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Analysis of Impacts of a Clean Energy Standard

as requested by Chairman Hall

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Preface

This report responds to a July 2011 request to the U.S. Energy Information Administration (EIA) from Chairman Ralph M. Hall of the U.S. House of Representatives Committee on Science, Space, and Technology, for an analysis of the impacts of a Clean Energy Standard (CES). The request, as outlined in the letter included in Appendix A, sets out specific assumptions and scenarios for the study.

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Introduction

This report responds to a request from Chairman Ralph M. Hall for an analysis of the impacts of a Clean Energy Standard (CES). The request, as outlined in the letter included in Appendix A, sets out specific assumptions and scenarios for the study.

Background

A CES is a policy that requires covered electricity retailers to supply a specified share of their electricity sales from qualifying clean energy resources. Under a CES, electric generators would be granted clean energy credits for every megawatt-hour (MWh) of electricity they produce using qualifying clean energy sources. Utilities that serve retail customers would use some combination of credits granted to their own generation or credits acquired from other generators to meet their CES obligations. Generators without retail customers or utilities that generated more clean energy credits than needed to meet their own obligations could sell CES credits to other companies.

The impact of a CES will be sensitive to its design details and to assumptions made regarding the cost of the different fuels and technologies that can be used for electricity generation. Chairman Hall's request asks for an evaluation of a particular CES under a variety of alternative assumptions regarding the costs of generation fuels and technologies.

The CES specified by Chairman Hall, hereinafter referred to as the Hall CES (HCES), has the following characteristics:

- Eligible resources to meet the HCES target include: hydroelectric, wind, solar, geothermal, biomass power, municipal solid waste, landfill gas, nuclear, coal-fired plants with carbon capture and sequestration, and natural gas-fired plants with either carbon capture and sequestration or utilizing combined cycle technology.
- Generators earn 0.5 MWh of compliance credits for every 1 MWh of generation from a combined cycle plant that burns natural gas, and 0.9 MWh of compliance credits for every 1 MWh of generation from coal- or gas-fired generation with carbon capture and sequestration. All other HCES-qualified resources earn one HCES credit for every MWh of generation.
- Generation using qualified resources from either new or existing plants in any economic sector can receive HCES credits.
- The HCES target starts from an initial share of 44.8 percent (qualified generation as a percent of sales) in 2013 and rises linearly to 80 percent in 2035. Beyond 2035, the target remains at 80 percent.
- The HCES will apply to utilities in the aggregate; utilities may trade compliance credits with other utilities.
- There is no option to purchase compliance credits from the government. All credits are backed by physical generation.
- All electricity retailers are covered by the requirement, regardless of ownership type or size.
- HCES credits earned in one year cannot be "banked" for use in a subsequent year. All credits must be used for compliance in the year that the underlying generation was produced.

- HCES obligations are based on total electricity sales, regardless of source. There is no provision for excluding any electricity sales from a seller's baseline based on resources used to produce the electricity or type of customer purchasing the electricity.
- The HCES operates independent of any State-level policies. The same underlying generation can be used to simultaneously comply with the HCES and any State generation requirements, if otherwise allowed for by both Federal and State law.

Like other EIA analyses of energy and environmental policy proposals, this report focuses on the impacts of those proposals on energy choices in all sectors and the implications of those decisions for emissions and the economy. This focus is consistent with EIA's statutory mission and expertise. The study does not account for any possible health or environmental benefits that might be associated with the HCES policy.

Analysis Cases

The analysis presented in this report starts from the *Annual Energy Outlook 2011 (AEO2011)* Reference case[1] (Ref), which is compared to a case that reflects the HCES requirements outlined in the previous section. The same comparison is repeated under a series of alternative assumptions regarding the costs of generation fuels and technologies. The assumptions used in the eight alternative cases, each of which is run with and without the HCES policy, are briefly summarized below and are more fully explained in Appendix E of the *AEO2011*.

Nuclear Low Cost (LC-Nuc): Capital and operating costs for new nuclear capacity start 20 percent lower than in the Reference case and fall to 40 percent lower in 2035.

Nuclear High Cost (HC-Nuc): Costs for new nuclear technology do not improve from 2011 levels in the Reference case through 2035.

Renewable Low Cost (LC-Ren): Costs of non-hydropower renewable generating technologies start 20 percent lower in 2011 and decline to 40 percent lower than Reference case levels in 2035. Capital costs of renewable liquid fuel technologies start 20 percent lower in 2011 and decline to approximately 40 percent lower than Reference case levels in 2035.

Renewable High Cost (HC-Ren): Costs of non-hydropower renewable generating technologies remain constant at 2011 levels through 2035. Costs are still tied to key commodity price indexes, but no cost improvement from "learning-by-doing" effects is assumed.

Natural Gas Low Cost (LC-Gas) (corresponds with High Shale Recovery case in the AEO2011): The estimated undeveloped technically recoverable shale gas resource base is 50 percent higher than in the Reference case with the per well recovery rate unchanged from the Reference case, resulting in more wells needed to fully recover the resource.

Natural Gas High Cost (HC-Gas) (corresponds with Low Shale Recovery case in the AEO2011): The estimated undeveloped technically recoverable shale gas resource base is 50 percent lower than in the Reference case with

[1] The Reference Case in this report includes some revisions to the AEO2011 Reference Case. The primary changes include an improved representation of interregional capacity transfers for reliability pricing and reserve margins. Also, capacity expansion decisions incorporate better foresight of future capital cost trends by including expectations of the commodity price index.

the per well recovery rate unchanged from the Reference case, resulting in fewer wells needed to fully recover the resource.

Coal Low Cost (LC-Coal): Regional productivity growth rates for coal mining are approximately 2.7 percent per year higher than in the Reference case, and coal mining wages, mine equipment costs, and coal transportation rates are between 22 and 25 percent lower by 2035 than in the Reference case.

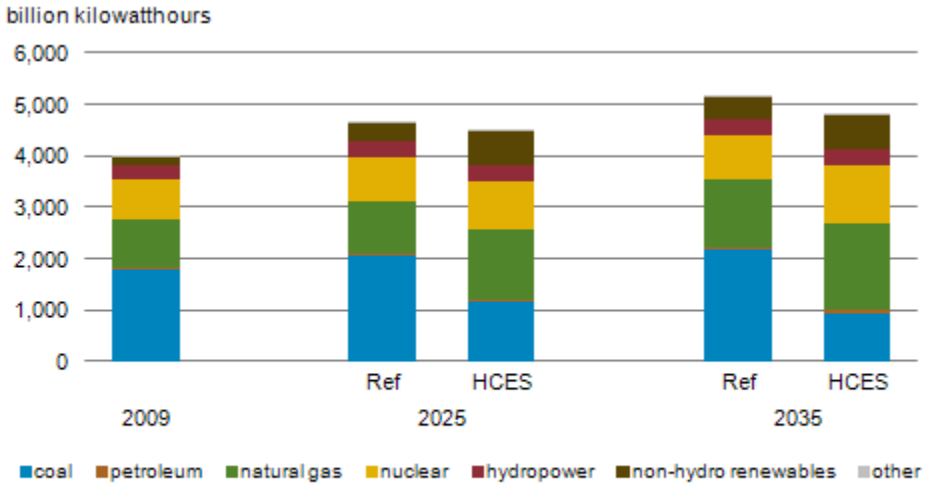
Coal High Cost (HC-Coal): Regional productivity growth rates for coal mining are approximately 2.7 percent per year lower than in the Reference case, and coal mining wages, mine equipment costs, and coal transportation rates are between 25 and 28 percent higher by 2035 than in the Reference case.

Results

HCES Impacts under AEO2011 Reference case

The HCES results in a large shift in the generation mix (Figure 1 and Table B1). Coal-fired generation, which grows by nearly 23 percent between 2009 and 2035 in the Reference case, decreases by 46 percent between 2009 and 2035 in the HCES case. Coal is primarily displaced by increased natural gas generation, which in the HCES case is 38 percent greater than the Reference case level in 2025 and 30 percent greater in 2035. Nuclear and renewable generation also exceed the Reference case projection in the HCES case, though the HCES effect on nuclear generation occurs primarily after 2025.

Figure 1. Total Net Electricity Generation

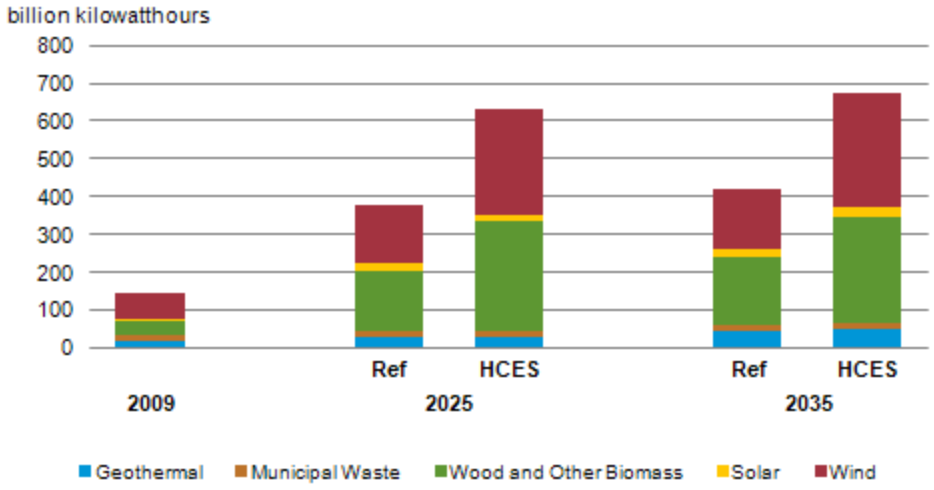


Source: U.S. Energy Information Administration, National Energy Modeling System, runs refhall.d082611b and ceshallnb.d083011a.

Among renewable sources, wind and biomass have the largest generation increases under the HCES (Figure 2 and Table B1). By 2035, there is nearly twice as much wind generation than without the HCES policy. Additional biomass generation is met primarily through increased co-firing of biomass in existing coal plants, which decreases in the latter part of the projection as new nuclear generation capacity comes online and existing coal capacity is retired.

HCES compliance strategies vary over time. Compliance through 2020 is attained primarily from existing nuclear and renewable capacity, renewable capacity projected to be built with or without the HCES policy, increasing dispatch of existing qualified natural gas plants, and increasing co-firing of biomass. After 2020, an increasing amount of incremental credits are achieved by generation from wind and nuclear capacity additions in excess of the Reference case, as well as coal-firedgeneration from existing plants retrofitted with sequestration technology.

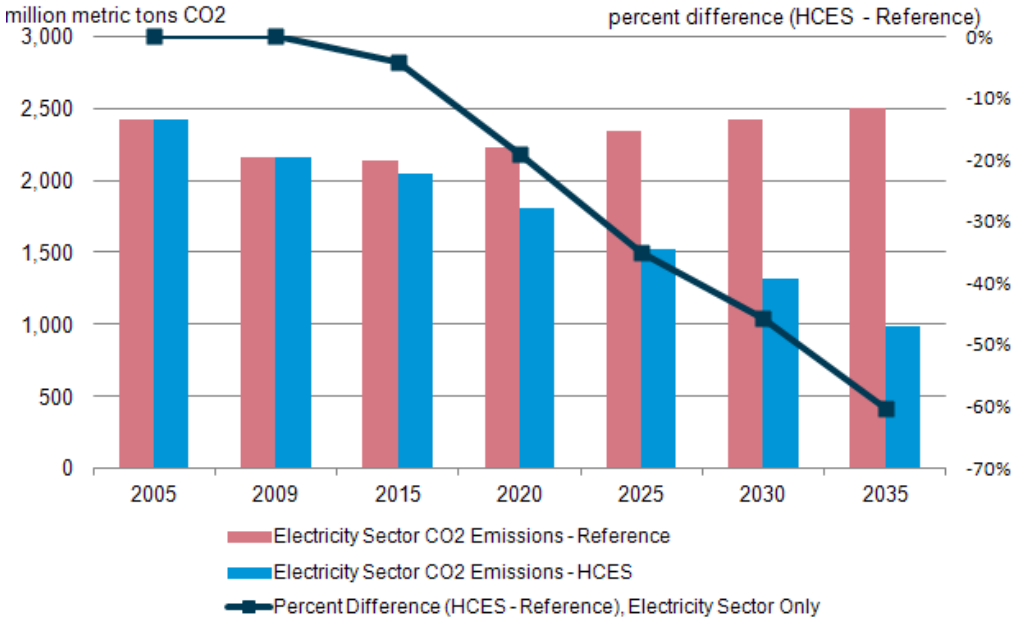
Figure 2. Total Non-Hydroelectric Renewable Generation



Source: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082611b and ceshallnb.d083011a.

Annual electricity sector carbon dioxide emissions decrease by more than 50 percent between 2009 and 2035 under the HCES (Figure 3 and Table B1). In the Reference case scenario, however, electricity-sector carbon dioxide emissions increase over the forecast period to reach 2,500 million metric tons of carbon dioxide (MMTCO2) by 2035. In 2025, the electric power sector accounts for 1,525 MMTCO2 under the HCES, which is 35 percent less than in the Reference case. By 2035, HCES electric power sector emissions are 60 percent below the Reference case.

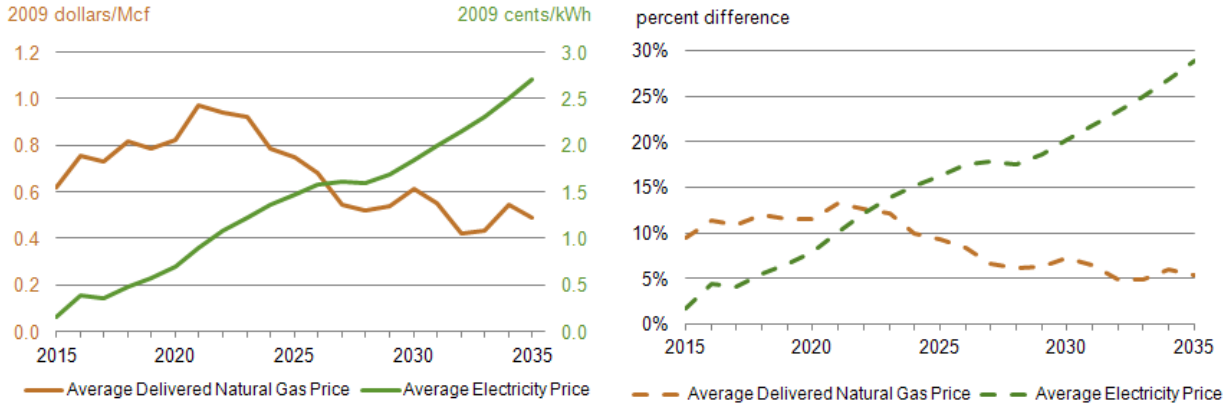
Figure 3. Electricity Sector Carbon Dioxide Emissions



Source: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082611b and ceshallnb.d083011a

The HCES has an increasing impact on average electricity prices from 2015 through 2035 (Figure 4 and Table B1). The impacts on electricity prices prior to 2015 are negligible, because the Reference case projects sufficient eligible generation to nearly meet the HCES requirement. Beyond 2015, electricity prices under the HCES rise above the Reference case level, and the difference grows steadily through 2035. In 2025, the average HCES electricity price is 10.5 cents/kWh – or about 1.5 cents (16 percent) greater than without the policy. In 2035, the average electricity price under the HCES exceeds the Reference case average price by 2.7 cents/kWh (29 percent).

Figure 4. HCES Impact on Electricity and Natural Gas Prices (HCES Difference from Reference Case)



Source: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082611b and ceshallnb.d083011a.

The HCES impact on electricity prices varies significantly across regions (Table 1). In 2035, the HCES impact on average electricity prices ranges between negative 1.6 cents/kWh (indicating that the average electricity price is actually lower under the HCES than the reference case) and positive 8.4 cents/kWh. Regions that are more dependent on generation fuels that are not HCES-eligible, primarily coal, in general experience a stronger price impact.

Natural gas prices increase under the HCES, particularly in the earlier part of the projection. Average delivered natural gas prices exceed Reference case average delivered prices by $0.75/Mcf (9.3 percent) in 2025, but only $0.49/Mcf (5.4 percent) in 2035. Unlike in the case of electricity, the HCES impact on natural gas prices does not increase throughout the entire projection. In earlier years of the legislation, natural gas accounts for much of the incremental HCES compliance, which results in a surge in natural gas prices. As other compliance options are built, however, the differential between natural gas prices with and without the HCES remains between about 5 percent and 10 percent from 2025 to 2035.

Table 1. Regional Electricity Prices (cents/kWh)

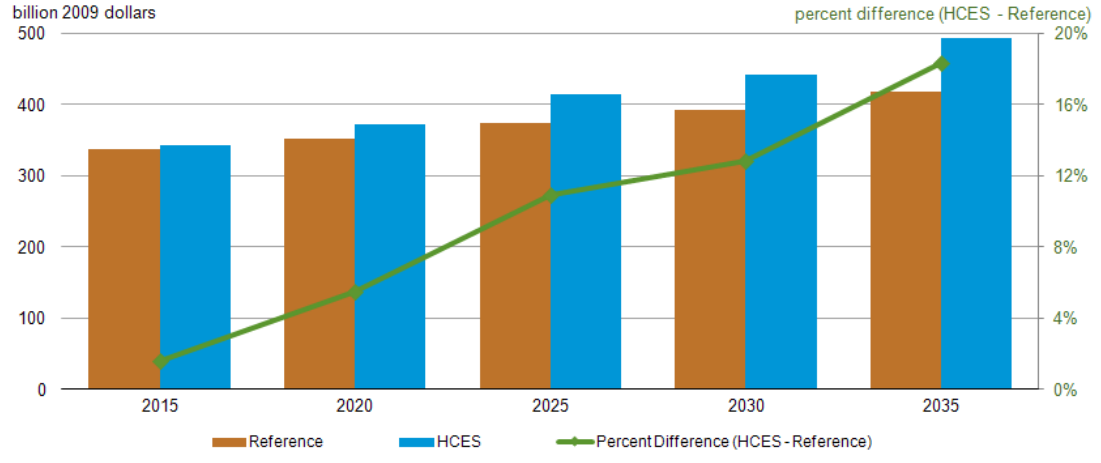
	Region	2009	2025		2035	
			Reference	HCES	Reference	HCES
1	ERCOT - ERCOT All	10.4	9.2	11.8	10.0	14.2
2	FRCC - FRCC All	11.6	10.9	13.4	11.2	15.0
3	MORE - MRO East	9.3	7.5	8.2	7.3	5.6
4	MROW - MRO West	7.6	6.8	8.3	6.9	9.0
5	NEWE - NPCC New England	15.7	13.6	15.0	13.1	16.8
6	NYCW - NPCC NYC/Westchester	19.9	16.8	19.1	16.9	22.3
7	NYLI - NPCC Long Island	18.1	16.7	21.2	16.6	25.1
8	NYUP - NPCC Upstate NY	11.6	11.9	14.1	12.6	17.1
9	RFCE - RFC East	12.2	10.7	13.3	10.9	16.4
10	RFCM - RFC Michigan	9.6	8.7	10.3	9.0	12.2
11	RFCW - RFC West	8.6	8.5	10.9	9.9	12.9
12	SRDA - SERC Delta	7.5	7.3	6.9	7.5	7.3
13	SRGW - SERC Gateway	7.8	6.5	8.5	7.0	11.3
14	SRSE - SERC Southeastern	9.1	8.7	9.2	8.5	9.9
15	SRCE - SERC Central	7.8	6.0	7.0	6.0	8.8
16	SRVC - SERC VACAR	8.6	8.1	8.7	8.3	9.8
17	SPNO - SPP North	7.9	7.6	9.5	7.5	10.2
18	SPNO - SPP South	6.9	7.8	10.2	8.5	12.4
19	AZNM - WECC Southwest	9.8	9.5	10.6	10.4	11.9
20	CAMX - WECC California	13.3	14.6	13.6	13.2	13.8
21	NWPP - WECC Northwest	7.0	4.6	4.6	5.2	5.6
22	RMPA - WECC Rockies	8.2	9.0	12.4	9.4	13.9
	U.S. Average	9.8	9.0	10.5	9.4	12.1

HCES electricity price is 10-25 percent greater than the Reference case electricity price
HCES electricity price is 25 percent or more greater than the Reference case electricity price

Source: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082611b and ceshallnb.d083011a.
Note: See Appendix C for a map of the NEMS electricity market module regions.

Electricity expenditures increase under the HCES as a result of higher electricity prices (Figure 5 and Table B1). However, because electricity sales decrease slightly, the impact is smaller than the impact on electricity prices. In 2035, total electricity expenditures under the HCES policy are 18 percent above the projected Reference case level. In 2025, the average household spends $1,277 per year on electricity – $115 above the Reference case –and by 2035, expenditures rise to $1,407 per year – $211 above the Reference case.

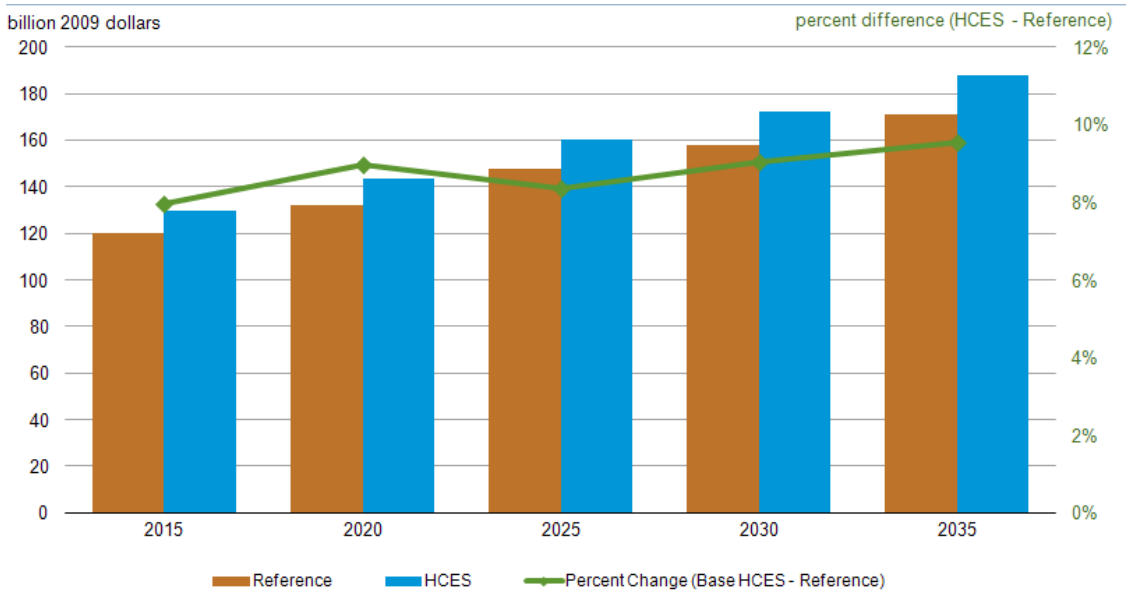
Figure 5. Total Electricity Expenditures



Source: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082611b and ceshallnb.d083011a.

Higher natural gas prices lead to increased natural gas expenditures outside the electricity sector under the HCES (Figure 6 and Table B1). In 2025, non-electric natural gas expenditures under the HCES exceed Reference case expenditures by 8 percent. This differential increases to 10 percent by 2035. In comparison to non-electric natural gas expenditures, natural gas expenditures in the electric power sector experience a dual upward pressure, from both higher prices and higher consumption. Particularly in early years, when increasing natural gas use at existing plants accounts for the greatest share of HCES compliance, the expenditure effect is quite large.

Figure 6. Natural Gas Expenditures, Not Including the Electric Power Sector

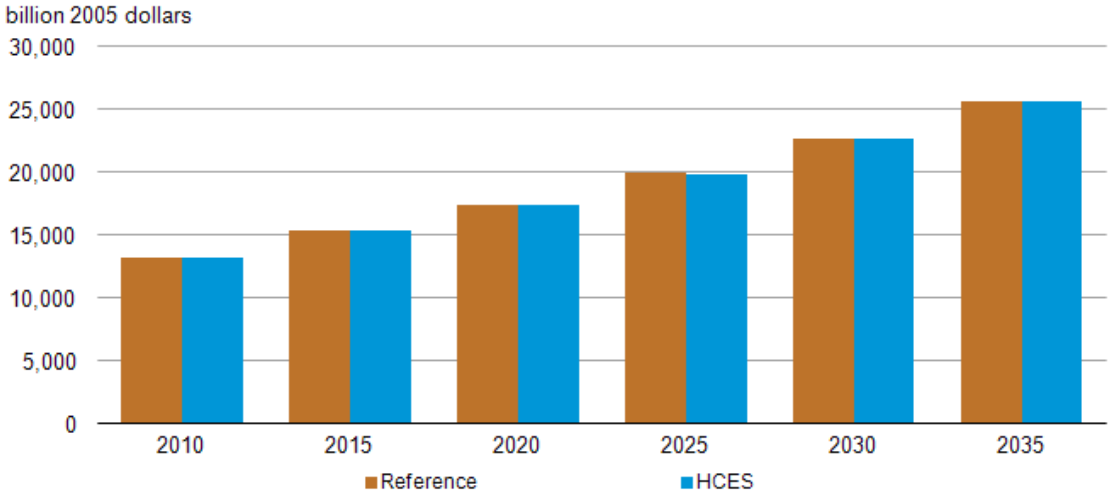


Source: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082611b and ceshallnb.d083011a.

The HCES reduces real GDP relative to the Reference case, though this effect moderates toward the end of the projection period (Figures 7 and 8 and Table B1). The peak negative impact is less than eight-tenths of one percent, realized in 2024. In the latter part of the projection, however, GDP under the HCES converges back toward the Reference case. GDP grows at an average annual rate of 2.68 percent between 2009 and 2035 under the HCES, just slightly below the Reference case growth rate of 2.69 percent. Real GDP per capita[2] in 2035 is $65,658 under the HCES, versus $65,848 in the Reference case – a reduction of about 0.3 percent.

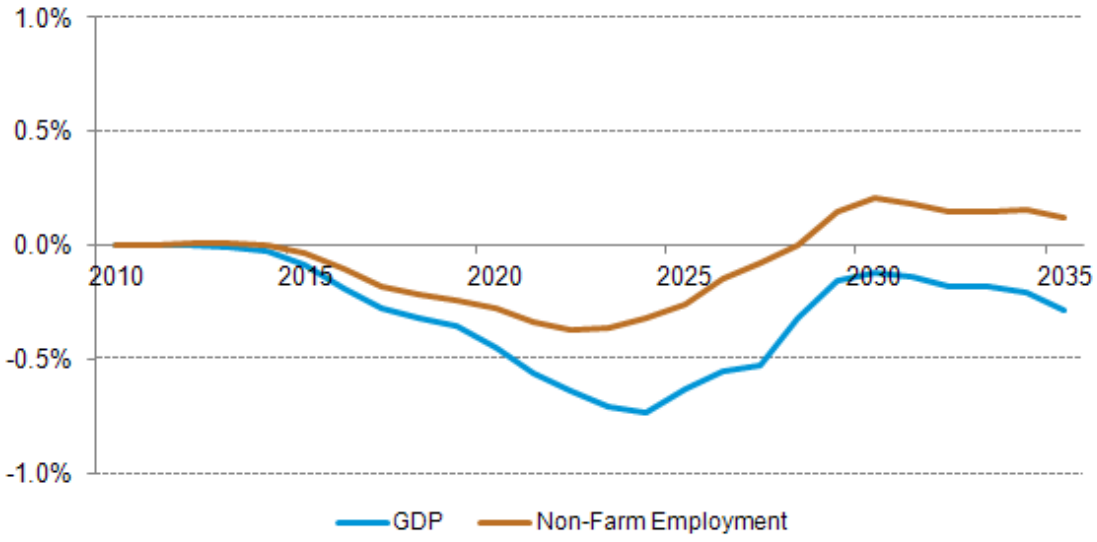
[2] Real GDP and real GDP per capita are reported in 2005 dollars.

Figure 7. Annual GDP



Source: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082611b and ceshallnb.d083011a.

Figure 8. HCES Impact on Employment and Real GDP, Percent Difference (HCES Difference from Reference Case)



Source: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082611b and ceshallnb.d083011a.

The HCES negatively affects non-farm employment from 2015 through the mid-2020's, but employment recovers toward the end of the projection period, following the trend of GDP. The change in overall energy prices peaks in 2025 and then begins to return to Reference case levels. In addition, the amount of diverted energy investment peaks in the mid-2020's, resulting in fewer diverted resources and productivity impacts later in the projection period. Service-sector employment leads the employment recovery, as services use relatively less energy than the manufacturing sector.

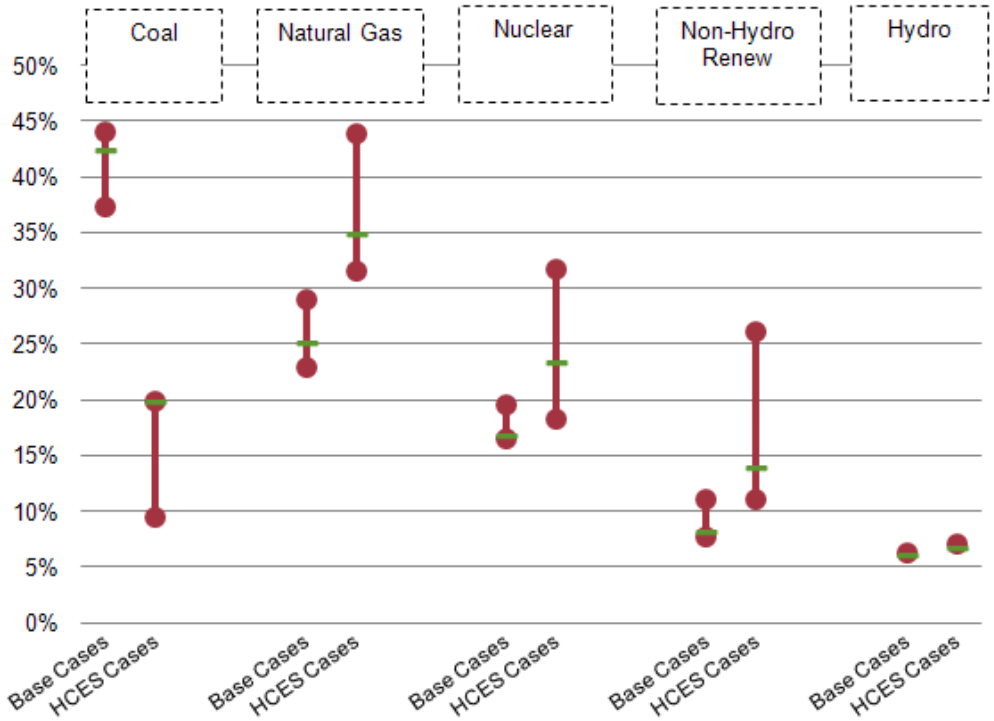
Sensitivity Analysis

The HCES could have a different effect when resource or technology costs diverge from the assumptions used in the Reference case. The following section considers the effect of the HCES when applied to different baseline scenarios. Per the request from Chairman Hall, EIA models the effect of the HCES given nine sensitivity scenarios, each of which are described in the introduction to this report.[3] Therefore, this section considers eighteen individual model scenarios – nine baseline sensitivity scenarios, and then the HCES under each of those scenarios. For the purpose of presenting the material in a digestible format, most of the discussion and Figures 10, 11, 12, and 14 below focus on the *impact* of the HCES, which is always described in reference to a specific corresponding baseline scenario. For example, the impact of the HCES on electricity prices in the low-cost nuclear case compares electricity prices under the HCES in the low-cost nuclear scenario to electricity prices in the low-cost nuclear case without the HCES. This approach isolates the effect of the policy from the underlying scenario assumptions. For this reason, the HCES cases with the highest or lowest impact on a given indicator do not necessarily reflect the cases that yield the highest or lowest level of that indicator. Tables B2 through B5 provide results for levels in all of the sensitivity cases.

The HCES causes coal-based generation to decline significantly in all sensitivity cases (Figure 9). In 2009, coal plants provided 45 percent of total power generation. However, by 2025 the share of generation from coal ranges from 22 percent to 27 percent in the HCES sensitivity cases, versus 41 percent to 46 percent in the base cases. The fall continues after 2025, when the share ranges from 10 percent to 20 percent in 2035 in the HCES sensitivity cases, versus 37 percent to 44 percent in the base cases. Of the HCES sensitivity cases, the highest share for coal occurs in the high-cost natural gas HCES case, while the lowest occurs in the high-cost coal HCES case. The HCES has the greatest impact – or causes the greatest reduction in coal-fired generation – in the low-cost renewable sensitivity case.

[3] The baseline scenarios are: the Reference case, high-cost nuclear, low-cost nuclear, high-cost renewables, low-cost renewables, high-cost gas, low-cost gas, high-cost coal and low-cost coal.

Figure 9. Fuel Shares of Total Generation in 2035, Range Over Sensitivity Cases



Note: The green dash shows the reference case value on the "base cases" graphs, and the basic HCES case (ie HCES applied to the AEO2011 Reference case) on the "CES cases" graphs.
Source: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082611b, ceshallnb.d083011a, refhallhn.d082611b, ceshallnbhn.d083011a, refhallln.d082611b, ceshallnbln.d083011a, refhallhr.d082611b, ceshallnbhr.d083011a, refhalllr.d082611b, ceshallnblr.d083011a, refhallhs.d082611b, ceshallnbhs.d083011a, refhallls.d082611b, ceshallnbls.d083011a, refhallhc.d082611b, ceshallnbhc.d083011a, refhalllc.d082611b, ceshallnblc.d083011a.

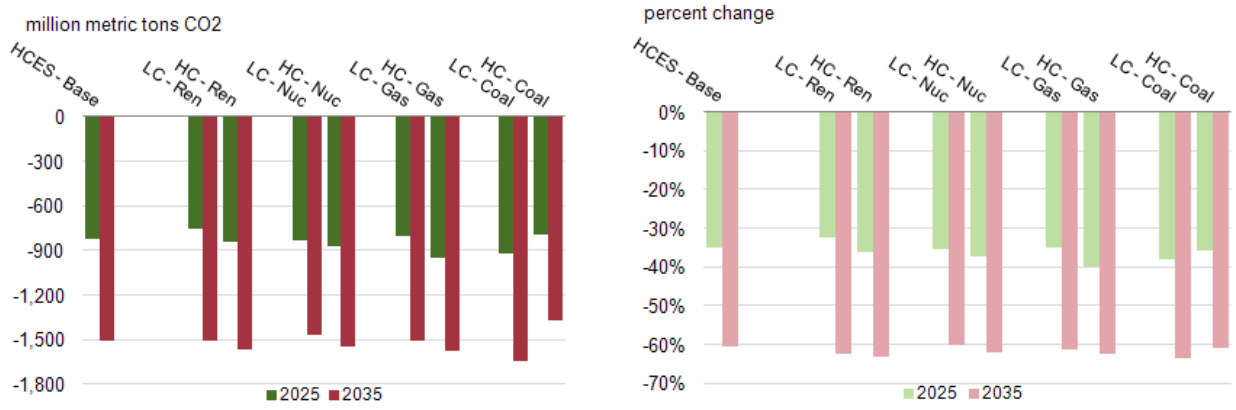
In contrast to the situation for coal, natural gas generation and non-hydroelectric renewable generation each increase significantly in the HCES sensitivity cases. However, there is significant variation in their share of total generation, depending on the underlying assumptions about their costs and the costs of other technologies. The share of generation coming from natural gas in the HCES sensitivity cases in 2035 varies from 32 percent to 44 percent, compared to 23 percent to 29 percent in the base cases. Among the HCES sensitivity cases, the highest share for natural gas occurs in the high-cost coal HCES case, while the lowest share occurs in the low-cost nuclear HCES case. Natural gas generation is most significantly impacted by the HCES in the high-cost nuclear case, where natural gas generation under the HCES exceeds the base case by 51 percent. The share of generation coming from non-hydroelectric renewables in the HCES sensitivity cases in 2035 varies from 11 percent to 26 percent – again, well above the 8 percent to 11 percent range of the base cases. The highest share occurs in the low-cost renewable HCES case and the lowest shares occur in the high-cost renewables and low-cost nuclear HCES cases. However, the impact of the HCES on the non-hydroelectric renewable generation is greatest in the low-cost renewable sensitivity case, in which non-hydroelectric renewable generation under the HCES exceeds the base case level by 118 percent.

Nuclear generation also increases under the HCES relative to baseline scenarios. However, the magnitude of the effect is extremely sensitive to the underlying baseline scenario. In the high-cost nuclear scenario, nuclear generation under the HCES is only 0.8 percent greater in 2035 than the associated low-cost nuclear baseline. In

contrast, nuclear generation under low-cost nuclear assumptions with the HCES exceeds the low-cost nuclear baseline by 54.6 percent. Significant effects on nuclear generation are primarily concentrated in the latter part of the projection period (2025 and after).

Natural gas is the leading source of generation by 2035 under the HCES in most of the HCES sensitivity cases. The notable exception to this trend is in the low-cost nuclear scenario, where relatively affordable nuclear capacity displaces natural gas as HCES-qualified baseload generation.

Figure 10. HCES Impact on Carbon Dioxide Emissions (HCES Difference from Corresponding Base Case)

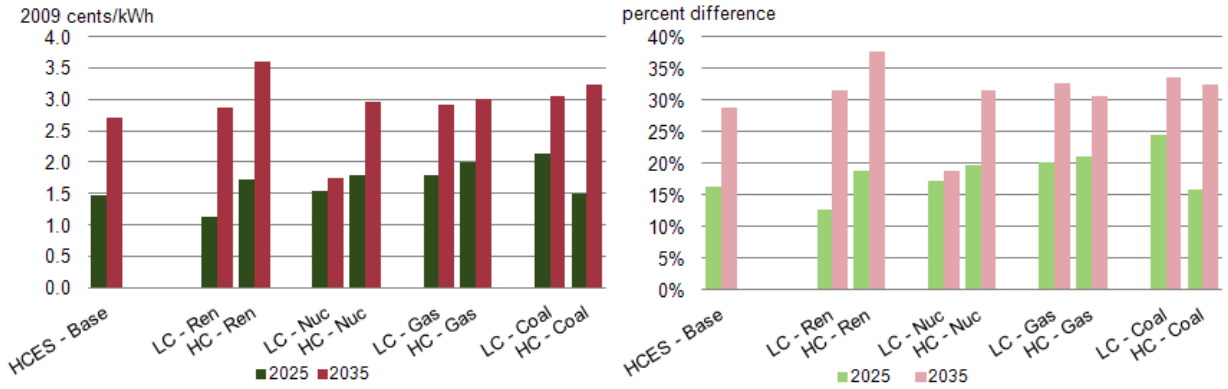


Source: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082611b, ceshallnb.d083011a, refhallhn.d082611b, ceshallnbhn.d083011a, refhallln.d082611b, ceshallnbln.d083011a, refhallhr.d082611b, ceshallnbhr.d083011a, refhalllr.d082611b, ceshallnblr.d083011a, refhallhs.d082611b, ceshallnbhs.d083011a, refhallls.d082611b, ceshallnbls.d083011a, refhallhc.d082611b, ceshallnbhc.d083011a, refhalllc.d082611b, ceshallnblc.d083011a.

Carbon dioxide emissions in the electric power sector fall significantly as a result of the HCES in all sensitivity cases (Figure 10). In each sensitivity case, the HCES results in emissions that are 33 percent to 40 percent lower than the associated base case levels in 2025, and 60 percent to 64 percent lower than the associated base case levels in 2035. Reductions are most significant in the low-cost coal scenario. Conversely, reductions in the high-cost coal scenario appear to be relatively modest – however, this is somewhat misleading, because the absolute level of emissions is actually lowest in the high-cost coal sensitivity case. The high cost of coal drives a reduction in coal-fired generation regardless of the HCES policy, and, therefore, the HCES policy has a lesser impact.

The HCES policy leads to higher electricity prices in all of the sensitivity cases (Figure 11). All alternative side cases exhibit higher average electricity prices under the HCES compared to the corresponding baseline. For example, the average electricity price in the baseline low-cost nuclear scenario is 9.3 cents/kWh in 2035, but with the HCES policy, the price is 11.0 cents/kWh. The difference between HCES and baseline electricity prices ranges from 1.7 cents/kWh to 3.6 cents/kWh in 2035. Electricity prices in 2035 without the HCES range from 8.9 cents/kWh to 10.0 cents/kWh, while under the HCES they range from 11.0 cents/kWh to 13.2 cents/kWh. Total and average household electricity expenditures follow a similar pattern, increasing across various sensitivity cases with the HCES. However, the price effect is again dampened by the resultant reduction in electricity sales, which ranges from 3.9 percent to 6.9 percent in the residential sector. The impact of the HCES on average household electricity expenditures ranges from increases of $131 to $279 per year in 2035 – or 11 percent to 23 percent above baseline expenditures.

Figure 11. HCES Impact on Electricity Prices (HCES Difference from Corresponding Base Case)

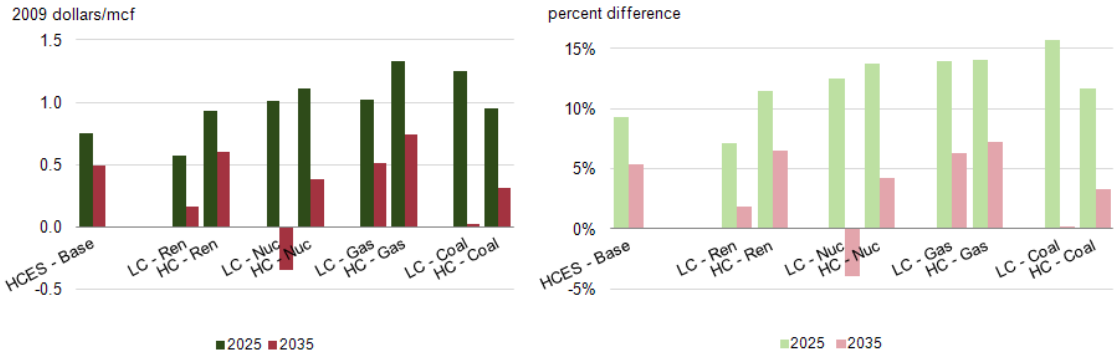


Source: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082611b, ceshallnb.d083011a, refhallhn.d082611b, ceshallnbhn.d083011a, refhallln.d082611b, ceshallnbln.d083011a, refhallhr.d082611b, ceshallnbhr.d083011a, refhalllr.d082611b, ceshallnblr.d083011a, refhallhs.d082611b, ceshallnbhs.d083011a, refhallls.d082611b, ceshallnbls.d083011a, refhallhc.d082611b, ceshallnbhc.d083011a, refhallic.d082611b, ceshallnblc.d083011a.

Electricity prices under the high-cost renewables scenario exhibit greater sensitivity to the HCES than in the other cases. Conversely, the price impact of the HCES is lowest in the low-cost nuclear scenario. In the high-cost renewables scenario, utilities still install significantly more non-hydroelectric renewable electricity than in the baseline high-cost renewable scenario. Because this technology is relatively more expensive to build, this additional cost translates into higher HCES credit prices (that is, compliance costs), which, in turn, increases electricity prices. In the low-cost nuclear scenario, the HCES has a relatively minimal impact over time, because a larger portion of overall HCES compliance can be met through generation from new nuclear capacity, the cost of which this scenario sets to be 40 percent less than the Reference case in 2035.

Natural gas prices generally increase under the HCES; however, the magnitude of this impact decreases toward the end of the projection horizon as other compliance options are increasingly available and attractive (Figure 12). This temporal pattern is generally consistent when the HCES is applied to alternative baseline scenarios. Interestingly, in the low-cost nuclear scenario, natural gas prices under the HCES in 2035 are actually lower than without the HCES policy, due to the much greater amount of nuclear generation capacity that is built in the latter part of this scenario. The HCES has the greatest price impact on natural gas in the high-cost natural gas case.

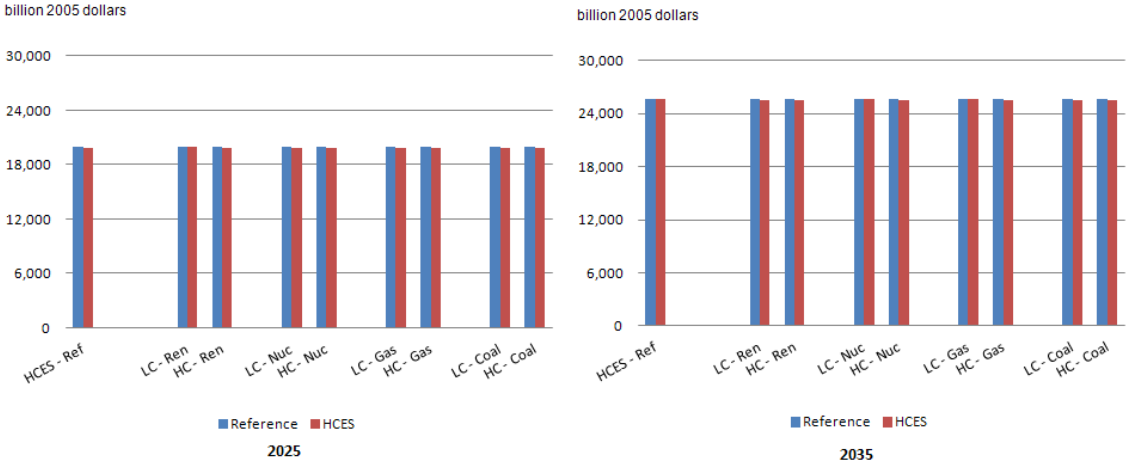
Figure 12. HCES Impact on Delivered Natural Gas Prices (HCES Difference from Corresponding Base Case)



Source: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082611b, ceshallnb.d083011a, refhallhn.d082611b, ceshallnbhn.d083011a, refhallln.d082611b, ceshallnbln.d083011a, refhallhr.d082611b, ceshallnbhr.d083011a, refhallir.d082611b, ceshallnblr.d083011a, refhallhs.d082611b, ceshallnbhs.d083011a, refhallls.d082611b, ceshallnbls.d083011a, refhallhc.d082611b, ceshallnbhc.d083011a, refhallic.d082611b, ceshallnblc.d083011a.

The finding that the HCES results in lower GDP is also robust across scenarios. However, consistent with the main case results, the impact on the growth rate of GDP is small. The average annual GDP growth rate over the 2009 to 2035 period ranges from 2.66 percent to 2.69 percent across the range of HCES sensitivity cases, compared to 2.68 percent to 2.69 percent in the corresponding base cases. In 2035, annual GDP ranges from $25,623 billion to $25,710 billion in the base case scenarios, versus a range of $25,514 billion to $25,705 billion under the HCES legislation (Figure 13). On a per capita basis, this translates to base case ranges between $65,686 per person and $65,909 per person, compared to a range of $65,406 per person to $65,897 per person under the HCES.

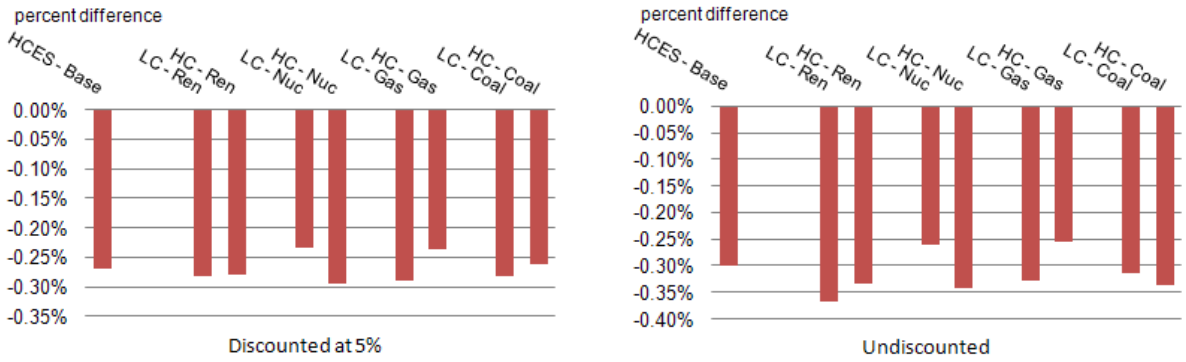
Figure 13. Annual GDP



Source: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082511b, ceshallnb.d083011a, refhallln.d082611b, ceshallnbln.d083011a, refhallhr.d082611b, ceshallnbhr.d083011a, refhallr.d082611b, ceshallnblr.d083011a, refhallhs.d082611b, ceshallnbhs.d083011a, refhalls.d082611b, ceshallnbls.d083011a, rehallhc.d082611b, ceshallnbhc.d083011a, refhalllc.d082611b, ceshallnblc.d083011a.

The negative effect on cumulative discounted GDP between 2009 and 2035 is less than 0.3 percent in all scenarios (Figure 14). In most sensitivity cases, annual GDP exhibits a recovery relative to the corresponding base case in the latter part of the projection (recall Figure 8). The nearer-term (2025) impact is strongest in the low-cost gas, high-cost nuclear, and low-cost coal scenarios. In the latter case, the differential is large because utilities cannot fully take advantage of the low-cost coal while still complying with the HCES. This forces retirement of plants that would be able to produce electricity relatively cheaply, and diverts investment from lower cost alternatives.

Figure 14. HCES Impact on Cumulative (2009-2035) GDP (HCES Difference from Corresponding Base Case)



Source: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d02611b. ceshallnb.d083011a, refhallhn.d082611b, ceshallnbhn.d083011a, refhalln.d082611b, ceshallnbln.d083011a, refhallhr.d082611b, ceshallnbhr.d083011a, refhallr.d082611b, ceshallnblr.d083011a, refhallns.do82611b, ceshallnbhs.d083011a, refhalls.d082611b, ceshallnbls.d083011a, refhallhc.d082611b, ceshallnbhc.d083011a, refhalllc.d082611b, ceshallnblc.d083011a.

Appendix A. Request Letter

RALPH M. HALL, TEXAS
CHAIRMAN

EDDIE BERNICE JOHNSON, TEXAS
RANKING MEMBER

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

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July 22, 2011

The Honorable Howard Gruenspecht
Acting Administrator
Energy Information Administration
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

Dear Administrator Gruenspecht:

On March, 15, 2011, I wrote then-Administrator Newell requesting an Energy Information Administration (EIA) analysis of the economic impacts of a Clean Energy Standard (CES). The purpose of this letter is to more fully define the assumptions for that study and to recommend the specific analyses I would like you to undertake.

The attached document details this request, which was developed after consultation with your staff. In brief, I request that you estimate the impact of the proposed CES on seven different economic factors, beginning with the base policy scenario as defined by the Annual Energy Outlook 2011 (AEO2011) and then modified using nine additional scenarios as defined in the attachment.

Should you have any further questions, please contact Andy Zach, Professional Staff with the Energy and Environment Subcommittee. In advance, thank you for your assistance.

Sincerely,

Ralph M. Hall

Ralph M. Hall
Chairman

cc: Secretary Steven Chu

Attachment: Details of Chairman Hall CES Analysis Request

Because of the uncertainties associated with the structure and legislative details of a CES, we would like the following details incorporated into the "Best Estimate CES" scenario.

- Eligible resources to meet the target will include: hydroelectric, wind, solar, geothermal, biomass power, municipal solid waste, landfill gas, nuclear, coal-fired plants with carbon capture and sequestration, and natural gas-fired plants with either carbon capture and sequestration or utilizing combined cycle technology. Generation may derive from the electric power sector or from industrial, commercial, or residential generators using qualified resources. Qualifying generation will be determined solely by resource and technology, and not by vintage of the plant or by difference from historic generation at a plant.
- CES target would start from an initial share of 40 percent (qualified generation as a percent of sales), utilities will achieve 80 percent qualified generation by 2035. Because the 40 percent is specified from historical values (2010), and the target share is to increase linearly through the ramping period, EIA will assume that the policy has an initial target of 44.8 percent in 2013. The target will increase by 1.6 percentage points each year thereafter, achieving 80 percent by 2035.
- There will be no sunset in the CES requirement. The 80 percent target will remain constant from 2035 onward.
- The "Best Estimate CES" case will assume utilities may trade credits for generation. The CES target will apply to utilities in the aggregate, and some utilities may generate more electricity from eligible resources and may trade compliance credits to other utilities, who may then apply those credits to a compliance deficit.
- Compliance with CES targets will be based on accumulated credits. In general, and unless otherwise indicated, credits will be worth a "face value" of 1 MWh for each MWh of generation. Credits for natural gas fired in a combined cycle will count 50 percent toward compliance (a utility will earn 0.5 MWh of compliance credits for every 1 MWh of natural gas generation from a combined cycle plant.) Credits from coal or natural gas with carbon capture and sequestration will count 90 percent towards compliance.
- There will be no option to purchase compliance credits from the government. All credits must be backed by physical generation.
- All utilities are covered by the requirement, regardless of ownership status or size.
- Utilities would not be able to "bank" excess credits earned in one year to be used for compliance in a subsequent year. All credits must be used for compliance in the year that the underlying generation was produced.
- Generation targets are specified based on sales of all electricity, regardless of source. There is no provision for excluding any electricity sales from each utility's baseline based on resources used to produce the lectricity or type of customer purchasing the electricity.
- The model will assume a national CES does not interfere with any similar policies in effect at the state level. Utilities may use the same underlying generation to simultaneously comply with any State generation requirements, if otherwise allowed for by both Federal and State law.

Utilizing the parameters outlined above, please examine several scenarios. In addition to examining the base policy scenario, as defined by the Annual Energy Outlook 2011 (AEO2011), please outline the following scenarios:

1. Best Estimate CES, as defined above;
2. Low Cost Nuclear, same as Best Estimate CES, but incorporating the "Low Cost Nuclear" assumptions developed for an AEO2011 summary case;
3. High Cost Nuclear, same as Best Estimate CES, but incorporating the "High Cost Nuclear" scenario developed as an AEO2011 summary case;
4. Low Cost Renewable, same as Best Estimate CES, but incorporating the "Low Cost renewable" scenario developed as an AEO2011 summary case;
5. High Cost renewable, same as Best Estimate CES, but incorporating "High Cost Renewable" scenario developed as an AEO2011 summary case;
6. Low Shale Gas Recovery, same as Best Estimate CES, but incorporating the assumptions from the "Low Shale Estimated Ultimate Recovery" case in the AEO2011;
7. High Shale Gas Recovery, same as Best Estimate CES, but incorporating the assumptions from the "High Shale Estimated Ultimate Recovery" case in the AEO2011;
8. High Coal Cost, same as Best Estimate CES, but incorporating the assumptions from the "High Coal Cost" scenario in the AEO2011;
9. Low Coal Cost, same Best Estimate CES, but incorporating the assumptions from the "Low Coal Cost" scenario in the AEO2011.

For each of the scenarios outlined above, please calculate

- projected average cost of electricity generation per megawatt-hour;
- overall nationwide electricity generation costs;
- average cost of electricity per household;
- national gross domestic product;
- gross domestic product per capita; and
- national employment levels.

Appendix B. Summary Tables

Table B1. The HCES compared to the Reference case

	2009	2025		2035	
		Reference	HCES	Reference	HCES
Generation (billion kilowatthours)					
Coal	1,772	2,049	1,156	2,184	951
Petroleum	41	45	44	47	45
Natural Gas	931	1,002	1,386	1,293	1,676
Nuclear	799	871	928	868	1,127
Conventional Hydropower	274	306	320	314	321
Geothermal	15	25	26	42	49
Municipal Waste	18	17	17	17	17
Wood and Other Biomass	38	162	291	181	281
Solar	3	18	18	21	23
Wind	71	153	277	159	301
Other	18	16	16	16	16
Total Generation	3,981	4,665	4,479	5,142	4,807
Capacity (gigawatts)					
Coal	317	323	262	330	267
Petroleum	116	87	87	87	86
Natural Gas	351	382	384	455	444
Nuclear	101	110	117	110	143
Conventional Hydropower	78	79	82	81	82
Geothermal	2	3	4	6	6
Municipal Waste	4	4	4	4	4
Wood and Other Biomass	7	17	17	20	20
Solar	2	11	11	13	14
Wind	32	53	92	55	100
Other (including pumped storage)	24	25	25	25	25
Total	1,033	1,095	1,086	1,185	1,193
Prices (2009 cents/kWh)					
Credit Price			8.1		10.8
Electricity Price	9.8	9.0	10.5	9.4	12.1
Residential	11.5	10.7	12.2	10.9	13.6
Commercial	10.1	9.3	10.8	9.4	12.2
Industrial	6.8	6.3	7.5	6.6	8.9
Average Delivered Natural Gas Price (2009 dollars/Mcf)	7.5	8.1	8.8	9.2	9.7
Expenditures (billion 2009 dollars except as noted)					
Total Electricity Expenditures	350	373	414	417	494
Residential Electricity Expenditures	156	157	172	176	207
Household Electricity Expenditures (2009 Dollars/Household)	1379	1162	1277	1196	1407
Total Natural Gas Expenditures	156	187	225	227	264
Electricity Sector Natural Gas Expenditures	34	39	65	55	77
Non-Electricity Sector Natural Gas Expenditures	122	148	160	171	188

Table B1. The HCES compared to the Reference case (cont.)

	2009	2025		2035	
		Reference	HCES	Reference	HCES
CES Compliance					
Credits Required (percent of sales)			64		80
Credits Achieved (percent of sales)			64		78
Generation Achieved (percent of sales)			64		78
Total Electricity Sales (billion kilowatthours)	3,556	4,105	3,913	4,428	4,064
Emissions					
Sulfur Dioxide (million tons)	5.7	4.1	3.1	3.7	2.4
Nitrogen Oxide (million tons)	2.0	2.0	1.5	2.0	1.2
Mercury (tons)	41	29	16	29	15
Carbon Dioxide (million metric tons CO_2)	2,160	2,345	1,525	2,500	991
Macroeconomic					
GDP (billion 2005 dollars)	12,881	20,012	19,885	25,686	25,612
Per Capita GDP (thousand 2005 dollars/person)	42	56	56	66	66
Employment, Non-Farm (million)	131	156	156	171	171
Employment, Manufacturing (million)	12	16	15	13	13

Source: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082611b, ceshallnb.d083011a.

Table B2. Low and high-cost renewable scenarios: the HCES compared to the sensitivity base cases

	2009	2025				2035			
		Low Cost Renewable		High Cost Renewable		Low Cost Renewable		High Cost Renewable	
		Base	HCES	Base	HCES	Base	HCES	Base	HCES
Generation (billion kilowatthours)									
Coal	1,772	2,030	1,238	2,034	1,126	2,142	559	2,134	762
Petroleum	41	45	44	46	43	47	43	48	44
Natural Gas	931	979	1,155	994	1,409	1,192	1,687	1,308	1,917
Nuclear	799	877	877	877	938	874	898	874	1,097
Conventional Hydropower	274	313	324	306	316	326	340	314	321
Geothermal	15	27	34	25	26	44	36	29	27
Municipal Waste	18	17	17	17	17	17	17	17	17
Wood and Other Biomass	38	182	344	150	236	205	341	145	182
Solar	3	24	25	16	16	48	75	17	18
Wind	71	168	478	158	277	261	787	186	287
Other	18	16	16	16	16	16	16	16	16
Total Generation	3,981	4,680	4,552	4,640	4,419	5,173	4,800	5,089	4,689
Capacity (gigawatts)									
Coal	317	322	260	321	261	330	229	327	260
Petroleum	116	87	87	88	86	87	86	86	86
Natural Gas	351	378	375	384	386	439	433	460	454
Nuclear	101	110	110	110	119	110	114	110	139
Conventional Hydropower	78	80	83	79	81	84	88	80	82
Geothermal	2	4	5	3	4	6	5	4	4
Municipal Waste	4	4	4	4	4	4	4	4	4
Wood and Other Biomass	7	18	24	11	11	22	38	12	12
Solar	2	15	15	10	10	27	41	11	11
Wind	32	58	165	55	91	88	277	64	95
Other (including pumped storage)	24	25	25	25	25	25	25	25	25
Total	1,033	1,101	1,153	1,090	1,077	1,222	1,339	1,183	1,171
Prices (2009 cents/kWh)									
Credit Price			6.6		8.6		12.4		14.0
Electricity Price	9.8	8.9	10.0	9.1	10.9	9.1	11.9	9.5	13.1
Residential	11.5	10.6	11.7	10.8	12.5	10.6	13.4	11.1	14.6
Commercial	10.1	9.0	10.2	9.4	11.2	9.1	12.1	9.6	13.3
Industrial	6.8	6.1	7.1	6.3	7.8	6.4	8.8	6.7	9.9
Average Delivered Natural Gas Price (2009 dollars/MCF)	7.5	8.0	8.6	8.1	9.1	8.9	9.1	9.3	9.9
Expenditures (billion 2009 dollars)									
Total Electricity Expenditures	350	366	398	377	423	406	482	423	524
Residential Electricity Expenditures	156	154	166	158	175	171	201	178	219
Household Electricity Expenditures (2009 Dollars/Household)	1,379	1,143	1,231	1,173	1,303	1,162	1,369	1,210	1,489
Total Natural Gas Expenditures	156	185	206	189	232	216	251	230	288
Electricity Sector Natural Gas Expenditures	34	38	50	39	68	49	72	57	92
Non-Electricity Sector Natural Gas Expenditures	122	147	156	149	165	167	179	174	195

Table B2. Low and high-cost renewable scenarios: the HCES compared to the sensitivity base cases (cont.)

	2009	2025				2035			
		Low Cost Renewable		High Cost Renewable		Low Cost Renewable		High Cost Renewable	
		Base	HCES	Base	HCES	Base	HCES	Base	HCES
CES Compliance									
Credits Required (percent of sales)			64		64		80		80
Credits Achieved (percent of sales)			64		63		79		78
Generation Achieved (percent of sales)			64		63		79		78
Total Electricity Sales (billion kilowatthours)	3,556	4,112	3,961	4,101	3,876	4,446	4,016	4,416	3,971
Emissions									
Sulfur Dioxide (million tons)	5.7	4.1	3.3	4.2	3.1	3.8	1.3	3.8	1.8
Nitrogen Oxide (million tons)	2.0	2.0	1.5	2.0	1.4	2.0	0.7	2.0	1.0
Mercury (tons)	41	29	16	29	15	29	7	28	12
Carbon Dioxide (million metric tons CO_2)	2,160	2,318	1,563	2,333	1,491	2,421	914	2,475	914
Macroeconomic									
GDP (billion 2005 dollars)	12,881	20,019	19,930	19,988	19,861	25,703	25,595	25,674	25,521
Per Capita GDP (thousand 2005 dollars/person)	42	56	56	56	55	66	66	66	65
Employment, Non-Farm (million)	131	156	156	156	155	171	171	171	170
Employment, Manufacturing (million)	12	16	16	16	15	13	13	13	13

Sources: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082611b, ceshallnb.d083011a, refhallhc.d082611b, ceshallnbhr.d083011a, refhalllr.d082611b, ceshallnblr.d083011a.

Table B3. Low and high-cost nuclear scenarios: the HCES compared to the sensitivity base cases

	2009	2025				2035			
		Low Cost Nuclear		High Cost Nuclear		Low Cost Nuclear		High Cost Nuclear	
		Base	HCES	Base	HCES	Base	HCES	Base	HCES
Generation (billion kilowatthours)									
Coal	1,772	2,047	1,110	2,060	1,062	2,169	897	2,185	838
Petroleum	41	45	43	45	44	47	44	46	45
Natural Gas	931	999	1,417	996	1,486	1,184	1,559	1,290	1,943
Nuclear	799	877	1,023	871	877	1,012	1,564	868	874
Conventional Hydropower	274	305	315	305	315	312	315	314	322
Geothermal	15	24	26	25	29	39	41	43	49
Municipal Waste	18	17	17	17	17	17	17	17	17
Wood and Other Biomass	38	162	283	159	284	183	265	178	265
Solar	3	18	18	18	18	21	23	21	26
Wind	71	154	180	154	280	158	198	161	391
Other	18	16	16	16	16	16	16	16	16
Total Generation	3,981	4,666	4,449	4,667	4,431	5,159	4,940	5,140	4,789
Capacity (gigawatts)									
Coal	317	322	260	322	265	330	257	330	265
Petroleum	116	87	88	87	87	87	85	86	84
Natural Gas	351	381	382	383	385	438	423	457	471
Nuclear	101	110	130	110	110	128	200	110	110
Conventional Hydropower	78	78	81	78	81	80	81	81	83
Geothermal	2	3	4	3	4	5	5	6	6
Municipal Waste	4	4	4	4	4	4	4	4	4
Wood and Other Biomass	7	17	17	17	17	20	20	20	21
Solar	2	11	11	11	11	13	14	13	15
Wind	32	54	61	54	94	55	67	56	131
Other (including pumped storage)	24	25	25	25	25	25	25	25	25
Total	1,033	1,093	1,062	1,095	1,083	1,185	1,181	1,187	1,215
Prices (2009 cents/kWh)									
Credit Price			9.2		9.7		8.5		12.4
Electricity Price	9.8	9.0	10.6	9.0	10.8	9.3	11.0	9.4	12.4
Residential	11.5	10.7	12.2	10.7	12.5	10.8	12.5	10.9	13.9
Commercial	10.1	9.3	10.9	9.2	11.1	9.3	11.1	9.5	12.5
Industrial	6.8	6.3	7.6	6.2	7.8	6.5	8.0	6.6	9.1
Average Delivered Natural Gas Price (2009 dollars/MCF)	7.5	8.1	9.1	8.0	9.1	9.0	8.6	9.1	9.5
Expenditures (billion 2009 dollars)									
Total Electricity Expenditures	350	373	416	372	422	414	461	419	502
Residential Electricity Expenditures	156	156	172	156	175	174	194	176	210
Household Electricity Expenditures (2009 Dollars/Household)	1,379	1,159	1,277	1,160	1,298	1,186	1,317	1,199	1,431
Total Natural Gas Expenditures	156	187	233	187	239	217	232	226	279
Electricity Sector Natural Gas Expenditures	34	39	69	39	74	48	61	55	92
Non-Electricity Sector Natural Gas Expenditures	122	148	164	148	165	168	171	171	187

Table B3. Low and high-cost nuclear scenarios: the HCES compared to the sensitivity base cases (cont.)

	2009	2025				2035			
		Low Cost Nuclear		High Cost Nuclear		Low Cost Nuclear		High Cost Nuclear	
		Base	HCES	Base	HCES	Base	HCES	Base	HCES
CES Compliance									
Credits Required (percent of sales)			64		64		80		80
Credits Achieved (percent of sales)			63		64		80		79
Generation Achieved (percent of sales)			63		64		80		79
Total Electricity Sales (billion kilowatthours)	3,556	4,105	3,907	4,106	3,886	4,441	4,168	4,424	4,030
Emissions									
Sulfur Dioxide (million tons)	5.7	4.2	2.9	4.3	3.0	3.8	2.1	3.9	2.0
Nitrogen Oxide (million tons)	2.0	2.0	1.5	2.0	1.4	2.0	1.1	2.0	1.0
Mercury (tons)	41	29	15	29	16	29	14	30	13
Carbon Dioxide (million metric tons CO_2)	2,160	2,342	1,511	2,352	1,477	2,447	978	2,498	947
Macroeconomic									
GDP (billion 2005 dollars)	12,881	20,011	19,862	20,012	19,860	25,708	25,705	25,684	25,588
Per Capita GDP (thousand 2005 dollars/person)	42	56	55	56	55	66	66	66	66
Employment, Non-Farm (million)	131	156	156	156	156	171	171	171	171
Employment, Manufacturing (million)	12	16	15	16	15	13	13	13	13

Sources: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082611b, ceshallnb.d083011a, refhallhn.d082611b, ceshallnbhn.d083011a, refhallln.d082611b, ceshallnbln.d083011a.

Table B4. Low and high-cost natural gas scenarios: the HCES compared to the sensitivity base cases

	2009	2025				2035			
		Low Cost Natural Gas		High Cost Natural Gas		Low Cost Natural Gas		High Cost Natural Gas	
		Base	HCES	Base	HCES	Base	HCES	Base	HCES
Generation (billion kilowatthours)									
Coal	1,772	1,948	987	2,134	1,078	2,078	771	2,239	941
Petroleum	41	46	45	45	43	47	45	48	44
Natural Gas	931	1,138	1,674	856	1,304	1,475	1,996	1,166	1,503
Nuclear	799	862	910	877	970	860	1,074	874	1,210
Conventional Hydropower	274	305	321	308	315	312	323	314	322
Geothermal	15	25	29	27	29	39	50	44	48
Municipal Waste	18	17	17	17	17	17	17	17	17
Wood and Other Biomass	38	168	256	155	289	184	248	165	283
Solar	3	18	18	18	19	21	23	22	25
Wind	71	145	186	161	291	152	280	180	319
Other	18	16	16	16	16	16	16	16	16
Total Generation	3,981	4,690	4,461	4,616	4,371	5,201	4,844	5,086	4,730
Capacity (gigawatts)									
Coal	317	314	257	327	271	321	256	336	273
Petroleum	116	93	87	86	84	93	86	86	84
Natural Gas	351	386	394	375	368	468	469	440	421
Nuclear	101	109	115	110	123	109	136	110	154
Conventional Hydropower	78	78	82	79	81	80	83	80	83
Geothermal	2	3	4	4	4	5	6	6	6
Municipal Waste	4	4	4	4	4	4	4	4	4
Wood and Other Biomass	7	17	17	17	17	20	20	20	20
Solar	2	11	11	11	12	12	14	13	15
Wind	32	51	63	56	97	53	92	62	106
Other (including pumped storage)	24	25	25	25	25	25	25	25	25
Total	1,033	1,091	1,060	1,095	1,086	1,191	1,191	1,182	1,191
Prices (2009 cents/kWh)									
Credit Price			9.2		13.1		11.0		13.6
Electricity Price	9.8	8.8	10.6	9.4	11.4	8.9	11.9	9.8	12.8
Residential	11.5	10.6	12.3	11.1	13.0	10.5	13.4	11.3	14.3
Commercial	10.1	9.0	10.9	9.7	11.8	8.9	11.9	10.0	13.1
Industrial	6.8	6.1	7.6	6.6	8.3	6.2	8.7	7.0	9.6
Average Delivered Natural Gas Price (2009 dollars/MCF)	7.5	7.3	8.3	9.4	10.8	8.1	8.7	10.3	11.1
Expenditures (billion 2009 dollars)									
Total Electricity Expenditures	350	366	415	386	444	401	484	436	519
Residential Electricity Expenditures	156	155	173	161	181	171	204	181	214
Household Electricity Expenditures (2009 Dollars/Household)	1,379	1,147	1,285	1,192	1,346	1,164	1,391	1,232	1,458
Total Natural Gas Expenditures	156	179	232	205	264	215	259	243	283
Electricity Sector Natural Gas Expenditures	34	41	78	40	76	59	80	55	83
Non-Electricity Sector Natural Gas Expenditures	122	138	153	166	188	156	179	189	201

Table B4. Low and high-cost natural gas scenarios: the HCES compared to the sensitivity base cases (cont.)

	2009	2025				2035			
		Low Cost Natural Gas		High Cost Natural Gas		Low Cost Natural Gas		High Cost Natural Gas	
		Base	HCES	Base	HCES	Base	HCES	Base	HCES
CES Compliance									
Credits Required (percent of sales)			64		64		80		80
Credits Achieved (percent of sales)			63		65		79		79
Generation Achieved (percent of sales)			63		65		79		79
Total Electricity Sales (billion kilowatthours)	3,556	4,112	3,880	4,081	3,869	4,460	4,061	4,408	4,022
Emissions									
Sulfur Dioxide (million tons)	5.7	3.9	2.8	4.0	3.0	3.8	1.8	3.7	2.2
Nitrogen Oxide (million tons)	2.0	2.0	1.4	2.0	1.4	2.0	1.0	2.1	1.1
Mercury (tons)	41	27	15	29	15	27	12	30	15
Carbon Dioxide (million metric tons CO_2)	2,160	2,290	1,487	2,387	1,434	2,450	945	2,527	948
Macroeconomic									
GDP (billion 2005 dollars)	12,881	20,030	19,835	19,962	19,846	25,704	25,643	25,677	25,573
Per Capita GDP (thousand 2005 dollars/person)	42	56	55	56	55	66	66	66	66
Employment, Non-Farm (million)	131	156	155	156	156	171	171	171	171
Employment, Manufacturing (million)	12	16	15	16	15	13	13	13	13

Sources: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082611b, ceshallnb.d083011a, refhallhs.d082611b, ceshallnbhs.d083011a, refhallls.d082611b, ceshallnbls.d083011a.

Table B5. Low and high-cost coal scenarios: the HCES compared to the sensitivity base cases

	2009	2025				2035			
		Low Cost Coal		High Cost Coal		Low Cost Coal		High Cost Coal	
		Base	HCES	Base	HCES	Base	HCES	Base	HCES
Generation (billion kilowatthours)									
Coal	1,772	2,132	1,095	1,906	978	2,260	878	1,876	447
Petroleum	41	45	44	46	44	47	45	48	45
Natural Gas	931	952	1,476	1,071	1,486	1,267	1,783	1,456	2,056
Nuclear	799	877	933	877	961	874	1,118	874	1,201
Conventional Hydropower	274	306	323	304	319	314	324	311	319
Geothermal	15	27	27	25	29	42	48	37	48
Municipal Waste	18	17	17	17	17	17	17	17	17
Wood and Other Biomass	38	156	282	180	257	169	268	219	196
Solar	3	18	19	18	18	21	24	21	26
Wind	71	156	190	153	301	164	293	158	318
Other	18	16	16	16	16	16	16	16	16
Total Generation	3,981	4,703	4,422	4,614	4,426	5,192	4,814	5,035	4,691
Capacity (gigawatts)									
Coal	317	327	273	308	247	338	279	312	212
Petroleum	116	86	87	88	89	86	87	88	86
Natural Gas	351	381	378	383	384	454	444	456	453
Nuclear	101	110	118	110	122	110	142	110	153
Conventional Hydropower	78	79	83	78	82	81	83	80	82
Geothermal	2	4	4	3	4	5	6	5	6
Municipal Waste	4	4	4	4	4	4	4	4	4
Wood and Other Biomass	7	17	17	17	17	20	20	20	20
Solar	2	11	11	11	11	13	14	13	16
Wind	32	54	64	53	99	57	96	55	105
Other (including pumped storage)	24	25	25	25	25	25	25	25	25
Total	1,033	1,098	1,065	1,083	1,083	1,192	1,201	1,168	1,161
Prices (2009 cents/kWh)									
Credit Price			11.1		8.2		13.2		14.6
Electricity Price	9.8	8.8	10.9	9.4	10.9	9.1	12.1	10.0	13.2
Residential	11.5	10.4	12.5	11.1	12.6	10.6	13.6	11.6	14.7
Commercial	10.1	9.0	11.2	9.6	11.2	9.1	12.2	10.0	13.4
Industrial	6.8	6.0	7.8	6.5	7.8	6.3	9.0	7.1	10.0
Average Delivered Natural Gas Price (2009 dollars/MCF)	7.5	8.0	9.3	8.2	9.1	9.2	9.2	9.4	9.7
Expenditures (billion 2009 dollars)									
Total Electricity Expenditures	350	365	425	382	424	409	495	434	522
Residential Electricity Expenditures	156	154	176	160	176	172	207	183	218
Household Electricity Expenditures (2009 Dollars/Household)	1,379	1,139	1,304	1,190	1,306	1,171	1,407	1,247	1,487
Total Natural Gas Expenditures	156	184	242	193	239	225	260	241	290
Electricity Sector Natural Gas Expenditures	34	37	75	43	73	55	79	64	98
Non-Electricity Sector Natural Gas Expenditures	122	147	166	150	166	170	181	177	192

Table B5. Low and high-cost coal scenarios: the HCES compared to the sensitivity base cases (cont.)

	2009	2025				2035			
		Low Cost Coal		High Cost Coal		Low Cost Coal		High Cost Coal	
		Base	HCES	Base	HCES	Base	HCES	Base	HCES
CES Compliance									
Credits Required (percent of sales)			64		64		80		80
Credits Achieved (percent of sales)			63		64		80		78
Generation Achieved (percent of sales)			63		64		80		78
Total Electricity Sales (billion kilowatthours)	3,556	4,148	3,885	4,050	3,881	4,494	4,070	4,324	3,928
Emissions									
Sulfur Dioxide (million tons)	6	4.1	3.1	3.9	2.9	3.6	2.1	3.7	1.2
Nitrogen Oxide (million tons)	2.0	2.0	1.4	2.0	1.2	2.1	1.1	2.0	0.7
Mercury (tons)	41	30	16	27	13	31	14	25	6
Carbon Dioxide (million metric tons CO_2)	2160	2,417	1,501	2,220	1,430	2,583	941	2,248	879
Macroeconomic									
GDP (billion 2005 dollars)	12,881	20,016	19,860	19,973	19,867	25,710	25,591	25,623	25,514
Per Capita GDP (thousand 2005 dollars/person)	42	56	55	56	55	66	66	66	65
Employment, Non-Farm (million)	131	156	156	156	156	171	171	171	170
Employment, Manufacturing (million)	12	16	15	16	15	13	13	13	13

Sources: U.S. Energy Information Administration. National Energy Modeling System, runs refhall.d082611b, ceshallnb.d083011a, refhallhc.d082611b, ceshallnbhc.d083011a, refhalllc.d082611b, ceshallnblc.d083011a.

Appendix C. Map of NEMS Electricity Market Module Regions