.49	62.71	60.17	63.04	55.54	55.76	58.95	54.57	46.96	52.91
Minnesota	25.71	25.99	29.39	27.25	26.72	25.28	26.74	22.87	19.21	21.21
Mississippi	23.25	21.71	23.78	24.68	25.92	23.73	25.73	24.51	26.30	25.19
Missouri	73.85	76.59	74.02	66.57	62.41	68.50	65.61	57.92	54.82	60.21
Montana	15.70	16.61	17.31	17.79	16.12	15.56	15.17	15.94	10.10	12.46
Nebraska	24.67	26.33	24.58	23.68	21.40	20.70	23.85	22.02	19.65	19.79
Nevada	14.71	15.42	16.02	14.43	13.89	12.86	13.67	13.60	13.26	13.70
New Hampshire	4.14	3.30	3.32	3.50	2.37	1.83	2.05	1.81	1.59	2.10
New Jersey	14.86	14.44	16.76	17.86	19.64	16.70	17.33	17.38	13.56	13.33
New Mexico	29.17	28.50	24.69	24.81	23.22	23.07	18.34	20.28	18.60	17.13
New York	32.29	30.03	30.49	29.09	27.67	22.04	24.42	21.45	23.45	25.00
North Carolina	57.33	56.04	57.46	52.11	51.12	47.50	48.36	46.06	37.11	40.13
North Dakota	29.74	29.04	29.21	30.14	29.27	29.34	30.36	28.33	27.43	27.42
Ohio	95.11	102.59	98.69	83.42	81.36	79.89	77.61	67.46	66.96	68.45
Oklahoma	47.48	44.54	42.27	39.85	35.53	30.72	33.51	27.62	25.30	26.74
Oregon	6.95	9.07	7.95	8.57	7.77	7.51	8.36	10.53	8.89	8.23
Pennsylvania	108.26	106.86	99.70	88.56	82.62	77.04	74.86	75.10	70.06	77.48
Rhode Island	3.33	2.56	2.49	2.78	2.57	2.80	3.16	2.81	3.18	3.38
South Carolina	33.70	28.46	32.76	29.54	27.74	25.25	28.79	24.95	22.84	25.03
South Dakota	3.22	3.18	3.04	1.91	2.64	2.47	2.88	3.19	2.28	2.40
Tennessee	37.67	33.95	37.49	33.90	36.23	32.35	26.12	24.04	19.72	24.03
Texas	223.74	227.85	226.33	214.91	208.77	212.40	202.18	190.79	176.88	180.30
Utah	32.10	35.25	34.74	33.21	27.73	27.48	28.67	28.45	26.44	29.94
Vermont	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Virginia	25.32	31.09	30.51	31.99	33.73	28.76	30.59	26.92	28.79	24.36

Washington	6.23	11.73	11.73	10.87	9.58	10.39	10.14	13.69	10.99	9.85
West Virginia	67.70	69.48	74.17	66.80	69.59	66.10	61.33	57.78	50.42	58.97
Wisconsin	37.43	43.76	40.12	41.97	38.89	41.20	39.88	33.28	31.51	35.00
Wyoming	43.88	46.75	43.70	43.85	40.73	40.91	40.72	36.48	35.24	34.08

(EIA, 2023b)

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