OnLocation
A KEYLOGIC COMPANY

Analysis of the Smith CES Proposal

Modeling Results and Insights

Prepared for API

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Project Overview

- OnLocation recently completed an analysis for API of a Clean Electricity Standard (CES) policy using the API21-NEMS model[1] that focused on the CES policy as proposed in the CLEAN Future Act (CFA) introduced to Congress in March 2021.
- As a follow-on task, API would like to explore the CES policy as specified in a July 2021 draft proposal by Senator Smith.[2]
- We created a CES case using API21-NEMS that reflects the key features of the policy described in the Smith Proposal.
- As with the CFA CES analysis, the Reference and Smith CES cases incorporate the extensions of the renewable production and investment tax credits and 45Q sequestration tax credits passed in the December 2021 Omnibus bill that were not included in the AEO 2021 Reference case.

[1] API21-NEMS is a version of the U.S. Energy Information Administration's National Energy Modeling System (NEMS) developed by OnLocation for use in this analysis. For more information about the NEMS model, visit https://www.eia.gov/outlooks/aeo/.
[2] See the document titled "Smith CES Proposal Draft July 19.pdf."

Summary of Key Findings

- Both the Smith CES and CFA CES policies are effective in reducing CO_2 emissions and achieving 80% clean electricity sales by 2030 in the power sector, although the definition of “clean” differs somewhat between the policies.
- After 2030, clean targets and the resulting emission reductions level off in the Smith case while emissions in the CFA case continue to decline for several years thereafter.
- The Smith CES crediting system provides more incentive for fossil fuel-fired generation with carbon capture technologies compared to the partial crediting system in the CFA bill that is based on life-cycle emissions.
- Natural gas with carbon capture plays a role in the Smith case but coal with carbon capture is not sufficiently economic enough to deploy in a material way.
- Electricity prices and power system costs in the Smith CES case are much lower than in the CFA case primarily due to the more relaxed targets post-2030; the ability to use fully credited natural gas generation with capture may also contribute to lower costs.

Smith Clean Electricity Standard Proposal

- The Smith proposal establishes a nationwide Clean Electricity Standard (CES) with the following requirements:
  - Goal: Load-serving entities (LSEs) must collectively achieve 80 percent clean electricity sales by 2030, with no obligation to achieve 100 percent by 2035.
  - CES credits would be issued to zero-emitting generating sources including renewables and nuclear as well as "coal-fired and gas-fired electric generating units (EGUs) retrofitted with CCS and achieving a minimum percentage of CO_2 capture" defined as 70 to 90 percent capture. No partial crediting would be issued to gas-fired generation without CO_2 capture.
  - Two glidepath options are outlined in the proposal to achieve 80 percent clean:
    1. One approach requires each LSE to achieve the same percentage increase of clean energy each year, with national electricity sales reaching an average 80% clean;
    2. The other approach requires each LSE to achieve 80% clean with percentage increases dependent on each LSE's baseline amount of clean electricity.
- Federal grants would be available to LSEs for each clean MWh achieved above goals, at least $150 billion for 10 years.
- Penalties may be imposed on LSEs that miss annual clean targets or "backslide".

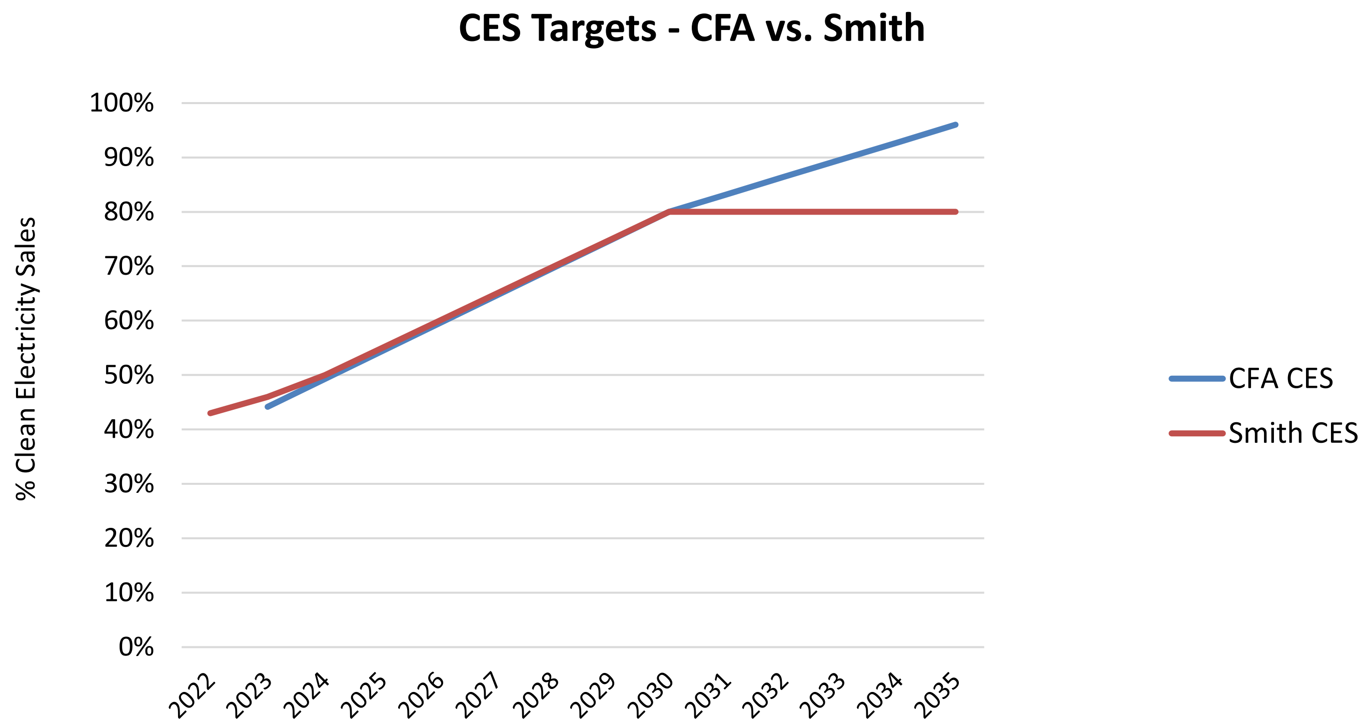
Smith CES Scenario Assumptions

- The Smith CES scenario is modeled as follows:
  - A national CES standard starting in 2022 defined as percent of clean electricity sales* (applied to load-serving entities or LSEs).
  - The standard achieves 80 percent clean by 2030 and uses the proposal's specified percentage increase of clean energy each year between 2023 and 2030. The standard remains at 80 percent clean each year after 2030.
  - CES credits are tradable among LSEs, which implies that all LSEs have the same 80% target as in Glidepath #2 but some LSEs will achieve more than 80% clean and will trade excess credits with other LSEs that are not able to achieve 80% using their resources alone.
  - Clean generation receives a full CES credit per MWh. This includes renewables, nuclear, and both coal and gas carbon capture technologies. No partial credits are available.
    - We will assume 90% capture rates for all carbon capture technologies.
  - Penalties for underachievement were not considered.
  - The effect of the proposed Federal grants is reflected in electricity prices that are adjusted outside of the model with a simple assumption that the estimated $150 billion appropriation will flow through to consumers between 2023-2032 (10 years).

** We interpret the definition of the standard to be percent of electricity sales which allows a small amount of generation to emit CO_2 due to transmission losses (generation minus losses = sales).*

CES Targets

- The CES targets in the CFA bill and the Smith proposal are very similar through 2030, but the Smith targets do not increase after 2030. In addition, the Smith targets start one year earlier (2022) and increase at a slightly slower rate in the first 2 years of the policy.



CES Credits by Technology

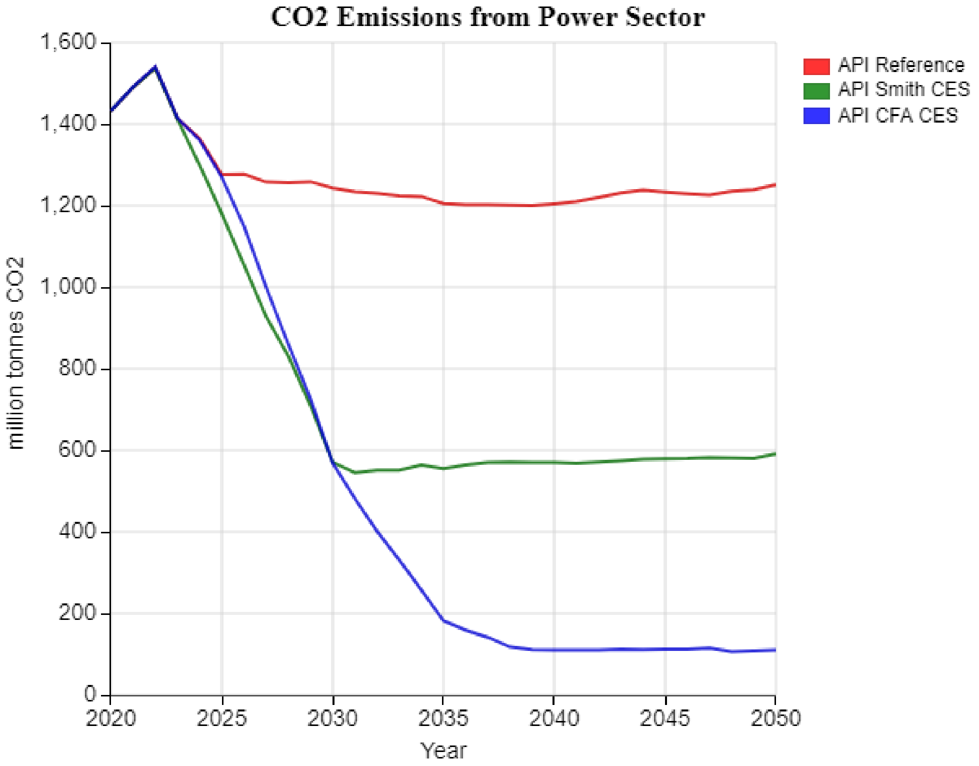
- The CES credits available to each technology are compared here between the Smith proposal and the CFA bill. The Smith proposal gives generation from carbon capture technologies the same CES full credit value as nuclear and renewable technologies.

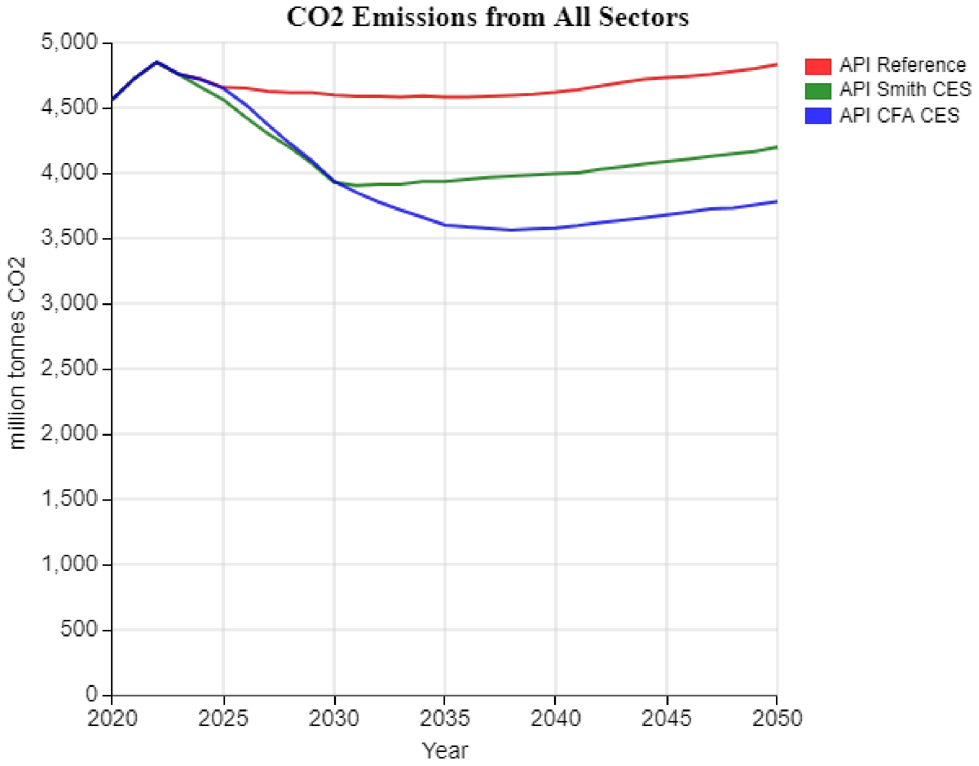
Technologies	Smith CES Credits	CFA CES Credits	
	2023 - 2050	2030	2035
Emissions Benchmark*	**n/a**	**0.82**	**0.40**
Nuclear and Renewables	Full credit	Full credit	Full credit
Coal with CO_2 Capture (90%)	Full credit	Partial credit	No credit
Natural Gas with CO_2 Capture (90%)	Full credit	Partial credit	Partial credit
Natural Gas Combined Cycle	No credit	Partial credit	No credit
Natural Gas Steam/Turbines	No credit	Partial credit	No credit
Conventional Coal	No credit	No credit	No credit

** Benchmark carbon intensity factors are expressed as metric tons CO_2 equivalent per MWh.*

Power Sector and Economy-Wide CO_2 Emissions

- Despite the difference in crediting schema, the two CES policies achieve essentially the same emission reductions through 2030 in meeting the 80% clean target as modeled.
- Emissions in both cases decline to below 600 million metric tonnes (mmt) CO_2 by 2030 or 54% below Reference case levels, with emissions continuing to decline in the CFA case due to increasing stringency. Emissions post-2030 reflect a mix of remaining conventional natural gas and coal generation.

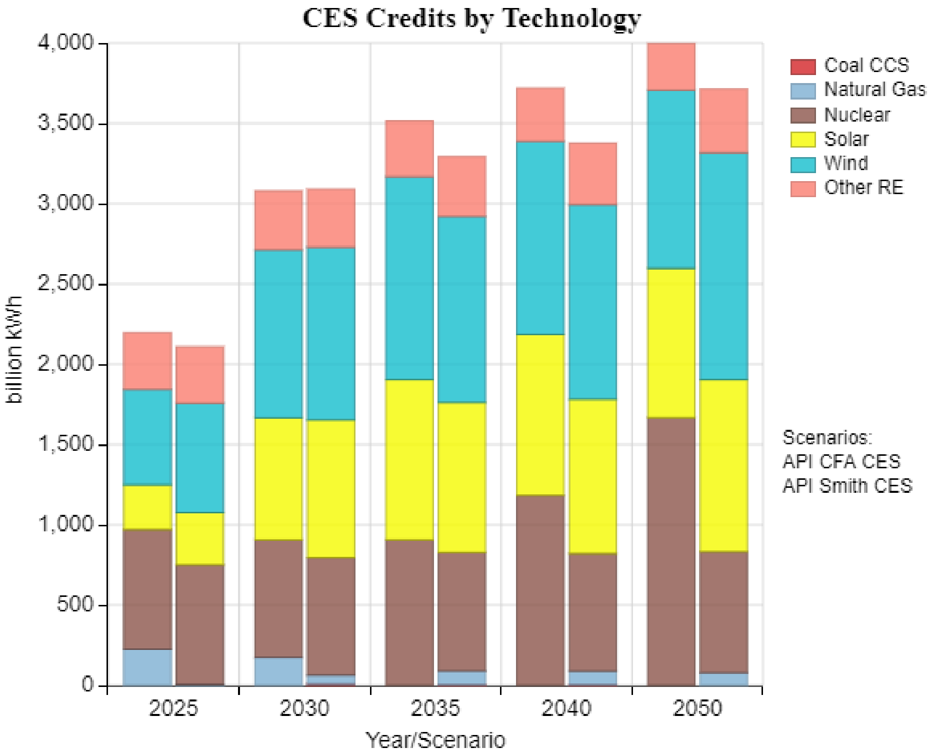


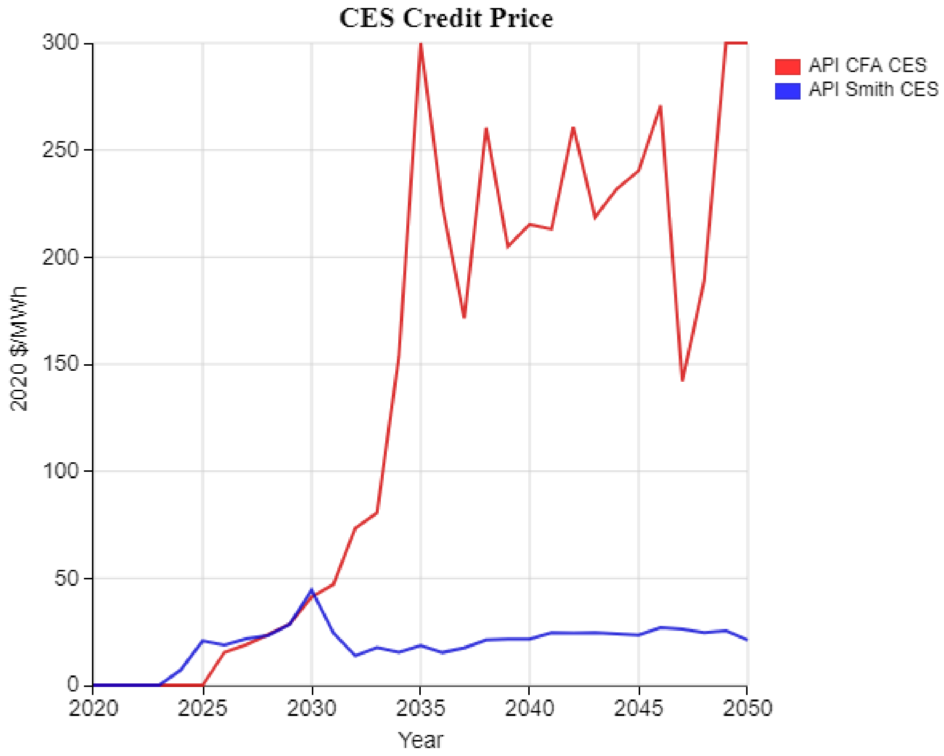


Note the difference in scales between the two charts.

CES Policy Credits and Credit Price

- To meet the 80% clean target in 2030, Smith CES credits are created by a mix of nuclear and renewable generation and some natural gas with 90% capture. After 2030, the number of CES credits continue to increase as electricity demand increases.
- The Smith marginal CES credit trading price reaches almost $50/MWh by 2030, then declines as the relative stringency of the policy declines. This is in sharp contrast to the CFA CES credit price that reaches an imposed CES price cap* of $300/MWh by 2035 and remains high through 2050.



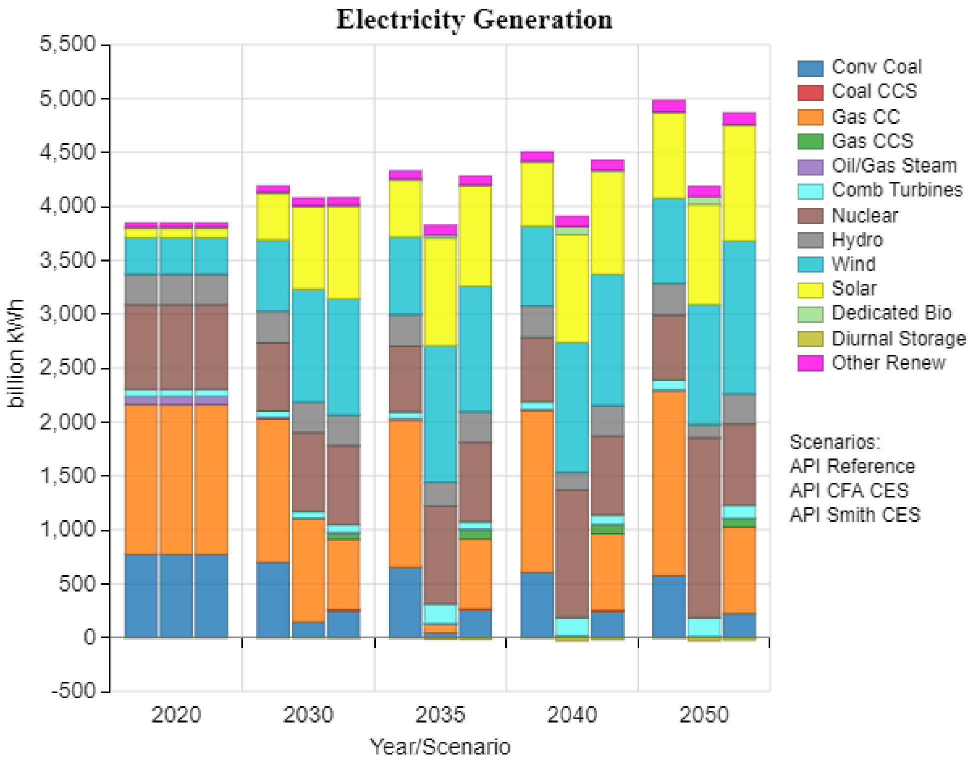


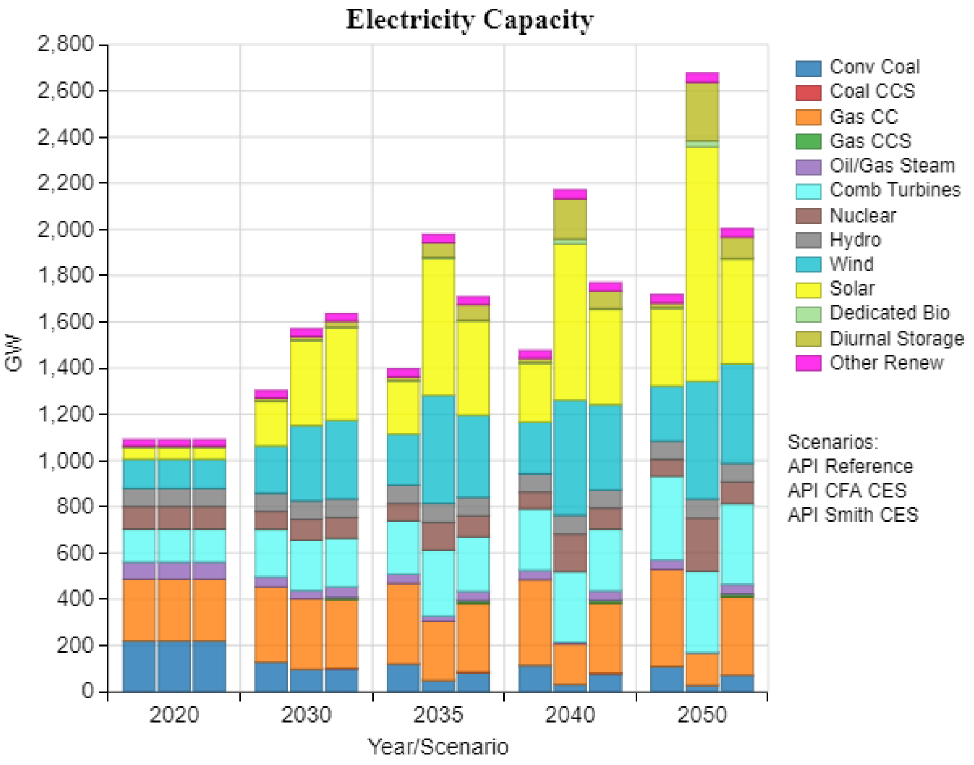
Note: End-year modeling effects may be distorting the costs in the last 5 years

** A CES price cap was added for purposes of model stability only.*

Electricity Generation and Capacity Mix

- The share of carbon-free renewable (especially solar and wind generation) and nuclear generation significantly increases in the CES cases compared to the Reference case, and conventional fossil-fueled generation decreases.
- The Smith CES case results in some natural gas CCS and more remaining conventional fossil than the CFA CES case.
- The total amount of capacity in the CES cases is higher than the Reference case due to the lower capacity utilization for variable generation renewables and their low contribution to reserve requirements.

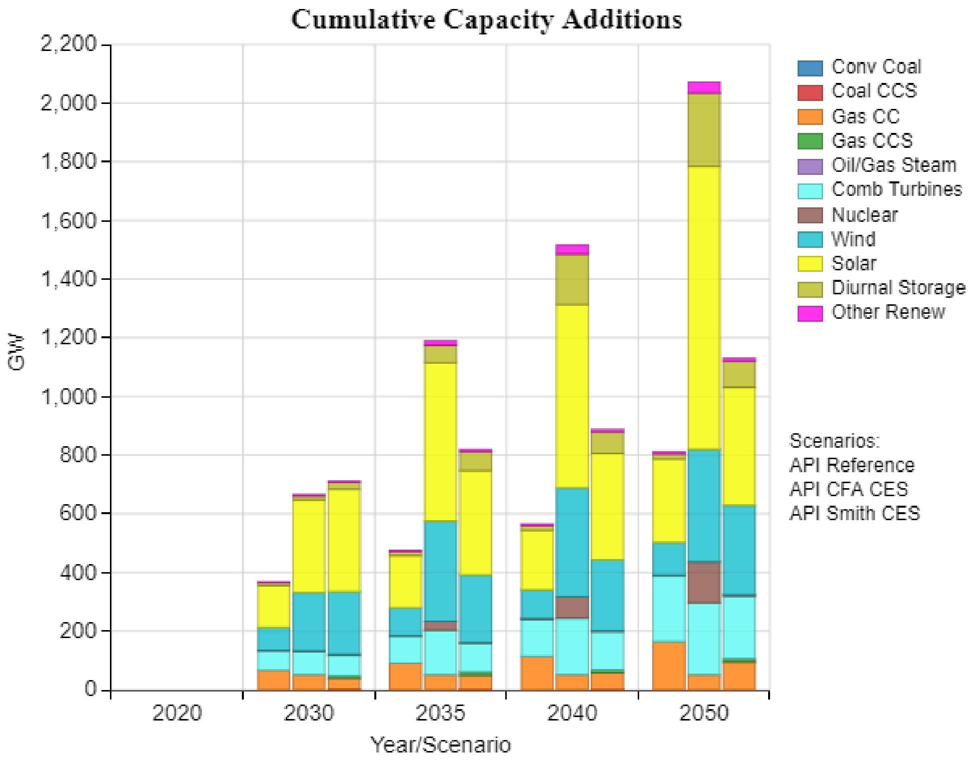


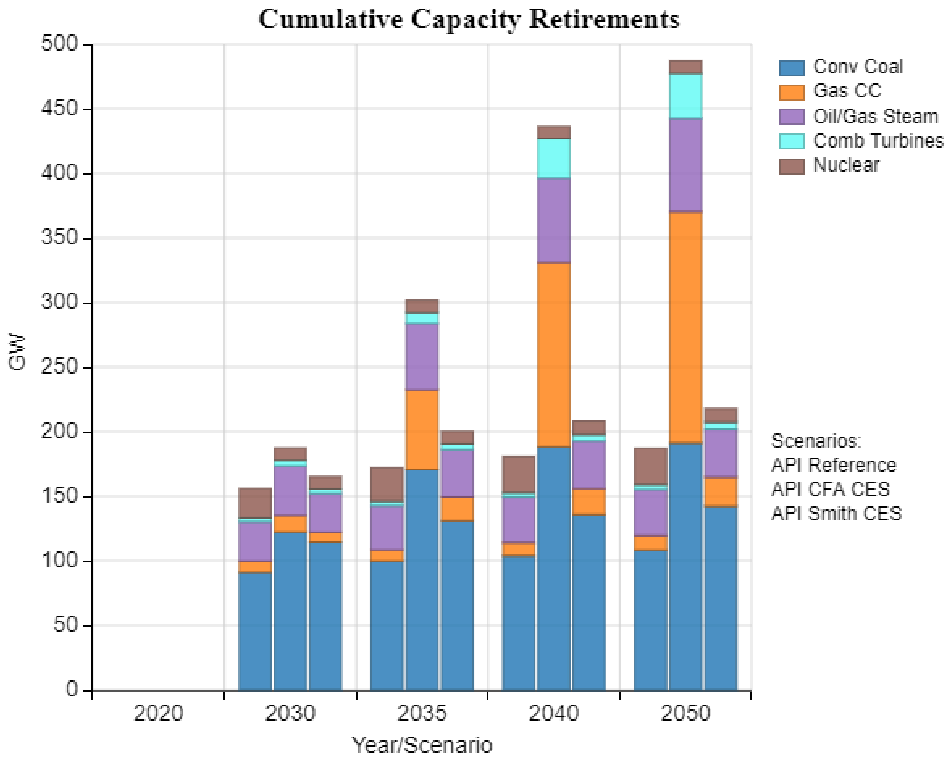


Note: Diurnal (battery) storage produces net negative generation due to losses.

Electric Capacity Additions and Retirements

- Capacity additions in the CES cases are dominated by wind, solar, and diurnal (battery) storage, but also include some new nuclear (in the CFA case only) and natural gas-fired facilities.
- Unlike the CFA CES, the Smith version does not cause significant retirements of conventional gas technologies. Both CES proposals lead to fewer nuclear plant retirements compared to the Reference case due to their improved financial prospects under the CES policy.

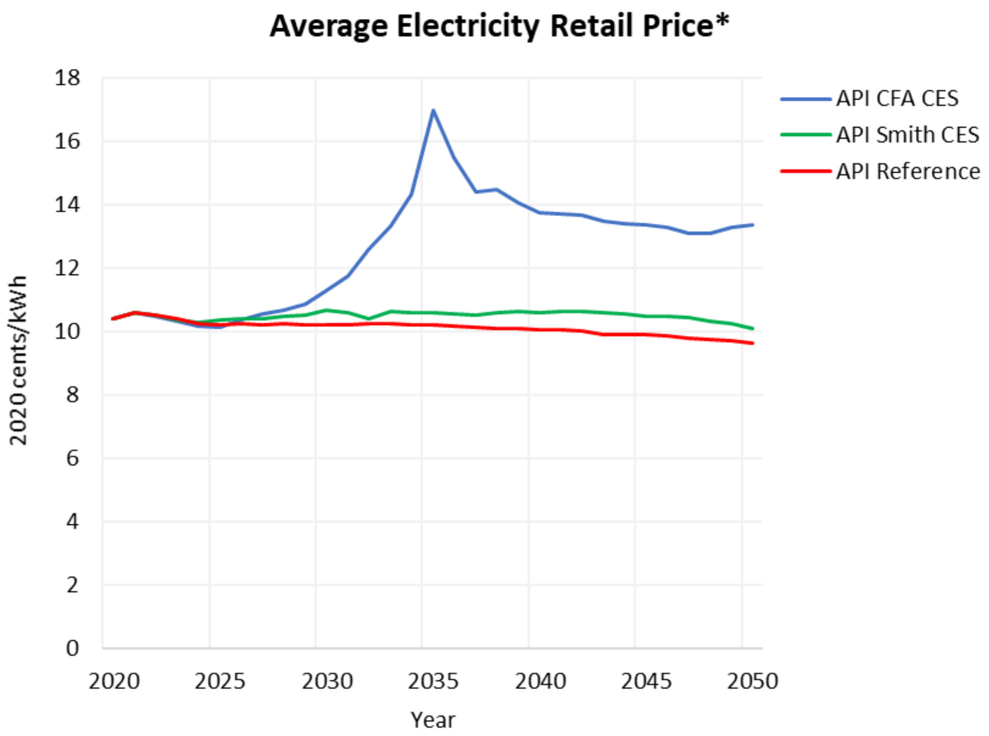


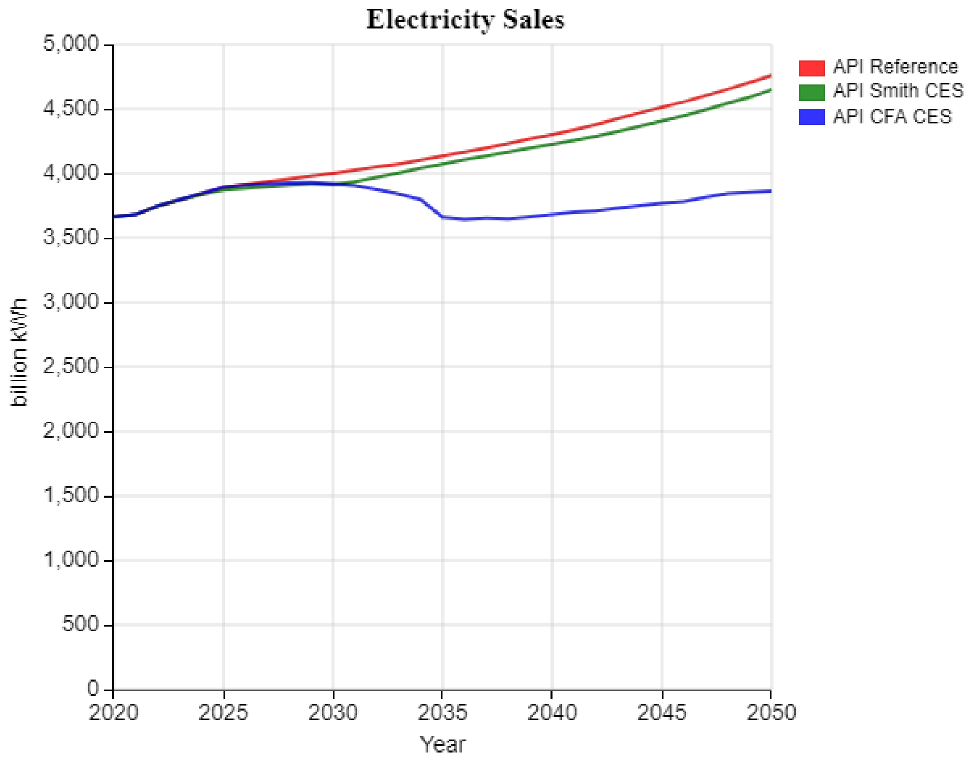


Note the difference in scales between the two charts.

Electricity Prices and Sales *(updated price chart)*

- The average electricity price* increases by about 0.5 cents/KWh by 2030 in the Smith case, much less than in the CFA case where prices increase by almost 7.0 cents/KWh by 2035. In both CES cases, prices decline somewhat as new capital investments decline and wholesale prices are reduced by low variable cost generators.
- Electricity sales decline in response to higher electricity prices due to behavioral responses (such as adjusting the thermostat) as well as a shift to onsite generation such as rooftop solar and industrial combined heat and power.

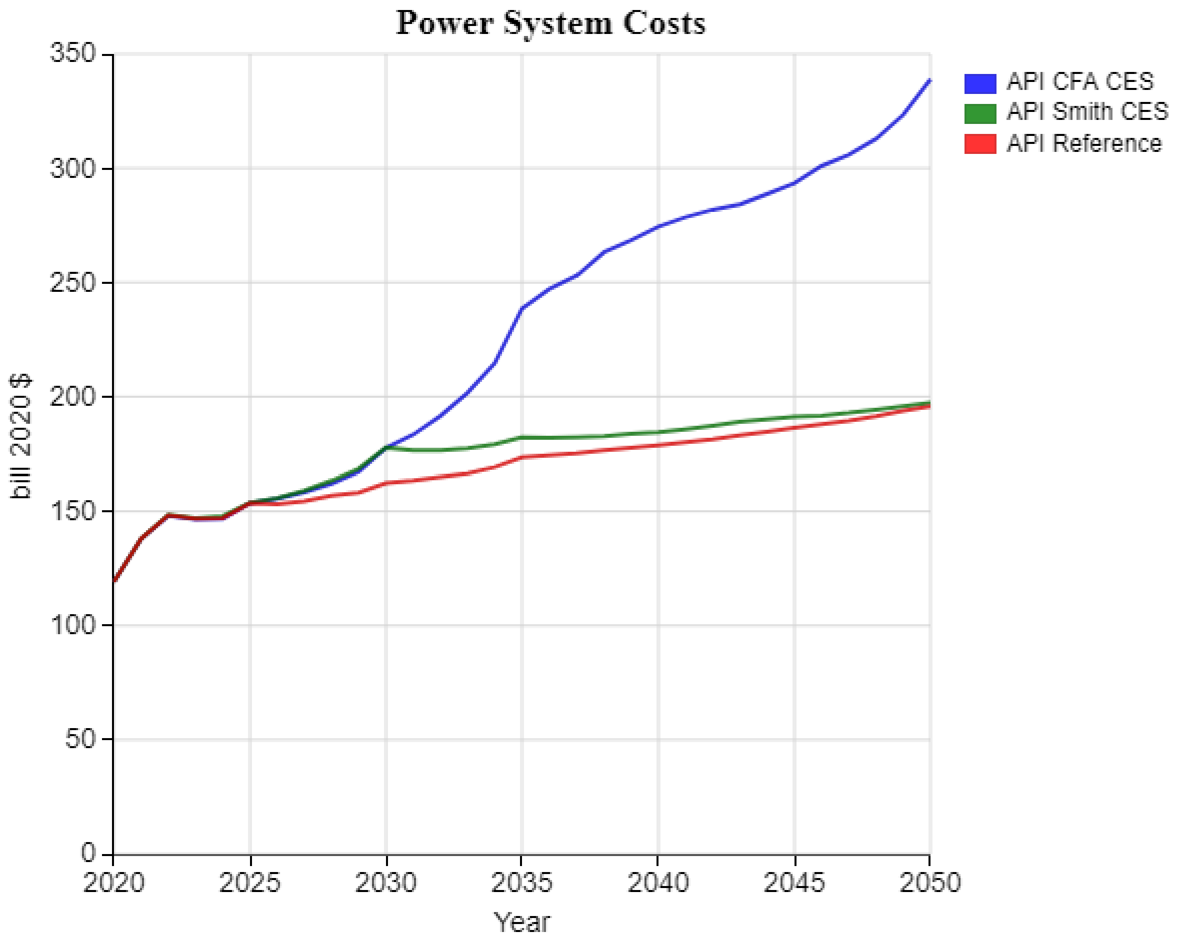




**Note: the electricity prices shown for the Smith CES case have been adjusted outside of the model for the proposed $150 billion Federal grant. See Appendix B for more information.*

Power System Costs*

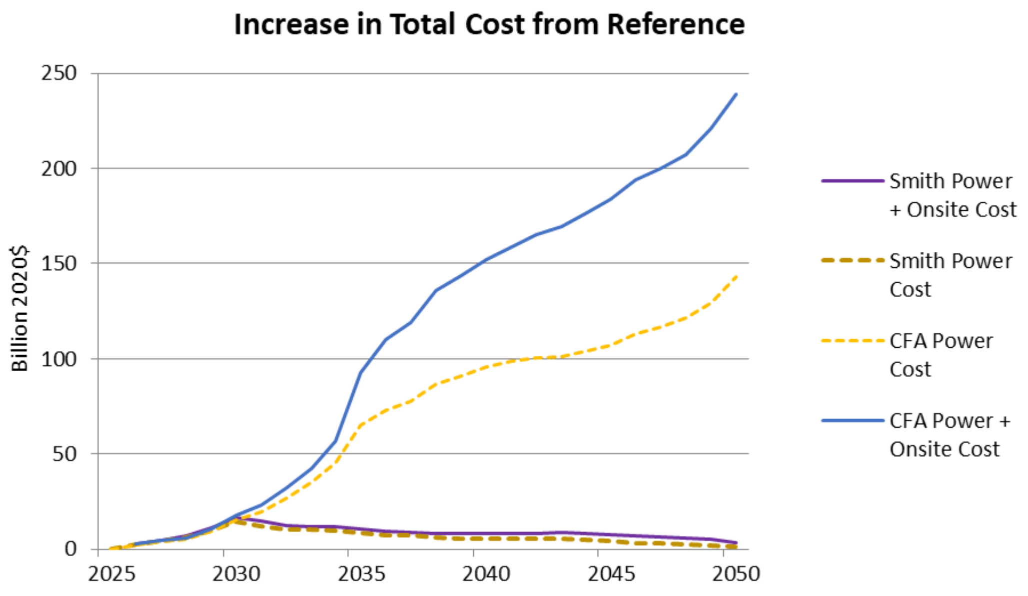
- The annual cost of power production increases are nearly identical in both CES cases through 2030. After 2030, costs in the Smith case gradually increase and in the CFA case continue to rapidly increase through 2050.
- The cost increases from capital investments outweigh reduced fuel costs due to the shift to renewable generation as well as lower total generation.
- The total increase in system costs in the Smith CES case between 2022 and 2050 is roughly $0.2 trillion undiscounted vs. about $1.8 trillion undiscounted in the CFA CES case.

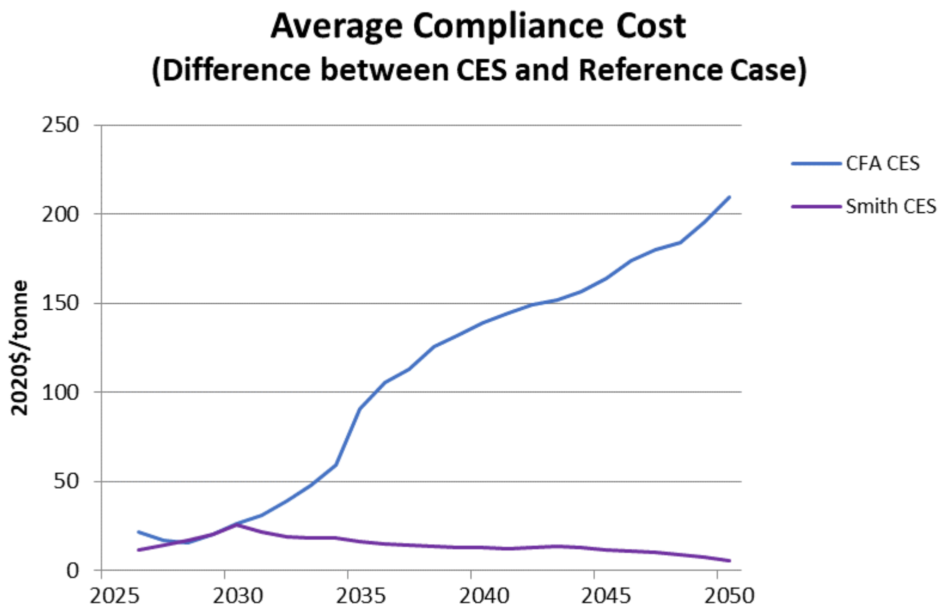


**System costs shown here reflect the cost of generation and added transmission costs associated with new generation capacity but exclude intraregional transmission maintenance and upgrades and distribution costs. See the Appendix for a detailed description of the system costs.*

Average Compliance Costs

- The average compliance cost is much higher under the CFA CES than with the Smith version, both in absolute terms as well as on a dollar per tonne basis; the CFA CES reaches a cost of over $200/tonne while the maximum annual cost is about $25 in 2030
  - The cost per tonne cost declines over time in the Smith case as the emission reductions remain relatively constant after 2030 and the incremental cost from the reference case becomes smaller.
  - This average cost of compliance is measured by the change in total cost (power system cost plus on-site generation cost) from the reference case in each year divided by the emission reductions in the same year.

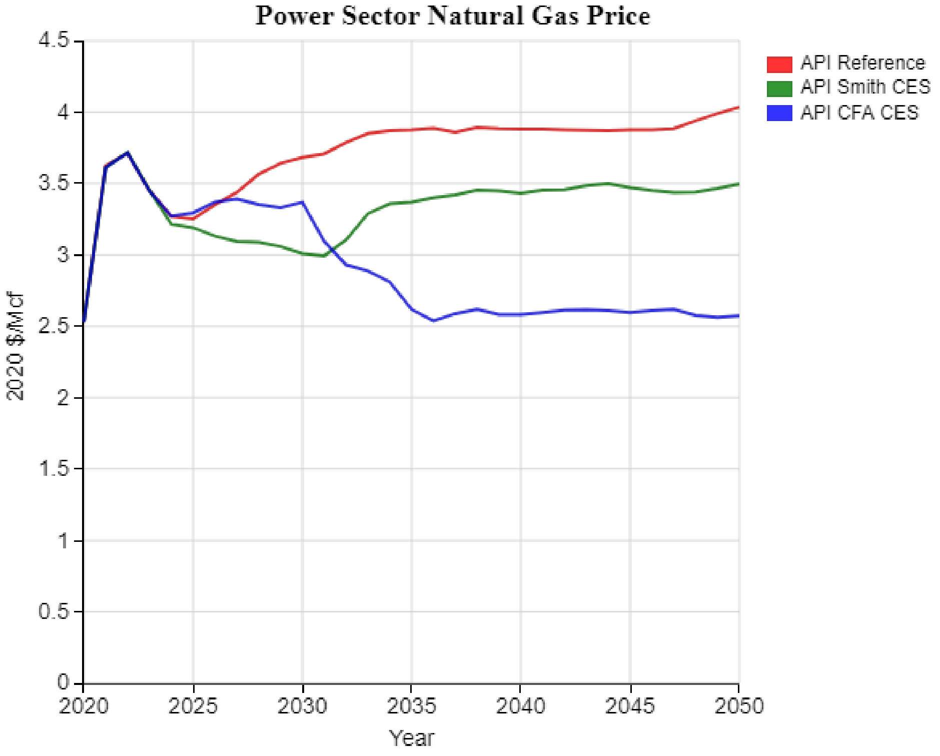


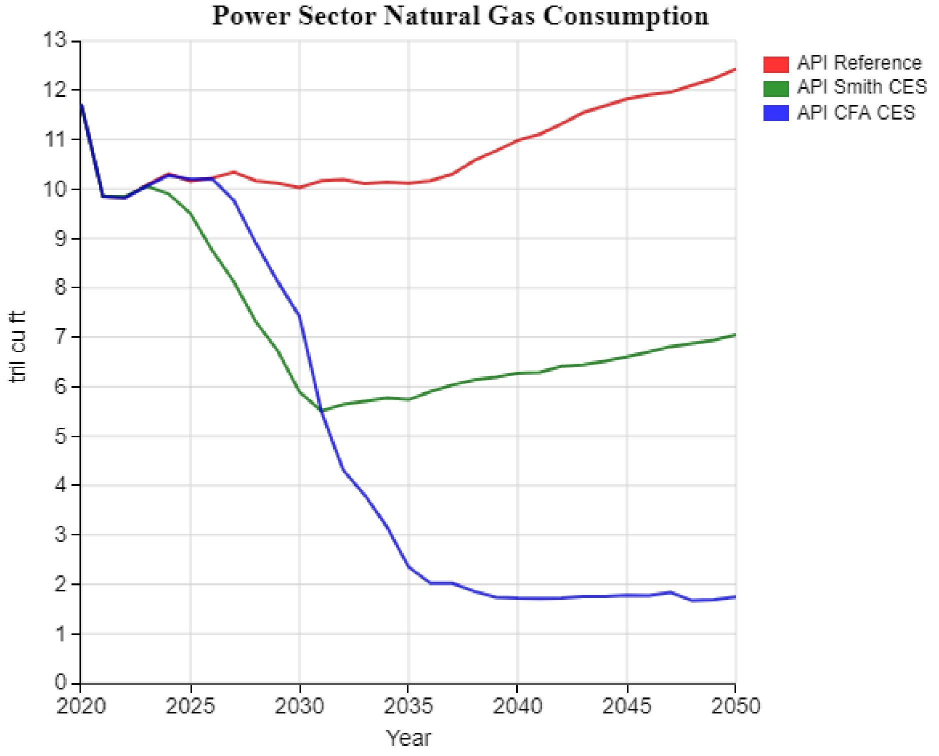


See Appendix A for a description of the average compliance costs.

Power Sector Natural Gas Prices and Consumption

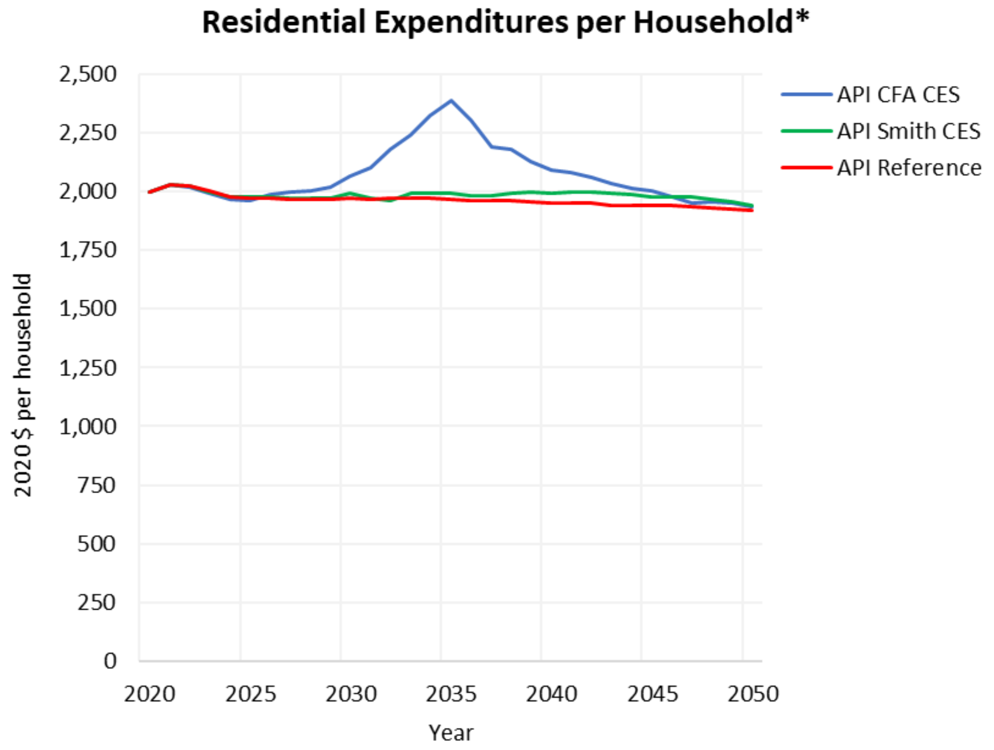
- Delivered natural gas prices to the power sector decline in both CES cases as natural gas generation is replaced by non-emitting sources. The price decline in the Smith CES case is greater in the early years due to the earlier policy start but less in later years, especially after 2030.
- Natural gas consumption in the power sector declines sharply through 2030 in the Smith CES case but rebounds after 2030 when the stringency of the policy is held constant and increased electricity demand allows for more gas generation.

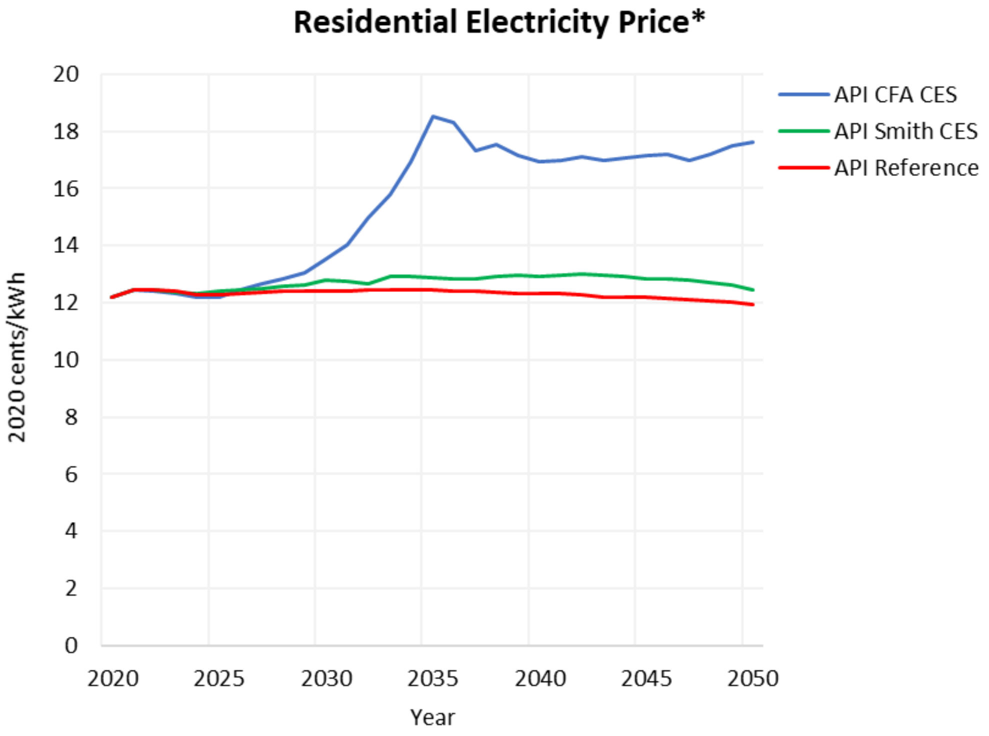




Household Energy Expenditures and Prices *(updated charts)*

- Household energy expenditures* increase in both CES cases primarily due to higher electric rates.*
- Overall, the Smith case has a much smaller impact with a peak increase in 2030 of about $20 per household per year or 1% compared to Reference case values vs. about $400 or 20% increase in 2035 in the CFA case.
- The price impact on expenditures is mitigated in part by reduced demand. Lower demand may mean reduced comfort (e.g., adjusting thermostats) and/or greater spending on energy efficient equipment and rooftop solar.





**Note: the expenditures and electricity prices shown for the Smith CES case have been adjusted outside of the model for the proposed $150 billion Federal grant. See Appendix B for more information.*

Modeling Insights of the CES Cases

- Both CES policies are effective in reducing CO_2 emissions and achieving 80% clean electricity sales by 2030 in the power sector, although the definition of “clean” differs somewhat between the policies.
- After 2030, clean targets and the resulting emission reductions level off in the Smith case while emissions in the CFA case continue to decline for several years thereafter.
- The Smith CES crediting system provides more incentive for fossil fuel-fired generation with carbon capture technologies compared to the partial crediting system in the CFA bill that is based on life-cycle emissions.
- Natural gas with carbon capture plays a role in the Smith case but coal with carbon capture is not sufficiently economic enough to deploy in a material way.
- Electricity prices and power system costs in the Smith CES case are much lower than in the CFA case primarily due to the more relaxed targets post-2030; the ability to use fully credited natural gas generation with capture may also contribute to lower costs.

Modeling Caveats

- The API21-NEMS model uses a complex set of assumptions about energy technologies and markets to represent current and future energy supply, demand, and prices within the U.S. The model cannot predict all of the changes that may occur under a challenging policy like the CFA CES scenario. The representation of the Smith CES policy does not push the model as far, but the following caveats still apply to some extent.
- The electricity model of API21-NEMS is designed to represent the current and evolving power grid. However, the rapid transformation of the grid as required by the CFA is outside the model's normal solution range, and therefore does not fully address the resulting challenges including, among others:
  - Variable generation and curtailment impacts on grid reliability are represented as a simplified abstraction and may lead to over- or under-estimating the cost for the CES;
  - The representation of the CES credit phase-down between 2030 and 2035 is only partially anticipated by the model which could lead to higher price impacts in that period and shortly thereafter.
- The macroeconomic model of API21-NEMS responds to changes in energy demand and prices but does not consider the projected policy-induced investments in energy equipment, so the projected impacts on GDP and employment growth are based on limited information.
- Only minor model modifications were made to represent the CES policy. A more in-depth study would include some structural model enhancements to better represent dispatch options and operating reserves. The study might also introduce additional carbon-free technologies or fuels as possibilities for the longer-term if not necessarily by 2035.
- Some impacts related to the policy that we could not include may lead to higher costs while other impacts could decrease costs compared to the modeling results; regardless, it is clear that the accelerated CFA CES requirement poses challenges that will need to be addressed by both modelers and policymakers.

Appendix A:

Methodology for Power System Costs and Compliance Cost per Tonne Estimate

Methodology for Power System and Compliance Costs

- Compliance costs are computed as the difference in power system costs between the CES scenario and the Reference case.
- Power system cost components include generation and some transmission capital investments, non-fuel operating and maintenance costs, and fuel expenses.
  - Capital costs reflect the full technology costs not including the effect of tax credits and are expressed as annuities of the investments (i.e., financed over their economic lifetimes).
  - Transmission investments include generator hookup fees and inter-regional transmission expansion costs. These investments do not include the cost of intra-regional transmission costs, annual costs of maintaining the grid, and distribution costs to deliver the power to consumers' homes and businesses.
- The total costs are approximated by adding incremental power system costs and increased investments in onsite generation that account for much of the decrease in sales.
  - Onsite generation investment costs were converted to annuities as well before being added to compliance costs.
- The average cost per metric tonne of CO_2 reduction is computed as the annual cost increase divided by annual emission reductions compared to the reference case.

Appendix B:

Adjustments for Smith Proposal Federal Grants

Adjustment for Smith Proposal Federal Grants

- The Smith CES proposal includes an appropriation of at least $150 billion to fund the 10 years of grants awarded to LSEs for achieving clean electricity sales targets above a specified baseline. The intent of the grants is to cover the cost of the clean energy requirements so "electricity ratepayers would theoretically not be required to bear the costs of this incremental clean energy."
- OnLocation took the Smith CES scenario modeling results for electricity prices and household expenditures and adjusted them to reflect an assumed $150 billion of Federal grants.
- We converted the $150 billion from nominal to real 2020$ using an assumed 2% per year inflation factor and applied the grants over 10 years (2023-2032).
- The amount of the grant applied in each year is assumed to be proportional to the difference in ratepayer expenditures between the Reference and Smith cases.
- The amount of the grant subtracted from the model's electricity price (cents/KWh) and household expenditures ($/household) is shown in the table below:

Grant (2020$)	2023	2024	2025	2026	2027	2028	2029	2030	2021	2032
cents/KWh	0.0	0.05	0.20	0.25	0.29	0.34	0.44	0.75	0.60	0.30
$/household	0.0	5.7	22.7	28.7	32.9	38.6	50.5	85.1	67.1	33.5

Electricity Price and Household Expenditures Adjustments

- The following charts illustrate the difference between the model results (without the grants) and the adjusted results with the Federal grants in the years 2023 to 2032.
- The adjusted prices and household expenditures are not as high in each year as projected in the model, especially in 2030, thereby reducing the consumer impact of the standard.
- However, the adjusted values are higher than the Reference case values which suggests that the $150 billion appropriation may not be sufficient to cover the full cost of the policy.