# The Impacts of EPA's Clean Power Plan on Electricity Generation and Water Use in Texas

## Additional Analysis

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This document represents the best opinion of CNA at the time of issue.

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# Abstract

The U.S. Environmental Protection Agency (EPA) has proposed a new rule under the Clean Air Act—the Clean Power Plan (CPP)—to control carbon dioxide (CO2) emissions from existing stationary electric power plants. In a prior study that focused on Texas, we modeled two scenarios—a baseline scenario (i.e., what happens if Texas continues as is, without CPP) and a CPP implementation scenario. We found that under the CPP implementation scenario Texas would not only lower its CO2 emissions, but also lower both water consumption and water withdrawals. In this report, we explore additional scenarios that use lower costs for photovoltaics (PV) and that include estimates for increased energy efficiency. We also look at additional scenarios for implementing the CPP that represent possibilities being discussed.

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# Executive Summary

The U.S. Environmental Protection Agency (EPA) has proposed a new rule called the Clean Power Plan (CPP) to control carbon dioxide ($CO_2$) emissions from stationary electric power plants. The rule requires states to hit two $CO_2$ intensity targets which for Texas include a final target of 791 lbs $CO_2$ per megawatt-hour (MWh) by 2029, and an interim target of 853 lbs $CO_2$/MWh which is the 2020-2029 average. The CPP has generated considerable public comment through the formal EPA process and in the media.

In November 2014, CNA released a report exploring the implications of the CPP for water use and other indicators in Texas. In that report, we compared a baseline scenario (i.e., what would happen if CPP were not implemented) with a scenario that implements CPP according to the current version of the rule.

In this report, we present additional scenarios that take into account comments on our prior report, as well as public comments on the CPP. The results of our new analysis support our prior conclusions, namely that (1) the CPP will produce water conservation benefits for Texas, (2) Texas is positioned to make significant cuts in its $CO_2$ intensity rate even without the CPP, and (3) the CPP will require modest adjustments for Texas.

Our principal findings from the prior study are described below:

1. Under the CPP scenario, water consumption by the Texas power sector could be cut by more than 20 percent compared with water consumption in 2012. This is about 88,000 acre-feet (ac-ft) per year.

2. The Texas power sector is already moving to cut the $CO_2$ intensity of its economy—the objective of the CPP—by shifting away from coal and toward natural gas and wind power.

3. The demand-side energy efficiency gains proposed by EPA would reduce the need for new power-generating capacity in Texas. As a result, Texas would avoid increased water use and would significantly reduce conventional air pollution and $CO_2$ emissions.

4. Under the CPP, the cost per unit of electricity produced would increase by 5 percent, but total system costs would decrease by 2 percent due to avoided generation capacity.

Additional findings from this study follow:

1. If a 10-percent cut in demand through energy efficiency were added to the Baseline with no other changes, that would bring Texas within 11 percent of EPA's final CO2 intensity target and push water savings to 12 percent relative to 2012.

2. Currently, the proposed rule calls for a steep initial change in CO2 intensity followed by a leveling off. Adopting a slower rate of implementation at the beginning of the implementation period but continuing the decline while maintaining the interim target, would increase water savings from about 20 to 35 percent relative to 2012.

3. If EPA dropped the interim target rate for 2020-2029 but kept the final target, that formulation would produce a cut in water consumption in 2029 that is similar to the current rule. However, the cumulative 2020-2029 savings would be less than half of that produced under EPA's current proposal with the interim rate—280,000 ac-ft versus 608,000 ac-ft.

4. Removing the interim target rate would produce a similar final rate of CO2 emissions in 2029, but cumulative emissions between 2020 and 2029 would be 43 percent of the cut delivered with the interim.

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# Texas and the Clean Power Plan

## Introduction

In November 2014, CNA released a study that looked at how water use in Texas could potentially be affected by the U.S. Environmental Protection Agency's (EPA) proposed Clean Power Plan (CPP) for stationary electric power plants. In that study [1], we explored two scenarios—a baseline scenario (i.e., what happens if Texas continues as is, without implementing CPP) and a CPP implementation scenario. Based on the results of our models, we concluded the following:

1. EPA's CPP will produce water conservation benefits for Texas.
2. Texas is positioned to make significant cuts in its $CO_2$ intensity rate even without the CPP.
3. Implementing the CPP will require modest adjustments for Texas to meet the final target.

In this report, we explore four additional scenarios. We developed these scenarios to address comments on our previous study as well as public comments on EPA's rule. The results of our additional analysis reinforce our prior conclusions.

The baseline scenarios we consider in this study are:

- *Baseline with no solar photovoltaics (BaselineNoPV)*—This is the same baseline scenario we used in our previous study. For that baseline, we used unsubsidized prices for solar photovoltaic (PV). Feedback from several researchers indicated that recent price information showed lower costs for PV than we had assumed and that PV should be coming into our solutions. As a result, we created a new Baseline, which we describe in the next bullet point.

- *Baseline*—This new baseline includes a substantially lower forecast for industrial PV prices than we used in the baseline scenario in our first report. The updated prices were supplied by the Electric Reliability Council of Texas (ERCOT) [2]. Others in Texas, including Austin Energy, confirmed the lower prices and higher adoption rates for PV. We use this baseline for comparisons with CPP scenarios later in this report.

- *Baseline plus 10 percent energy efficiency (BaselineEE10)*—In this scenario, we assume lower prices for PV, as well as a 10-percent level of energy efficiency by 2029. We did not include energy efficiency gains in the baseline scenario in our previous study. This level of efficiency is called for by EPA in their proposed numbers for Texas.

The CPP implementation scenarios we include in this study are:

- *Rapid early drop in $CO_2$ intensity (Shoulder)*—This scenario represents our interpretation of the CPP as represented in the current draft rule [3]. It requires a final target for $CO_2$ intensity of 791 lbs/MWh by 2029. It also requires an interim target of 853 lbs $CO_2$/MWh, which is the average of the annual rates between 2020 and 2029. The resulting graph looks like a shoulder, thus the name. In the prior report, we labeled this scenario *CPP*. It requires a rapid shift from coal-fired power generation to natural gas combined cycle (NGCC) generation in order to meet both the interim and final targets.

- *Slow start with continuing decline (Glidepath)*—The rapid shift required in the Shoulder scenario has drawn considerable criticism. Commenters stated that this way of implementing the CPP could cause problems with system reliability [2]; they suggested that a slower initial pace of implementing the rules—a "glidepath"—would avoid this problem [4-6]. This scenario represents that approach. We assume that the interim target must be met. EPA has said that this could be a legitimate option for implementing the CPP [7].

- *Final target only (FinalOnly)*—Some commenters suggested that EPA do away with the interim target, keeping just the final target; there are indications that EPA has decided to do this [8]. This scenario drops the interim target and keeps the final target.

# Baseline scenarios

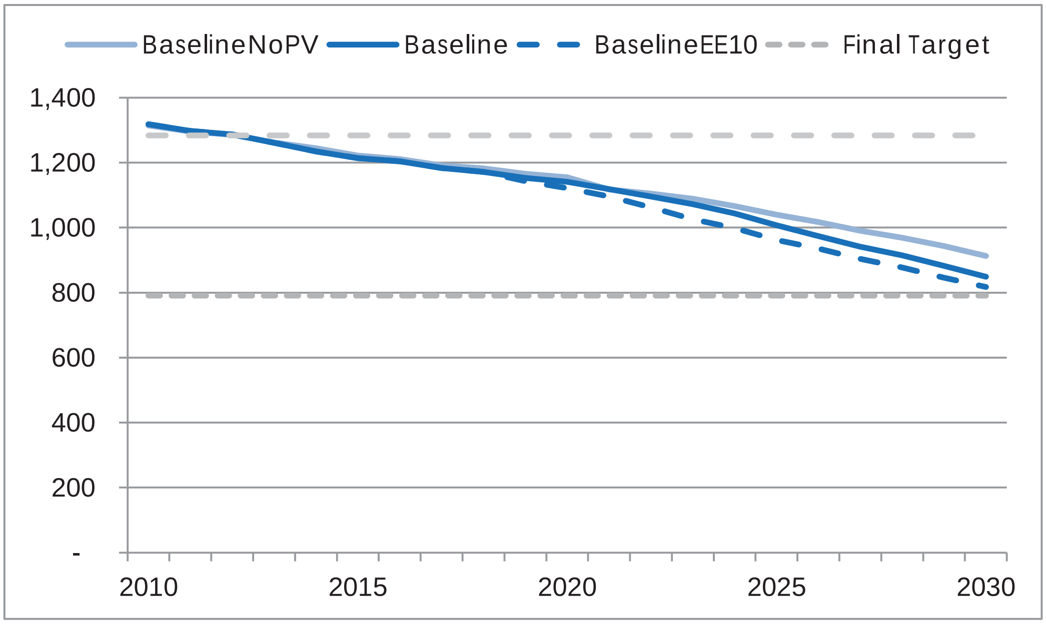
In this section, we compare the three baseline scenarios: BaselineNoPV, Baseline, and BaselineEE10.The purpose is to pull out the impacts of lower PV prices and energy efficiency before looking at the CPP scenarios.

Figure 1 shows the $CO_2$ intensity rates for the three scenarios. By 2029, BaselineNoPV intensity is 943 lbs $CO_2$/MWh, a drop of 26 percent compared with the 2012 value of 1,284. (The gray line toward the top of the figure shows this value.) In this version of the baseline, Texas would achieve 68 percent of the required 38 percent reduction to reach the final target, which is 791 $CO_2$/MWh (lower gray line).

When the cost of PV is cut, the final share of generation for PV amounts to 8 percent of generation, which is about one-third of all renewable power. In contrast, the share of PV in BaselineNoPV is negligible. The change produces an intensity rate of 882 lbs/MWh, a 31-percent drop in intensity compared with 2012. In this scenario, Texas reaches 88 percent of the reduction needed to hit EPA's final target.

Adding energy efficiency sufficient to cut electricity demand by 10 percent between 2020 and 2029 would further reduce the final intensity rate to 824 lbs/MWh, which is just 11 percent away from the final target rate.

Figure 1. Lower costs for PV (*Baseline*) and the inclusion of 10-percent energy efficiency (*BaselineEE10*) draw the baseline closer to the final target. (Units = lbs $CO_2$/MWh)




In addition to cutting $CO_2$ intensity, we also see reductions in water consumption, water withdrawals, system costs, and $NO_x$ emissions under both the Baseline and BaselineEE10 scenarios.

It's worth noting that the Baseline, with low PV costs and no energy efficiency, produces a large amount of renewable energy relative to all but one of the other scenarios (Glidepath). There are two reasons for this outcome. First, PV is cost-competitive in this scenario so it helps optimize costs; PV is not cost-competitive in the BaselineNoPV scenario. Second, there is a higher demand for total generating capacity in the Baseline, unlike the scenarios that include energy efficiency.

A summary of select indicators for the three baseline scenarios is provided in table 1.

Table 1. Adding lower PV costs and energy efficiency to the baseline cuts $CO_2$ intensity, water use, system costs, $NO_x$ emissions, and natural gas fired power generation.

| Indicator | Period | BaselineNoPV | Baseline | BaselineEE10 |
|---|---|---|---|---|
| Final $CO_2$ intensity rate (lbs/MWh) | 2029 | 943 | 882 | 845 |
| Percentage of final target | 2029 | 69% | 81% | 89% |
| Interim $CO_2$ intensity rate (lbs/MWh) | '20-'29 | 1,049 | 1,019 | 983 |
| Change in water consumption | '12-'29 | -5% | -9% | -12% |
| Change in water withdrawals | '12-'29 | -16% | -20% | -23% |
| Change in system costs | '12-'29 | 33% | 29% | 23% |
| Change in $NO_x$ emissions | '12-'29 | -10% | -14% | -18% |
| Change in gas generation | '12-'29 | 45% | 31% | 18% |
| Change in wind & PV generation | '12-'29 | 154% | 236% | 148% |
| Renewables share in fuel mix | 2029 | 17% | 23% | 19% |
| Demand met by efficiency (GWh/yr) | 2029 | 0 | 0 | 57 |

# CPP implementation scenarios

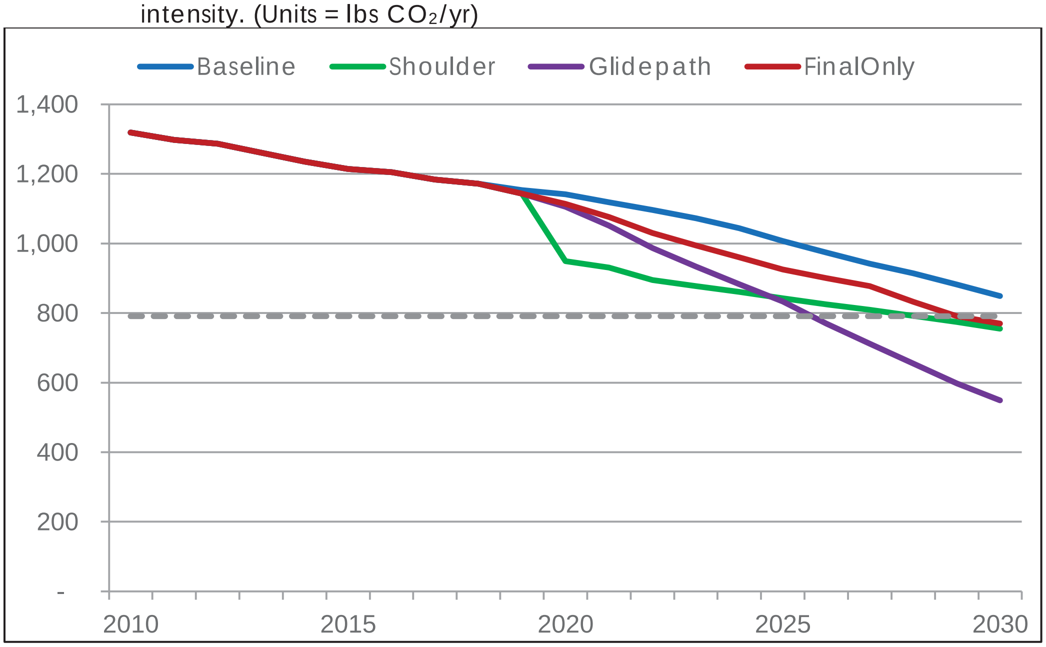
Because EPA has given the states wide latitude to design their own method of implementing CPP and because EPA has not yet determined the final rules, many variations are possible.

As noted, we focus on three potential CPP implementation scenarios in this report: the Shoulder, the Glidepath, and the FinalOnly. The Shoulder and Glidepath scenarios bookend the possibilities for the time over which the interim target will be met—from right away to very late. The FinalOnly scenario, as the name implies, represents the implementation of the CPP without an interim target.

For this analysis, we used a model, developed at CNA [1, 9], to find the economically optimal way of hitting the $CO_2$ target(s). All three of our scenarios assume that $CO_2$ emissions would be regulated at the state level and that individual generating units would have a requirement to limit emissions. We also assume that generating units would not have a technology requirement (i.e., coal units would not be forced to either adopt carbon capture and sequestration or close). These technology requirements would dramatically increase costs and reduce reliability. Instead, we assume that these facilities could meet their obligation by supporting lower intensity options that others might take, such as energy efficiency or renewable energy generation, thus diluting the facility's own intensity rates. This pathway allows the least expensive generating options available in the system to be optimally employed.

The CPP implementation scenarios are presented in figure 2 along with the new Baseline. All four of the scenarios shown include lower costs for PV, and the three implementation scenarios include a 10-percent cut in demand by 2029 by increasing the level of energy efficiency. All three CPP scenarios meet or exceed the final target intensity rate of 791 lbs/MWh (lower gray line). The Shoulder and Glidepath scenarios also meet the interim target (the 2020-2029 average of 853 lbs/MWh), but they arrive at this target in different ways.

Figure 2. Different CPP implementation options produce different results for $CO_2$ intensity. (Units = lbs $CO_2$/yr)




The Shoulder scenario shows an immediate shift from coal generation to NGCC. For this scenario, the capacity factor (i.e. the percent of the time a facility runs during the year) for coal moves from 64 percent to 25 percent and NGCC increases from 48 to 61 percent. Once this shift is achieved, the line slowly converges toward the Baseline and coal-fired generation levels off. Natural gas generation slowly declines after the initial bump, while wind, PV, and energy efficiency grow and have larger shares of the mix. We assume that nuclear-powered generation is constant in all of the scenarios because new construction is not cost-competitive, but we expect existing plants to continue to run.

In contrast, under the Glidepath scenario, CPP implementation is incremental and $CO_2$ intensity diverges steadily from the Baseline. This steady divergence is necessary to make up for the slow start. The longer the delay in cutting $CO_2$, the steeper the decline needs to be and the more coal needs to be pushed out of the mix. The final intensity rate for this scenario is 598, which surpasses the EPA final target requirement by 39 percent.

Coal-fired generation does not level off in the Glidepath scenario, but declines gradually. The share of coal in the generation mix is 11 percent by 2029, while it's 18 percent in the Baseline scenario and 15 percent in the Shoulder scenario. In 2019, before CPP implementation starts, the coal share for every scenario is 26-percent, and it is 33 percent in 2012. As coal moves out of the Glidepath scenario, wind and PV move in; in the end, they produce 29 percent of power generation. The Glidepath scenario requires the largest absolute amount of renewable generation—136 GWh per year compared with 120 in the Baseline and 91 in Shoulder. In 2012 renewable generation was about 34 GWh. This scenario shows that there is a trade-off between a quick start and a slow start, which is the degree to which coal-fired power can continue to be used. A slower start reducing $CO_2$ means that there must be a deeper cut at the end.

For the FinalOnly scenario, the results resemble the Baseline scenarios, except that the cut in $CO_2$ intensity is steeper. In contrast to BaselineEE10, this scenario cuts coal generation in half instead of by a third, and coal is replaced mostly by NGCC, with some additional wind and PV. Table 2 provides indicators for power generation from the scenarios.

Table 2. Glidepath cuts coal and grows renewables the most.

| Indicator | Period | Baseline | Shoulder | Glidepath | FinalOnly |
|---|---|---|---|---|---|
| Increase in total demand | '12-'29 | 25% | 12% | 12% | 12% |
| Demand met by energy efficiency (GWh) | 2029 | 0 | 58 | 59 | 60 |
| Total generation capacity (GW) | 2029 | 131 | 110 | 115 | 111 |
| Coal generation (GWh) | 2029 | 92 | 69 | 40 | 77 |
| Change in coal generation | '12-'29 | -34% | -50% | -71% | -44% |
| Gas generation (GWh) | 2029 | 276 | 270 | 252 | 265 |
| Change in gas generation | '12-'29 | 31% | 28% | 20% | 26% |
| Wind & PV generation (GWh) | 2029 | 120 | 91 | 136 | 85 |
| Change in wind & PV generation | '12-'29 | 236% | 156% | 284% | 140% |
| Wind & PV share in mix | 2029 | 23% | 19% | 29% | 18% |
| Nuclear generation | 2029 | 38 | 38 | 38 | 38 |

# $CO_2$ emissions

The combination of EPA's final target of 791 lbs $CO_2$/MWh and the rate of demand growth of 1.3 percent we use [10] implies a 24-percent drop in annual $CO_2$ emissions between 2012 and 2029. Most of this occurs between 2020 and 2029, with just a 2-percent drop between 2012 and 2019.

Removing the interim rate requirement produces a considerably lower cut in cumulative emissions. Compared with the Baseline, the cumulative cut in $CO_2$ emissions between 2020 and 2029 for Shoulder, Glidepath, and FinalOnly is 16, 17, and 7 percent (table 3). The drop in annual emissions relative to the Baseline is similar between Shoulder and FinalOnly at 22 and 24 percent, while Glidepath gives a much greater cut of 41 percent.

Table 3. The Shoulder and FinalOnly scenarios have similar final targets but different cumulative emission reductions. Glidepath has the largest annual cut by 2029.

| Indicator | Period | Baseline | Shoulder | Glidepath | FinalOnly |
|---|---|---|---|---|---|
| Final $CO_2$ intensity rate (lbs/MWh) | 2029 | 882 | 774 | 598 | 791 |
| Percentage of final target | 2029 | 81% | 103% | 139% | 100% |
| Interim $CO_2$ intensity rate (lbs/MWh) | '20-'29 | 1,019 | 855 | 853 | 950 |
| $CO_2$ emissions (million tons) | 2029 | 215 | 189 | 146 | 193 |
| Change in $CO_2$ emissions | '12-'29 | -13% | -24% | -41% | -22% |
| Change in cumulative emissions | '20-'29 | - | -16% | -17% | -7% |

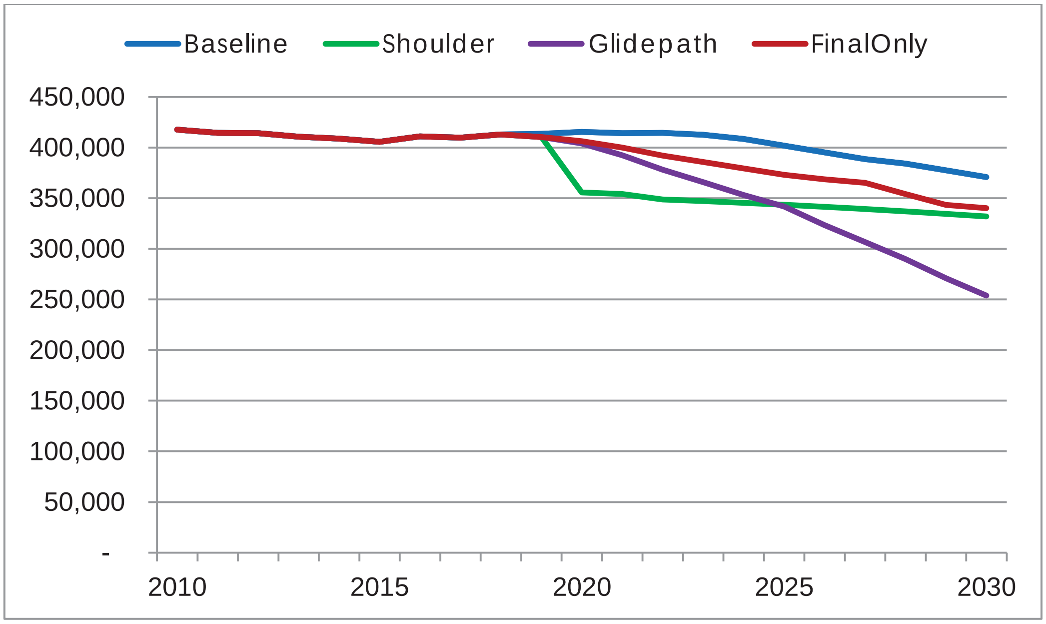
# Water use

Water withdrawn and consumed for thermal cooling varies by fuel type, plant efficiency, and cooling type. For a given cooling technology, nuclear generation uses more water than coal generation does. Coal, in turn, uses more than NGCC. Wind does not require any water for generation, and PV uses water only for washing. Energy efficiency, which avoids generation altogether, has no water requirement [1]. For these reasons, EPA's four building blocks—higher coal plant efficiency, switching from coal to NGCC, greater use of renewable power, and increased energy efficiency—would all save water.

Figure 3 shows the results for water consumption under the four scenarios. With the displacement of coal and greater use of NGCC, wind, and PV, water consumption declines by 9 percent in the Baseline compared to 2012 (table 4). It is not an accident that figure 2 and 3 look similar; it is a result of the synergy between $CO_2$ content and cooling needs.

The Shoulder and FinalOnly scenarios show similar water consumption numbers in 2029, but the cumulative savings are quite different. Under the Shoulder scenario the cumulative water consumption savings between 2020 and 2029 are nearly twice that of FinalOnly -- 608,000 ac-ft versus 308,000 ac-ft.

Figure 3. Cumulative water consumption is larger for the Shoulder and Glidepath scenarios than FinalOnly.
(Units = ac-ft/yr)




Following the Glidepath scenario produces the largest water savings. In 2029, under the Glidepath scenario water consumption would be 35 percent lower than it was in 2012, and water withdrawals would be 40 percent lower. Cumulative water consumption savings between 2020 and 2029 are about 100,000 ac-ft over the next best scenario (i.e., the Shoulder scenario), and 400,000 ac-ft over FinalOnly. We see these savings for the Glidepath scenario because it has the greatest displacement of relatively thirsty coal and the largest implementation of wind and PV.

Table 4. The Glidepath scenario produces the greatest savings in water consumption and withdrawals.

| Indicator | Period | Baseline | Shoulder | Glidepath | FinalOnly |
|---|---|---|---|---|---|
| Water consumption (000 ac-ft) | 2029 | 377 | 335 | 271 | 343 |
| Change in water consumption | '12-'29 | -9% | -19% | -35% | -17% |
| Cumulative water consumption savings (000 ac-ft) | '20-'29 | - | 608 | 706 | 308 |
| Water withdrawals (million ac-ft) | 2029 | 8.0 | 7.6 | 6.0 | 7.3 |
| Change in water withdrawals | '12-'29 | -20% | -24% | -40% | -26% |

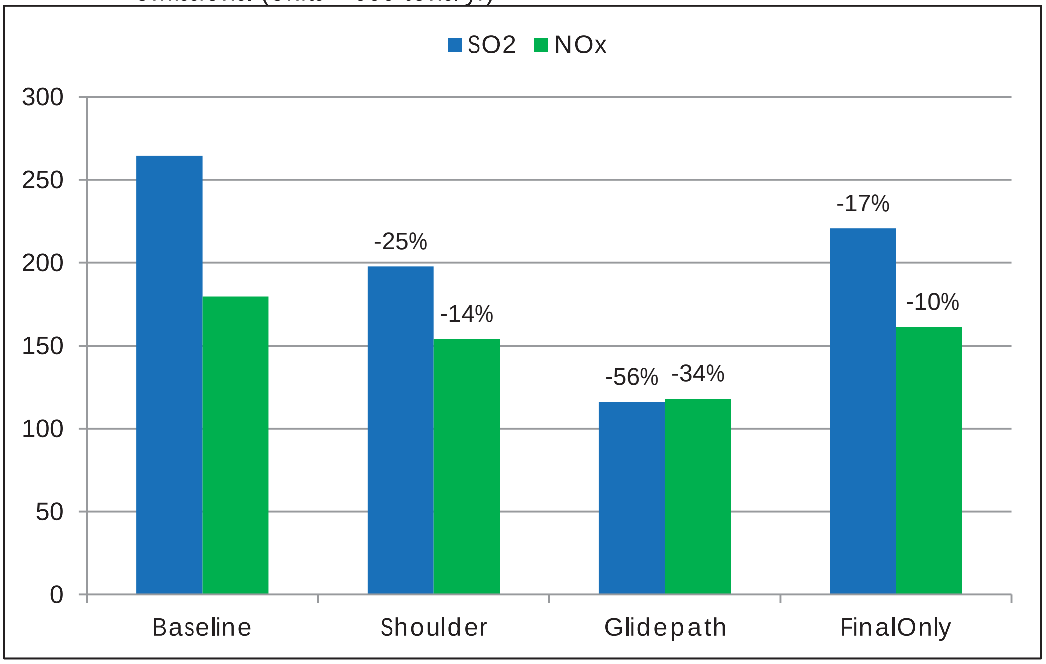
# $SO_2$ and $NO_x$ emissions

In electricity generation, sulfur dioxide ($SO_2$) emissions are exclusively associated with coal-fired power, while nitrogen oxides ($NO_x$) emissions come from both coal and natural gas, though natural gas emits roughly one-tenth the amount of $NO_x$ as coal. Wind and PV emit neither $SO_2$ nor $NO_x$, and energy efficiency avoids emissions altogether [1].

Figure 4 shows $SO_2$ and $NO_x$ emissions by scenario in 2029. The lower the coal-fired generation in each scenario, the lower the emissions. The Glidepath scenario cuts $SO_2$ and $NO_x$ emissions relative to the Baseline by 56 and 34 percent, respectively.

Relative to 2012, all the scenarios cut emissions. The Baseline, Shoulder, Glidepath, and FinalOnly scenarios cut $SO_2$ by 34, 50, 71, and 45 percent (blue bars in figure 4), respectively, and $NO_x$ by 14, 27, 44, and 23 percent (green bars).

Figure 4. The Glidepath scenario produces the largest drops in $SO_2$ and $NO_x$ emissions. (Units = 000 tons/yr)

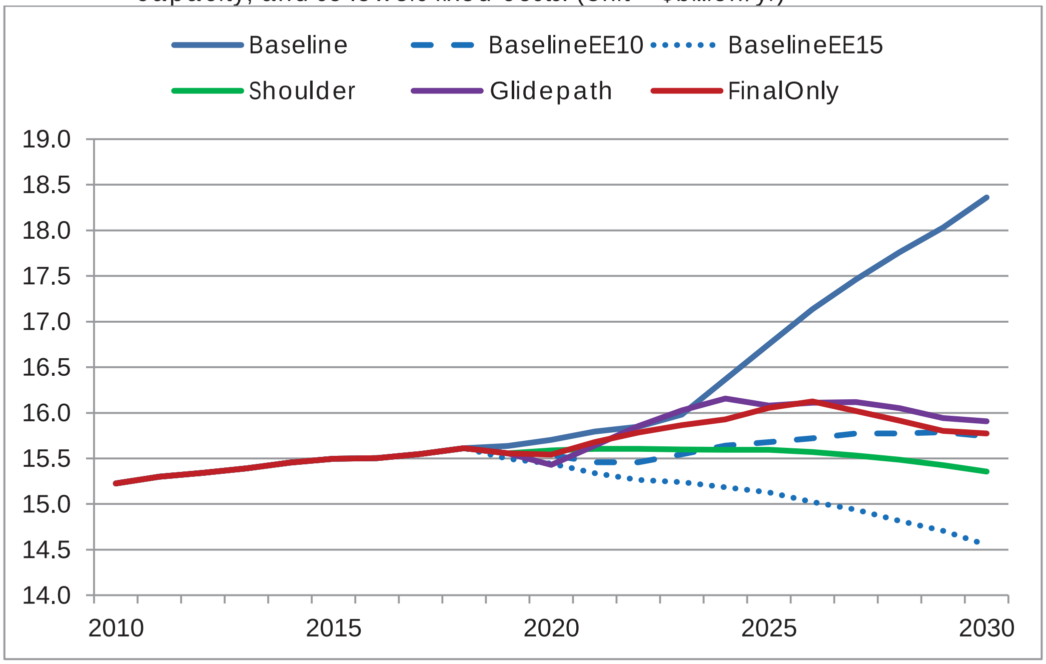



Note: Numbers indicate change from the Baseline in 2029.

# System, fixed, and variable costs

System costs are made up of fixed and variable costs, which vary by the generating capacity required and by fuel costs. Energy efficiency is less expensive than building and operating generating capacity. In figure 5 we present fixed costs for the Baseline and three CPP scenarios. We also show the BaselineEE10 and add here an additional baseline with 15 percent energy efficiency, BaselineEE15. We add the latter scenario for comparison because 15 percent is about the energy efficiency improvement limit in this time frame. The Baseline, which has no energy efficiency, has the highest capacity need and therefore the largest fixed costs, while the opposite is true for BaselineEE15. The three CPP options have fixed costs similar to BaselineEE10.

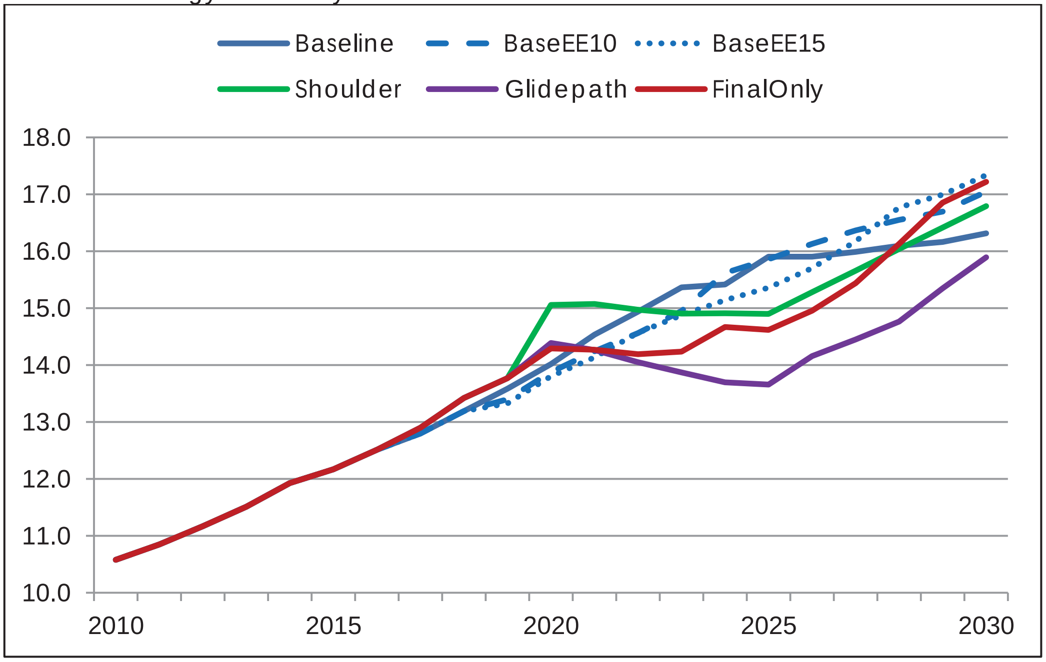
Figure 5. Fixed costs. Energy efficiency decreases the need for generation capacity, and so lowers fixed costs. (Unit = $billion/yr)




Note: Y-axis does not start at 0 in order to show detail.

The rapid increase that occurs in the Baseline in figure 5 is because renewables have higher fixed costs but lower variable costs. This can be seen in figure 6, which presents variable costs. Glidepath has the largest amount of renewable generation and shows the lowest variable costs. Table 5 summarizes the system, fixed, and variable costs.

Figure 6. Renewable energy has no fuel cost, and so keeps variable costs down. Energy efficiency adds to variable costs.




Note: Y-axis does not start at 0 in order to show detail.

Table 5. The CPP scenarios all have 10-percent energy efficiency, which helps to lower fixed and system costs. Variations between these options are small.

| Indicator | Period | Baseline | Shoulder | Glidepath | FinalOnly |
|---|---|---|---|---|---|
| System costs ($ billion) | 2029 | 34.2 | 31.8 | 31.3 | 32.7 |
| Change in system costs | '12-'29 | 29% | 23% | 20% | 18% |
| Fixed costs ($ billion) | 2029 | 18.0 | 15.4 | 15.9 | 15.8 |
| Variable costs ($ billion) | 2029 | 16.2 | 16.4 | 15.3 | 16.9 |

# Summary

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4. Removing the interim target rate would produce a similar final rate of $CO_2$ emissions in 2029, but cumulative emissions between 2020 and 2029 would be 43 percent of the cut delivered with the interim.

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