RESOURCES *for the* FUTURE

Projected Effects of the Clean Energy Standard Act of 2019

Issue Brief 19-03 by **Paul Picciano**, **Kevin Rennert**, and **Daniel Shawhan** — May 2019

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Summary of Modeling Results

Relative to a "no additional policy" baseline, the proposed Clean Energy Standard Act of 2019 is projected to:

- Reduce power sector greenhouse gas emissions in 2035 by 61%, with cumulative emission reductions between 2020 and 2035 of approximately 10 billion metric tons of carbon dioxide (CO_2) equivalent;
- Increase generation by renewables from 30% to 56% of total generation in 2035;
- Avoid retirement of 43 GW of nuclear generation capacity as of 2035. This would increase nuclear generation from 10% to 18% of total generation in 2035;
- Reduce generation from fossil sources from 60% to 26% of total generation in 2035;
- Provide net benefits of $579 billion over the 2020–2035 time period;
- Prevent 30,000 premature deaths from air pollution in the US over the 2020–2035 time period; and
- Increase nationally averaged retail electricity rates by 4% in 2035.

Introduction

On May 8, 2019, Senator Tina Smith (D-MN) and Rep. Ben Ray Luján (D-NM) introduced the "Clean Energy Standard Act of 2019" (hereafter referred to as "the Act" or "the Policy"). Under the Act, suppliers of retail electricity would be required to account for a percentage of their retail sales as coming from sources that are "clean," measured according to the amount of greenhouse gas emissions per unit of electricity generated. Under the Act, the nationally averaged percentage requirement for clean electricity increases from approximately 51% of retail sales in 2021 to approximately 77% in 2035 and approximately 96% in 2050.

The full legislative text is available **here**, and a summary from the sponsors is available **here**. For an overview of clean energy standards at both the federal and state levels, see this **RFF Issue Brief**.

Structure of the Clean Energy Standard Act of 2019

Under the Act, generators of clean electricity would be awarded full or partial "clean energy credits," which may be sold or traded, for each clean megawatt-hour (MWh) generated. To demonstrate compliance with their annual obligation, Retail Electricity Suppliers would surrender sufficient clean energy credits, obtained either from their own clean generation or purchased from others. In addition to being able to trade credits, compliance entities may also hold or "bank" credits, thereby allowing for overcompliance in the early years of the Policy and undercompliance in the later years. The increasing clean energy requirement and associated demand for clean energy credits would provide a continued incentive for adding clean generation to the grid until the power sector is almost entirely decarbonized after 2050.

The Act defines one clean energy credit as representing one megawatt-hour of electricity generated with zero greenhouse gas emissions. Emission sources that would qualify for full credits under the Act include wind, solar, hydropower, and nuclear.[1] Partial credits are awarded on a sliding scale based on the net greenhouse gas emissions of a generator relative to a benchmark emissions intensity of 0.4 metric tons of CO_2 per megawatt-hour (MWh)[2], thereby providing incentives for fossil-fuel generation equipped with carbon capture and storage as well as biomass, and waste-to-energy generation. Emissions intensity calculations for the purpose of crediting generators would account for lifecycle greenhouse gas emissions, including those associated with the extraction and production of the fuels combusted, among other factors. The Policy would also award credits for qualified combined heat and power, and would give extra credit to a limited amount of low- or zero-emission, innovative, dispatchable technologies.

Rather than set a nationally uniform compliance target for all suppliers of retail electricity, the compliance obligation for each individual Retail Electricity Supplier is set based upon its own historical percentage of clean generation —specifically, its clean energy percentage for the calendar year of enactment of the legislation. The rate of annual escalation of such targets is further delineated between large and small Retail Electricity Suppliers as follows: The clean energy compliance requirement for a given Retail Electricity Supplier with annual retail sales above 2 million MWh escalates by 2.75% per year until it reaches 60%, then by 1.75% per year until the compliance target reaches 90%. Beginning in 2040, for such Retail Electricity Suppliers that have reached targets of 90%, the percentage requirement increases by 1% annually until it reaches 100%. Retail electricity suppliers with initial annual retail sales less than 2 million MWh have a compliance obligation that escalates by 1.5% per year to a maximum of 90%. After 2040, small Retail Electricity Suppliers that had reached a 90% obligation would have their percentage requirement increased by 1% annually.

The Act provides cost containment measures in the form of an Alternative Compliance Payment (ACP) that Retail Electricity Suppliers may make in lieu of surrendering clean energy credits. The ACP is set to start at 3 cents per kilowatt-hour and escalate at 3% annually until the end of 2029, then 5% annually thereafter. The Act also contains provisions to reduce the annual escalation rate of the compliance obligations in response to sustained and significant usage of the ACP for compliance, as well as to increase their annual rate of escalation in response to sustained low credit prices.

Modeling the Policy with E4ST

We utilized a detailed model of the US power sector, the *Engineering, Economic, and Environmental Electricity Simulation Tool* (E4ST), to assess changes in power sector greenhouse gas emissions, composition of the fleet of generators, and societal welfare, including effects on premature mortality and retail electricity prices, resulting from the Act.

In interpreting the results presented below, it is important to note that all models provide an imperfect approximation of the real world. See page 5 for further detail on the model and modeled policy specifications including ways in which they differ from the Act.

Changes to Generation and Emission Reductions

As shown in Figure 1, compliance with the clean energy requirements posed by the Policy is projected to drive significant changes in the composition of the generation fleet compared to a baseline without additional policy. These changes include substantial increases in zero-emission sources, the avoidance of expected retirements in the existing nuclear fleet, and decreased generation from fossil sources. Specifically, compared with a policy baseline that assumes no additional policy, in 2035 the legislation is projected to increase wind generation by 16%, solar generation by 9%, and nuclear generation by 8%, while decreasing coal and natural gas generation by 10% and 24%, respectively.

The shift of the power sector to lower-carbon sources yields associated emission reductions compared with the no additional policy baseline (Figure 2). Specifically, nationwide CO_2 equivalent emissions from the power sector decrease by 967 million metric tons, or 61%, in 2035, relative to the baseline 2035 value.[3] This reduction is attributed to 80% lower emissions from coal (45% of the total reduction)

Figure 1: US Electricity Generation under the Clean Energy Standard Act of 2019

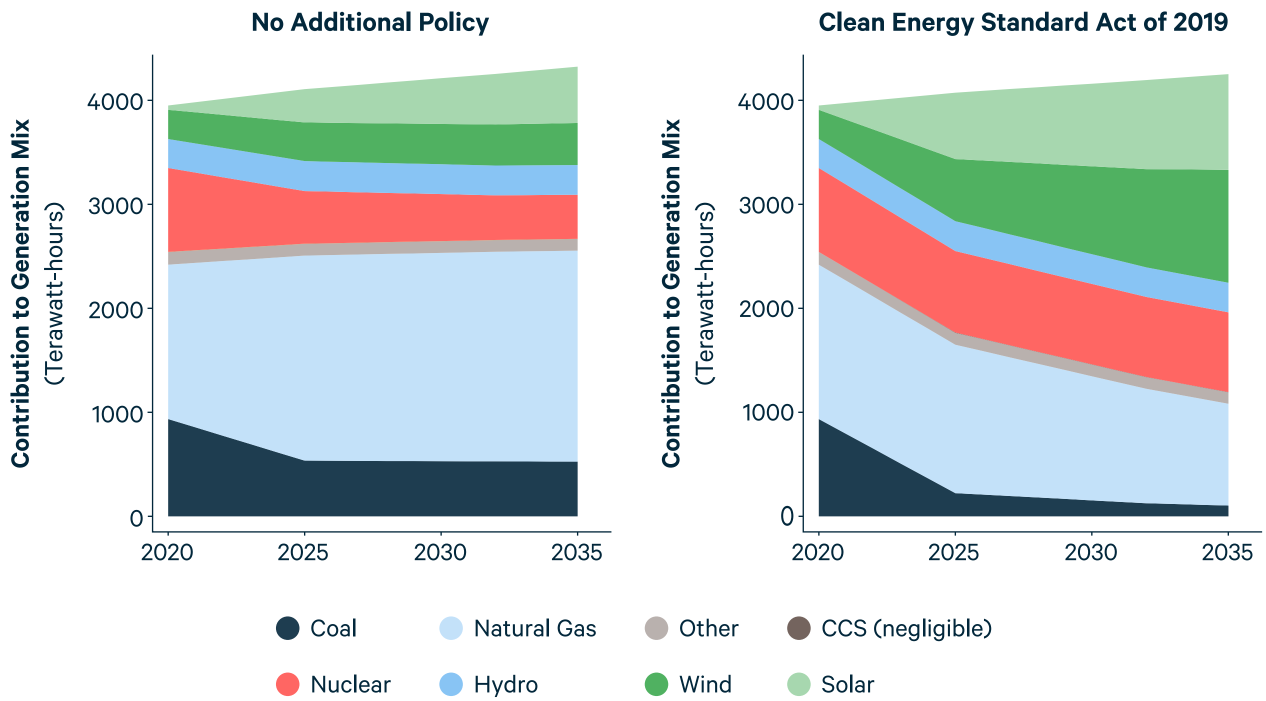
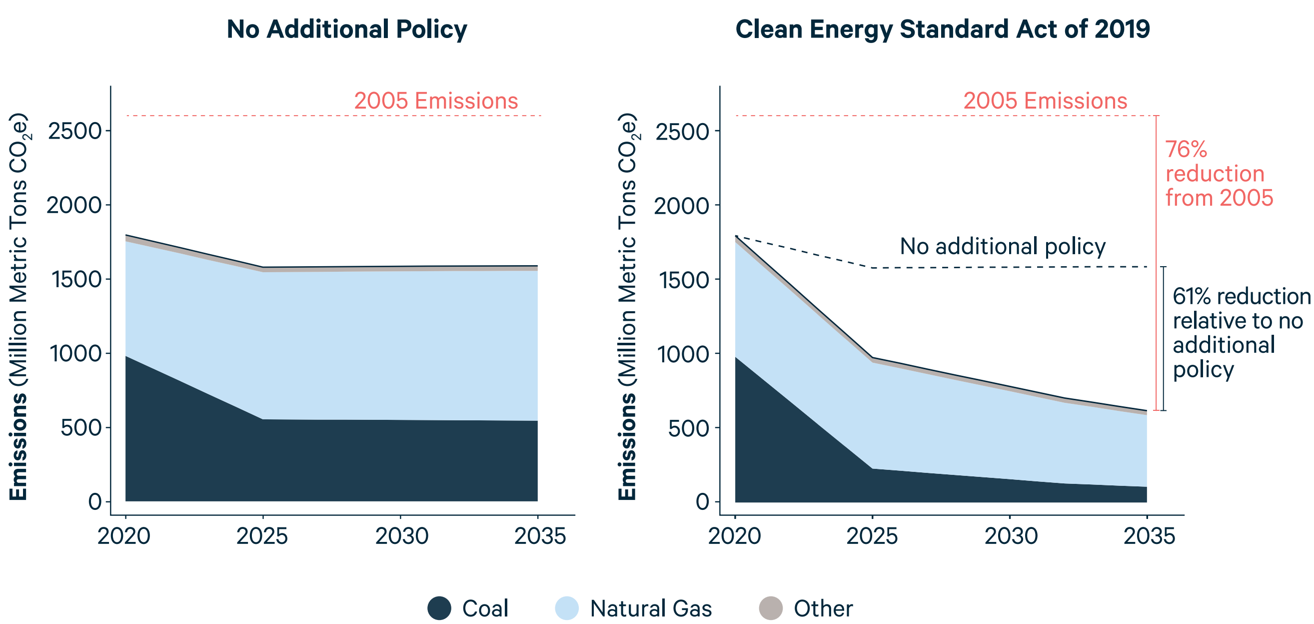


Figure 2: Electric Sector Emissions under the Clean Energy Standard Act of 2019



and 52% lower emissions from natural gas (55% of the total reduction). Cumulatively, from 2020 to 2035, emissions decrease by 9.9 billion metric tons, or 38%.

Projected Effects on Welfare

The net benefits of the Policy over the 2020–2035 time period have an estimated value of $579 billion. All dollar values in this section are net present values from the perspective of 2021, assuming a 3% continuous discount rate. All dollar values in this brief are reported in 2013 dollars. A breakdown of the welfare benefits is shown in Figure 3. The Act is projected to:

- Reduce cumulative greenhouse gas emissions by approximately 10 billion metric tons between 2020 and 2035. This is estimated to reduce $470 billion worth of net harm to society that would otherwise be caused by climate change.
- Prevent 30,000 premature deaths from air pollution in the US over the 2020–2035 time period by reducing sulfur dioxide and nitrogen oxide emissions from power plants. The estimated value of this is $226 billion.
- Increase the net profits of the power generation industry by $19 billion.
- Increase retail electricity rates between 2020 and 2035 (Figure 4) by an average of 2.7%, with a projected increase in 2035 of 3.9%. The estimated total cost from higher electricity rates is $106 billion.[4]
- Increase US government expenditures by $29 billion, primarily due to increased expenditures in the form of the 10% investment tax credit for the increased amounts of solar energy capacity built under the Policy.

Discussion and Future Work

In our assessment of the legislation, an aspect that particularly merits further consideration is the application of different clean energy percentage requirements to different Retail Electricity Suppliers in the same market. Given the strong competitive advantage that could be realized by Retail Electricity Suppliers that started from a low clean energy requirement, structuring the Policy in this manner could potentially incentivize a rapid shift towards such Retail Electricity Suppliers, which would reduce the intended effectiveness of the bill at increasing clean energy use, and also raise equity concerns for disadvantaged suppliers and their customers. The use of a slower requirement growth rate for suppliers that are initially small exacerbates this issue.

Figure 3: US Welfare Effects of Clean Energy Standard Act of 2019 (Net Present Value, 2020–2035)

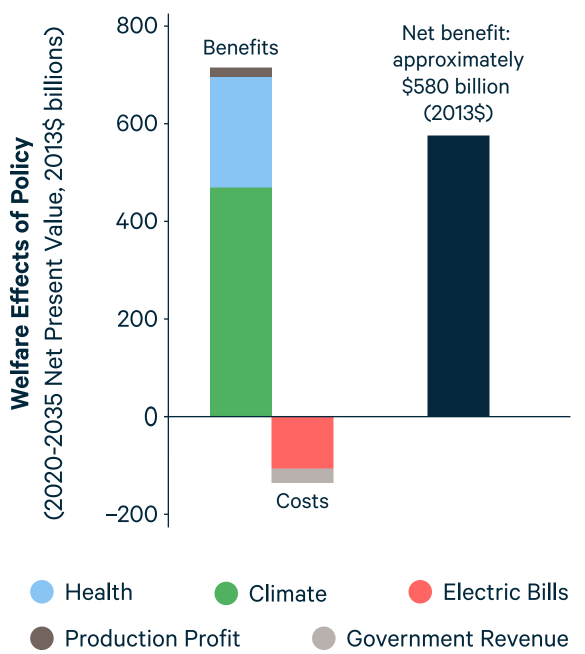
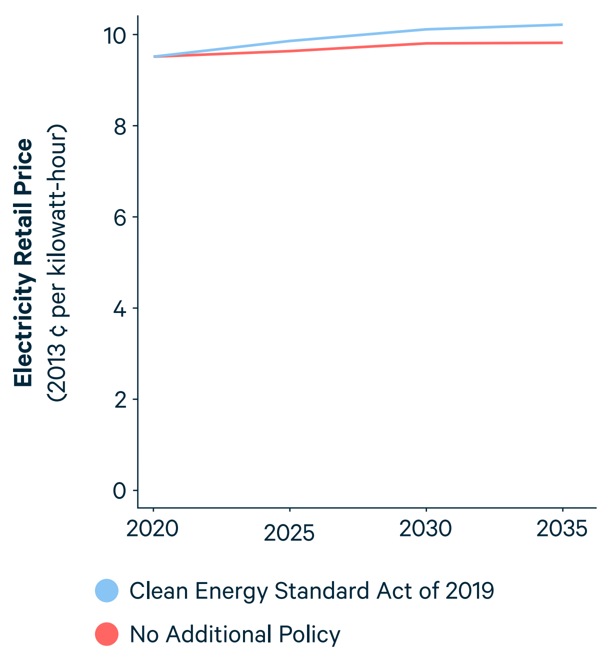


Figure 4: US Average Retail Electricity Price under the Clean Energy Standard Act of 2019



Two additional modeled effects of the Act that are not discussed in this brief are the projected effects of the Policy on wholesale market prices as well as on state-level electricity prices. The Act is projected to decrease clearing prices in wholesale electricity markets, though such decreased clearing prices are projected to be more than offset for eligible clean energy generators through revenues from CES credit sales. Preliminary state-level analysis of the Act shows that the effects on electricity bills would vary geographically, with increases tending to be lowest in regions that are cost-effective places for wind energy development, and even lower if such regions currently derive a large portion of their generation from coal.

Further in-depth analysis of the Act that will evaluate its effects on wholesale power markets, provide state-level results for electricity prices, incorporate an expanded set of buildable clean energy technologies, and compare its effects to other potential CES policy designs and other types of carbon pricing is forthcoming.

Model Characteristics

The **Engineering, Economic, and Environmental Electricity Simulation Tool** (E4ST) is software built for benefit-cost analysis of policies, regulations, power infrastructure additions, and more. E4ST simulates in detail how the power sector will respond to such changes. It models successive multi-year periods, predicting hourly system operation along with generator construction and retirement, and various other outcomes. E4ST's advantages over other models include its high spatial detail, its realistic representation of power flows and system operation, its integration of an air pollution and health effects model, its uniquely comprehensive benefit-cost analysis capabilities, its high-quality generator data, its inclusion of Canada, and its unique adaptability, transparency, and shareable nature. E4ST has been used to analyze various policies and investments, including in projects for the US Department of Energy and the US Department of the Interior. E4ST has been developed by researchers at Resources for the Future and Cornell and Arizona State Universities, with funding, input, and review by the Department of Energy, the National Science Foundation, the New York Independent System Operator, and the Power Systems Engineering Research Center. More information is available at **e4st.com**.

Modeling Set-Up and Assumptions

To represent the Policy, the modeling included the following elements:

- For the purpose of calculating and applying the clean energy percentage requirements in each year, we aggregated all of the Retail Electricity Suppliers in each state up to the state level.
- To calculate the starting renewable energy requirement in each state in 2020, we calculated the proportion of each state's 2017 in-state generation that met the bill's definition of clean, then scaled it up using the pre-2040 requirement scale-up rates in the bill.
- The national average clean energy requirements modeled were 51% in 2021, 60% in 2025, 69% in 2030, and 77% in 2035. The market shares of clean energy differed somewhat from these requirements because of banking of Clean Energy Credits and because we report the percentages as percentages of total generation, which is approximately 6% higher than retail sales due to transmission and distribution losses.
- We simulated 2025, 2032, and 2037 both with and without the Act. We linearly interpolated to calculate results in years between and before these years.
- Buildable technologies in the model included natural gas combined cycle with and without 90% carbon capture and sequestration, natural gas turbines, nuclear, onshore wind, offshore wind (9 sites), solar, and coal with 90% carbon capture and sequestration.
- We assumed a demand elasticity of -0.4.
- Our assumed methane leakage rates are 0.000434375 short tons per million British thermal units for natural gas and 0.000175 for coal (Lenox et al. 2013).
- Our assumed damage per ton values for CO_2 and methane come from IWG (2015) and Marten et al. (2014).
- For mortality, we use the COBRA air pollution fate-and-transport model (EPA 2018) and the midpoint between the mortality estimates produced using the Krewski et al. (2009) and LePeule et al. (2012) exposure-mortality functions.
- Our assumed generator costs are medium ("mid")

values from the National Renewable Energy Laboratory (Vimmerstedt et al. 2018). Wind costs assume type-5 turbines.

- Our assumed demand growth and fuel prices come from the 2019 Annual Energy Outlook high oil and gas resource and technology case. We repeated the simulations with lower natural gas prices based on NYMEX futures prices. It changed the effects of the Policy little.
- The greenhouse gas emissions we include in this analysis are CO_2 and methane, which are the main two from the power sector. We combine them into "CO_2 equivalent" by multiplying the tons of methane by 32 and adding them to the tons of CO_2.[5]

Differences between the Model Set-Up and the Act

The model set-up described above differs from the proposed legislation in a number of ways. For example, though the model represents all technologies in the existing generator fleet, it does not represent *new* builds of biomass, combined heat and power, battery energy storage, or geothermal, all of which are technologies eligible for crediting under the Act. Additionally, the model represents new builds of fossil generation with carbon capture and storage, but does not provide for retrofitting carbon capture to existing generation. The model also does not provide extra credit for dispatchable low- or zero-emitting generation technologies, or credit for imported clean generation in Canada or Mexico. Implementation of some of these aspects of the Policy and these technologies as buildable in the model is currently underway and the results from the simulations presented here will be updated upon completion. Given that the model finds the least-cost solution for complying with the Policy, the inclusion of additional sources of credits, either from outside the United States or from additional technologies as compliance tools can be expected only to lower the projected costs of the Policy relative to the current results.

In addition to the above assumptions that increase the estimated cost of the Policy, this analysis also makes two assumptions which decrease the estimated cost. First, the responsiveness of hourly load to electricity prices is based entirely on the electricity price within the same hour, rather than, say, partly on the electricity price in the preceding months. Furthermore, we assume that this load response is consistent with recovery of generation and transmission capacity costs in hours of peak scarcity, rather than through a time-invariant per-kWh charge. Second, we assume that the only emissions counted other than generators' own smokestack emissions are upstream methane releases from the natural gas and coal fuel cycles. If additional emissions were to be counted, such as those associated with building, decommissioning, and maintaining generators, as called for in the legislation, the cost of compliance would be higher, though the Policy would also result in greater emissions reductions.

In addition, the bill bases the clean energy percentage requirement of each Retail Electricity Supplier on the clean energy percentage of that supplier in the year the bill passes. Our analysis instead assumes that the bill would be changed to apply the same percentage requirement to all Retail Electricity Suppliers in a given state.

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Notes

1 They might no longer qualify for full credits once lifecycle emissions are counted, as called for in the Act.

2 The formula for awarding clean energy credits is: Generator credit = 1 – ((generator emissions rate) / (0.4 Metric Tons per MWh)).

3 Some readers may be interested in comparisons with the US power sector's greenhouse gas emissions in 2005, since that is a standard comparison year. Our modeling projects that that the power-sector greenhouse gas emissions in 2035 under the Policy would be 76% lower than the estimated US power sector greenhouse gas emissions in 2005. This counts CO_2 and methane.

4 This $106 billion cost is the reduction in what economists call "consumer surplus." In this case, it could instead be called "end-user surplus" because it is the total across all users of electricity, both residential and non-residential.

5 Thirty-two is the estimated 100-year global warming potential of methane and is also the approximate ratio of the estimated damage per ton of methane versus of CO_2.

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