Chapter 7: Economic Cost Estimates

7.1 Synopsis

This chapter presents the economic impact results of the illustrative control strategies developed by EPA for the purpose of providing an approach of actions that could be taken to meet attainment of two $PM_{2.5}$ NAAQS alternatives: a revised 15 µg/m^3 annual/ 35 µg/m^3 daily standard (15/35) and a more stringent alternative14 µg/m^3 annual/ 35 µg/m^3 daily (14/35). Each of these alternative approaches is incremental to meeting the current 15 µg/m^3 annual/ 65 µg/m^3 daily (15/65) standard and have a proposed implementation date of 2020. Given the possible impacts of this guidance on manufacturing industries, the transportation sector, electricity generators, consumers, and U.S. Gross Domestic Product (GDP) as a whole, we believe it is important to gauge the extent to which other parts of the economy might also be affected by the implementation of these $PM_{2.5}$ NAAQS alternatives. Therefore, an analysis of the economy-wide effects of implementing the two $PM_{2.5}$ NAAQS scenarios is conducted by applying estimated direct costs to EPA's computable general equilibrium model (EMPAX-CGE). As the chapter will show, the social costs for each standard are only slightly greater than the engineering costs applied to the CGE model.

Before the chapter begins with a background and description of EMPAX-CGE followed by a presentation of the results, three stipulations are highlighted below that will assist the reader in interpreting the economic impacts and relating these impacts to the attainment costs presented in Chapter 6.

(a) The selection criteria for the 15/35 and 14/35 control strategies, and their related compliance costs, are designed to select the least cost controls, from an engineering cost standpoint, that generate the highest $PM_{2.5}$ reductions and benefit per ton estimates, but not necessarily the lowest economic impact. Therefore, although the control strategies are selected to reduce $PM_{2.5}$ at the lowest engineering cost, they do not represent the lowest impact strategies from a social cost standpoint. Thus, while this economic impact analysis presents results for the control strategy approach detailed in Chapter 3 of the RIA, it should not be viewed as the only economic impact estimate of the $PM_{2.5}$ NAAQS or even as the approach with the lowest social cost. Instead, the results should be viewed as guidance or useful information for states preparing their implementation plans. It is likely that states will design implementation plans that present an alternative control strategy and in some cases design plans that take into account secondary impacts to industries and consumers within their borders. In such a case, the end result would be a set of SIPs that are more economically optimal and may have lower industry impacts than those described below.

(b) The costs analyzed in this economic impact chapter include only the modeled engineering costs detailed in Chapter 6, section 6.2 as well as an additional $180 million in supplemental costs for the 14/35 scenario (Chapter 6, section 6.3). Not included in estimating economic impacts, are the extrapolated cost estimates detailed in Chapter 6, section 6.4. Therefore, the direct costs for the two scenarios range from $850 million (1999 dollars) in 2020 for the 15/35 alternative to $2.6 billion (1999 dollars) for alternative 14/35 during the same year. Since a large portion of the attainment costs are not included, social cost estimates may underestimate the impact these standards will have on the economy.

(c) In the interest of learning how possible changes in manufactured-goods prices might affect businesses and households, along with how changes in electricity/energy prices might affect industry groups that are large energy users, EPA employed the “EMPAX-CGE” computable general equilibrium (CGE) model, which has been peer reviewed and used in recent analyses of the Clean Air Interstate Rule (CAIR) and the Clean Air Visibility Rule (CAVR). As with similar models, EMPAX-CGE focuses on the cost-side of spillover effects on the economy. This implies its estimated industry-sector impacts may be overstated because EMPAX-CGE is not configured to capture the beneficial economic consequences of the increased labor availability and productivity expected to result from air quality improvements. If these labor productivity improvements were included, the small production output decreases projected by the model might be partially or entirely offset. EPA continues to investigate the feasibility of incorporating labor productivity gains and other beneficial effects of air quality improvements in CGE models.

7.1.1 Results Summary

Results of the macroeconomic analysis generally show small nation-wide impacts of the $PM_{2.5}$ NAAQS on manufacturing and energy industries, as well as small regional impacts. The 15/35 alternative generates a 0.01 percent decrease in GDP in 2020 while 14/35 results in a 0.02 percent GDP decrease for the same year. On average, industries show less than one-half of one percent decrease in output with the exception of cement manufacturing, which has output reductions of just over one-half of one percent for 14/35. However, as stated above, a large portion of the attainment costs are not inputted into EMPAX-CGE. Furthermore, the model does not incorporate productivity benefits resulting from air quality improvements. Therefore, as a result of these two potentially offsetting conditions, it is difficult for EPA to determine if the results presented here overstate or understate the impacts on industry output and U.S. GDP.

7.2 Background

To complement the analysis of effects on specific manufacturing sectors from AirControlNET, implications for mobile sources from MOBILE6.2 and NONROAD, and changes in electricity generation from IPM (only for the 14/35 standard), the macroeconomic implications of the $PM_{2.5}$ NAAQS standards have been estimated using EPA’s EMPAX-CGE model. The focus of this component of the $PM_{2.5}$ NAAQS analysis is on examining the sectoral and regional distribution of economic effects across the U.S. economy. This section briefly discusses the EMPAX model and the approach used to incorporate findings from other models in EMPAX-CGE.

7.2.1 Background and Summary of EMPAX-CGE Model

EMPAX was first developed in 2000 to support economic analysis of EPA’s maximum achievable control technology (MACT) rules for combustion sources (reciprocating internal combustion engines, boilers, and turbines). The initial framework consisted of a national multimarket partial-equilibrium model with linkages only between manufacturing industries and the energy sector. Modified versions of EMPAX were subsequently used to analyze economic impacts of strategies for improving air quality in the Southern Appalachian mountain region as part of efforts associated with the Southern Appalachian Mountain Initiative (SAMI).

Recent work on EMPAX has extended its scope to cover all aspects of the U.S. economy at a regional level in either static or dynamic modes. Although major regulations directly affect a large number of industries, substantial indirect impacts can also result from changes in production, input use, income, and household consumption patterns. Consequently, EMPAX now includes economic linkages among all industrial and energy sectors as well as households that supply factors of production such as labor and purchase goods (i.e., a CGE framework). This gives the version of EMPAX called EMPAX-CGE the ability to trace economic impacts as they are transmitted throughout the economy and allows it to provide critical insights to policy makers evaluating the magnitude and distribution of costs associated with environmental policies. The dynamic version of EMPAX-CGE employed in this analysis, and its data sources, are described in Section 7.3.

7.2.2 Modeling Methodology for the $PM_{2.5}$ NAAQS Standards

EMPAX-CGE can be used to analyze a wide array of policy issues and is capable of estimating how a change in a single part (or multiple parts) of the economy will influence producers and consumers across the United States. However, some types of policies, including the $PM_{2.5}$ NAAQS standard, are difficult to capture adequately within a CGE structure because of the boiler- and firm-specific nature of emission reduction costs. Consequently, an interface has been developed that allows linkages between EMPAX-CGE and the detailed technology models discussed in Chapter 6 (AirControlNET, MOBILE6.2, NONROAD, and IPM). These linkages give the combined modeling system the advantages of technology detail and broad macroeconomic coverage, thereby permitting EMPAX-CGE to investigate economy-wide policy implications.

As discussed in Chapter 6, the three technology models estimate cost changes by industry and region of the United States for the sectors of the economy affected by the $PM_{2.5}$ NAAQS standard. In order for EMPAX-CGE to effectively incorporate these additional costs, they have to be expressed in terms of the productive inputs used in CGE models (i.e., capital, labor, and material inputs produced by other industries). Rather than assume the costs represent a proportional scaling up of all inputs, Nestor and Pasurka (1995) data on purchases made by industries for environmental-protection reasons are used to allocate these additional expenditures across inputs within EMPAX-CGE. Once these expenditures are specified, the incremental costs from the technology models can be used to adjust the production technologies in the CGE model. For the 14/35 scenario, additional linkages are made between EMPAX-CGE and IPM to handle specific IPM findings related to resource costs and fuel consumption in electricity generation.[1]

[1] See Appendix E in the RIA for the Final CAIR rule for additional discussion of these IPM-EMPAX linkages (http://www.epa.gov/interstateairquality/technical.html).

7.3 EMPAX-CGE Model Description: General Model Structure

This section provides additional details on the EMPAX-CGE model structure, data sources, and assumptions. The version of EMPAX-CGE used in this analysis is a dynamic, intertemporally optimizing model that solves in 5 year intervals from 2005 to 2050. It uses the classical Arrow-Debreu general equilibrium framework wherein households maximize utility subject to budget constraints, and firms maximize profits subject to technology constraints. The model structure, in which agents are assumed to have perfect foresight and maximize utility across all time periods, allows agents to modify behavior in anticipation of future policy changes, unlike dynamic recursive models that assume agents do not react until a policy has been implemented.

Nested CES functions are used to portray substitution possibilities available to producers and consumers. Figure 7-1 illustrates this general framework and gives a broad characterization of the model.[2] Along with the underlying data, these nesting structures and associated substitution elasticities determine the effects that will be estimated for policies. These nesting structures and elasticities used in EMPAX-CGE are generally based on the Emissions Prediction and Policy Analysis (EPPA) Model developed at the Massachusetts Institute of Technology (Babiker et al., 2001). Although the two models are quite different (EPPA is a recursive dynamic, international model focused on national level climate change policies), both are intended to simulate how agents will respond to environmental policies.

[2] Although it is not illustrated in Figure 7-1, some differences across industries exist in their handling of energy inputs. In addition, the agriculture and fossil-fuel sectors in EMPAX-CGE contain equations that account for the presence of fixed inputs to production (land and fossil-fuel resources, respectively).

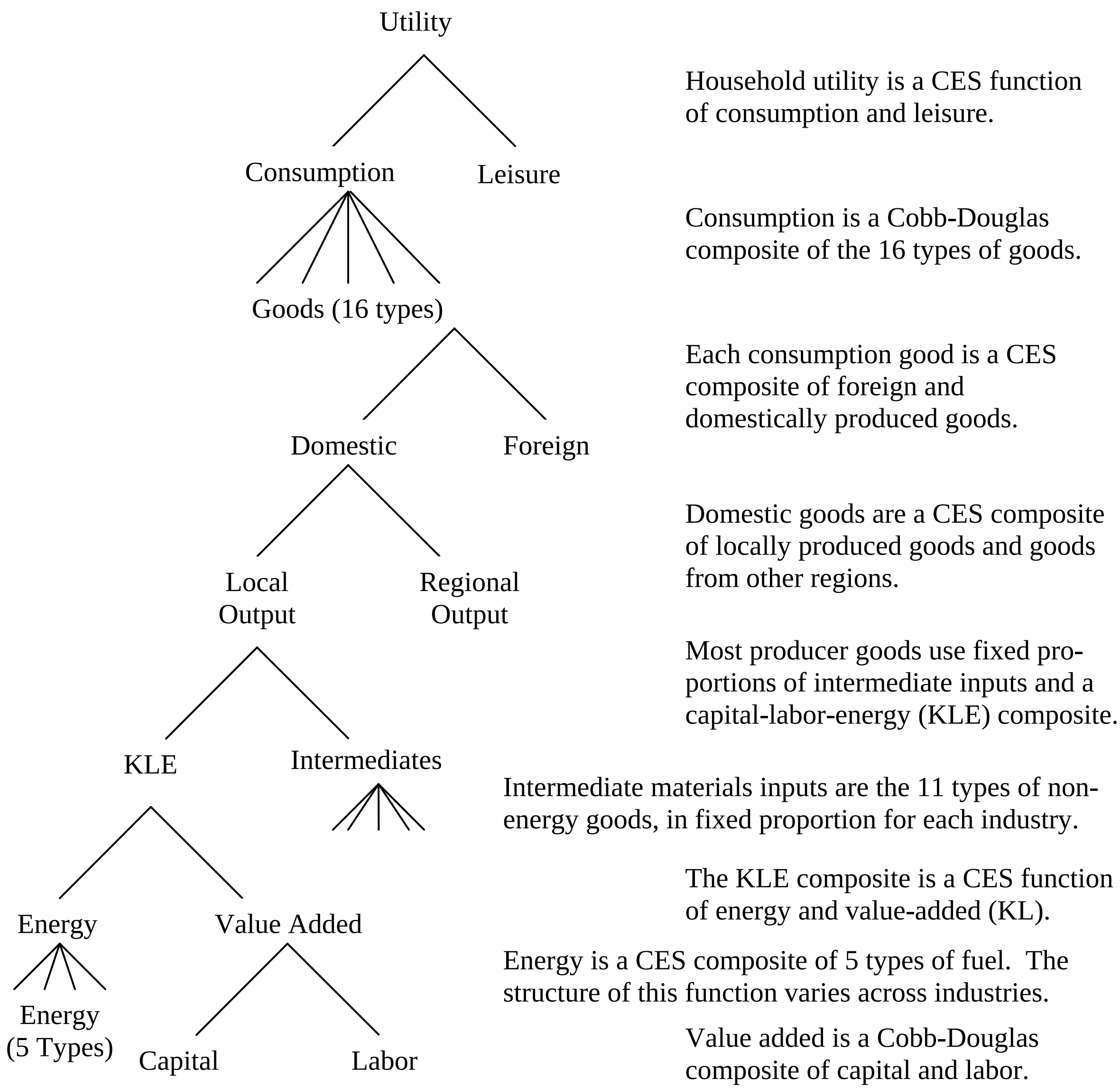

Figure 7-1. General Production and Consumption Nesting Structure in EMPAX-CGE

Given this basic similarity, EMPAX-CGE has adopted a comparable structure. EMPAX-CGE is programmed in the GAMS[3] language (Generalized Algebraic Modeling System) and solved as a mixed complementarity problem (MCP) [4] using MPSGE software (Mathematical Programming Subsystem for General Equilibrium).[5] The PATH solver from GAMS is used to solve the MCP equations generated by MPSGE.

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[3] See Brooke, Kendrick, and Meeraus (1996) for a description of GAMS (http://www.gams.com/).
4 Solving EMPAX-CGE as a MCP problem implies that complementary slackness is a feature of the equilibrium solution. In other words, any firm in operation will earn zero economic profits and any unprofitable firms will cease operations. Similarly, for any commodity with a positive price, supply will equal demand, or conversely any good in excess supply will have a zero price.
5 See Rutherford (1999) for MPSGE documentation (http://debreu.colorado.edu).

7.3.1 Data Sources

The economic data come from state level information provided by the Minnesota IMPLAN Group[6] and energy data come from EIA.[7] Although IMPLAN data contain information on the value of energy production and consumption in dollars, these data are replaced with EIA data for several reasons. First, the policies being investigated typically focus on energy markets, making it essential to include the best possible characterization of these markets in the model. Although the IMPLAN data are developed from a variety of government data sources at the U.S. Bureau of Economic Analysis and U.S. Bureau of Labor Statistics, these data do not always agree with energy information collected by EIA directly from manufacturers and electric utilities. Second, it is necessary to have physical quantities for energy consumption in the model to portray effects of environmental policies. EIA reports physical quantities, while IMPLAN does not. Finally, although the IMPLAN data reflect the year 2000, the initial baseline year for the model is 2005. Thus, AEO energy production and consumption, output, and economic growth forecasts for 2005 are used to adjust the year 2000 IMPLAN data.

EMPAX-CGE combines these economic and energy data to create a balanced social accounting matrix (SAM) that provides a baseline characterization of the economy. The SAM contains data on the value of output in each sector, payments for factors of production and intermediate inputs by each sector, household income and consumption, government purchases, investment, and trade flows. A balanced SAM for the year 2005 consistent with the desired sectoral and regional aggregation is produced using procedures developed by Babiker and Rutherford (1997) and described in Rutherford and Paltsev (2000). The methodology relies on standard optimization techniques to maintain the calculated energy statistics while minimizing the changes needed in the economic data to create a new balanced SAM that matches AEO forecasts for the baseline model year of 2005.

These data are used to define 10 regions within the United States, each containing 40 industries. Regions have been selected to capture important differences across the country in electricity generation technologies, while industry aggregations are controlled by available energy consumption data. Prior to solving EMPAX-CGE, these regions and industries are aggregated up to the categories to be included in the analysis.

Table 7-1 presents the industry categories included in EMPAX-CGE for policy analysis. Their focus is on maintaining as much detail in the energy intensive sectors[8] as is allowed by available energy consumption data and computational limits of dynamic CGE models. In addition, the electricity industry is separated into fossil fuel generation and nonfossil generation, which is necessary because many electricity policies affect only fossil fired electricity.

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[6] See http://www.implan.com/index.html for a description of the Minnesota IMPLAN Group and its data.
[7] These EIA sources include *AEO 2003*, the *Manufacturing Energy Consumption Survey*, *State Energy Data Report*, *State Energy Price and Expenditure Report*, and various annual industry profiles.
[8] EIS industry categories are based on EIA definitions of energy-intensive manufacturers in the *Assumptions for the Annual Energy Outlook 2003*.

Table 7-1. EMPAX-CGE Industries

EMPAX Industry	NAICS Classifications
Coal	2121
Crude Oil[a]	211111
Electricity (fossil and nonfossil)	2211
Natural Gas	211112, 2212, 4862
Petroleum Refining	324
Agriculture	11
Energy-Intensive Sector: Food	311
Energy-Intensive Sector: Paper and Allied	322
Energy-Intensive Sector: Chemicals	325
Energy-Intensive Sector: Glass	3272
Energy-Intensive Sector: Cement	3273
Energy-Intensive Sector: Iron and Steel	3311
Energy-Intensive Sector: Aluminum	3313
Other Manufacturing	312-316, 321, 323, 326-327, 331-339
Services	All Others
Transportation[b]	481-488

[a] Although NAICS 211111 covers crude oil and gas extraction, the gas component of this sector is moved to the natural gas industry.

[b] Transportation does not include NAICS 4862 (natural gas distribution), which is part of the natural gas industry.

Figure 7-2 shows the five regions run in EMPAX-CGE in this analysis, which have been defined based on the expected regional distribution of policy impacts, availability of economic and energy data, and computational limits on model size. These regions have been constructed from the underlying 10 region database designed to follow, as closely as possible, the electricity market regions defined by the North American Electric Reliability Council (NERC).[9] Note that, for purposes of presenting results, the four regions; *Northeast*, *Southeast*, *Midwest* and *Plains*, have been aggregated into an "East" region to approximate the region of interest in this analysis.

[9] Economic data and information on nonelectricity energy markets are generally available only at the state level, which necessitates an approximation of the NERC regions that follows state boundaries. For the IAQR analysis, these approximations include Northeast = NPCC + MAAC, Southeast = SERC + FERC, Midwest = ECAR + MAIN, Plains = MAPP + SPP + ERCOT, and West = WSCC. See http://www.nerc.com/ for further discussion of these regions.

Figure 7-2. Regions defined in EMPAX-CGE

7.3.2 Production Functions

All productive markets are assumed to be perfectly competitive and have production technologies that exhibit constant returns to scale, except for the agriculture and natural resource extracting sectors, which have decreasing returns to scale because they use factors in fixed supply (land and fossil fuels, respectively). The electricity industry is separated into two distinct sectors: fossil fuel generation and nonfossil generation. This allows tracking of variables such as heat rates for fossil fired utilities (Btus of energy input per kilowatt hour of electricity output).

All markets must clear (i.e., supply must equal demand in every sector) in every period, and the income of each agent in the model must equal their factor endowments plus any net transfers. Along with the underlying data, the nesting structures shown in Figure 7-1 and associated substitution elasticities define current production technologies and possible alternatives.

7.3.3 Utility Functions

Each region in the dynamic version of EMPAX-CGE contains four representative households, classified by income, that maximize intertemporal utility over all time periods in the model subject to budget constraints, where the income groups are:

- $0 to $14,999,
- $15,000 to $29,999,
- $30,000 to $49,999, and
- $50,000 and above.

These representative households are endowed with factors of production including labor, capital, natural resources, and land inputs to agricultural production. Factor prices are equal to the marginal revenue received by firms from employing an additional unit of labor or capital. The value of factors owned by each representative household depends on factor use implied by production within each region. Income from sales of these productive factors is allocated to purchases of consumption goods to maximize welfare.

Within each time period, intratemporal utility received by a household is formed from consumption of goods and leisure. All consumption goods are combined using a Cobb Douglas structure to form an aggregate consumption good. This composite good is then combined with leisure time to produce household utility. The elasticity of substitution between consumption goods and leisure depends on empirical estimates of labor supply elasticities and indicates how willing households are to trade off leisure time for consumption. Over time, households consider the discounted present value of utility received from all periods' consumption of goods and leisure.

Following standard conventions of CGE models, factors of production are assumed to be intersectorally mobile within regions, but migration of productive factors is not allowed across regions. This assumption is necessary to calculate welfare changes for the representative household located in each region in EMPAX-CGE. EMPAX-CGE also assumes that ownership of natural resources and capital embodied in nonfossil electricity generation is spread across the United States through capital markets.

7.3.4 Trade

In EMPAX-CGE, all goods and services are assumed to be composite, differentiated "Armington" goods made up of locally manufactured commodities and imported goods. Output of local industries is initially separated into output destined for local consumption by producers or households and output destined for export. This local output is then combined with goods from other regions in the United States using Armington trade elasticities that indicate agents make relatively little distinction between output from firms located within their region and output from firms in other regions within the United States. Finally, the domestic composite goods are aggregated with imports from foreign sources using lower trade elasticities to capture the fact that foreign imports are more differentiated from domestic output than are imports from other regional suppliers in the United States.

7.3.5 Tax Rates and Distortions

Taxes and associated distortions in economic behavior have been included in EMPAX-CGE because theoretical and empirical literature found that taxes can substantially alter estimated policy costs. The IMPLAN economic database used by EMPAX-CGE includes information on taxes such as indirect business taxes (all sales and excise taxes) and social security taxes. However, IMPLAN reports factor payments for labor and capital at their gross of tax values, which necessitates use of additional data sources to determine personal income and capital tax rates. Information from the TAXSIM model at the National Bureau of Economic Research (Feenberg and Coutts, 1993), along with user cost of capital calculations from Fullerton and Rogers (1993), are used to establish tax rates.

Along with these rates, distortions associated with taxes are a function of labor supply decisions of households. As with other CGE models focused on interactions between tax and environmental policies (e.g., Bovenberg and Goulder [1996]; Goulder and Williams [2003]), an important feature of EMPAX-CGE is its inclusion of a labor leisure choice—how people decide between working and leisure time. Labor supply elasticities related to this choice determine, to a large extent, how distortionary taxes are in a CGE model. Elasticities based on the relevant literature have been included in EMPAX-CGE (i.e., 0.4 for the compensated labor supply elasticity and 0.15 for the uncompensated labor supply elasticity). These elasticity values give an overall marginal excess burden associated with the existing tax structure of approximately 0.3.

7.3.6 Intertemporal Dynamics and Economic Growth

There are four sources of economic growth in EMPAX-CGE: technological change from improvements in energy efficiency, growth in the available labor supply (from both population growth and changes in labor productivity), increases in stocks of natural resources, and capital accumulation. Energy consumption per unit of output tends to decline over time because of improvements in production technologies and energy conservation. These changes in energy use per unit of output are modeled as AEEIs, which are used to replicate energy consumption forecasts by industry and fuel from EIA. [10] The AEEI values provide the means for matching expected trends in energy consumption that have been taken from the AEO forecasts. They alter the amount of energy needed to produce a given quantity of output by incorporating improvements in energy efficiency and conservation. Labor force and regional economic growth, electricity generation, changes in available natural resources, and resource prices are also based on the AEO forecasts.

Savings provide the basis for capital formation and are motivated through people's expectations about future needs for capital. Savings and investment decisions made by households determine aggregate capital stocks in EMPAX-CGE. The IMPLAN dataset provides details on the types of goods and services used to produce the investment goods underlying each region's capital stocks. Adjustment dynamics associated with formation of capital are controlled by using quadratic

[10] See Babiker et al. (2001) for a discussion of how this methodology was used in the EPPA model (EPPA assumes that AEEI parameters are the same across all industries in a country, while AEEI values in EMPAX-CGE are industry specific).

adjustment costs experienced when installing new capital, which imply that real costs are experienced to build and install new capital equipment.

Prior to investigating policy scenarios, it is necessary to establish a baseline path for the economy that incorporates economic growth and technology changes that are expected to occur in the absence of the policy actions. Beginning from the initial balanced SAM dataset, the model is calibrated to replicate forecasts from AEO. Upon incorporating these forecasts, EMPAX-CGE is solved to generate a baseline consistent with them through 2025. Once this baseline is established, it is possible to run the "counterfactual" policy experiments discussed below.

7.4 Results for $PM_{2.5}$ NAAQS 15/35 and 14/35

This section compares attainment of the revised $PM_{2.5}$ NAAQS standard (alternative 15/35) and a more stringent alternative (14/35) to a baseline for the economy that includes the Clean Air Interstate Rule (CAIR), the Clean Air Mercury Rule (CAMR), the Clean Air Visibility Rule (CAVR), and the current $PM_{2.5}$ NAAQS standard 15 $\mu g/m^3$ annual/ 65 $\mu g/m^3$ daily (15/65). Impacts are measured in the 2020 implementation year and are the result of engineering costs described in Section 7.1 (b). Thus, the following graphs compare the 15/35 and 14/35 standards to an economic growth path that incorporates impacts from CAIR, CAMR, CAVR, and $PM_{2.5}$ NAAQS 15/65 through the year 2020.

7.4.1 Projected Impacts on U.S. Industries of Incremental Costs of Reaching Tighter Standards (15/35 and 14/35)

Impacts of the alternative $PM_{2.5}$ NAAQS standards on manufacturing costs can affect output and prices of all industries in the EMPAX-CGE model. These effects may increase or decrease output and/or revenue, depending on their implications for production costs and technologies and shifts in household demands. In general, the impacts on industries will be dependent on the control strategies and follow a pattern similar to the stringency of the $PM_{2.5}$ NAAQS standards.

As shown in Figure 7-3a, impacts on industrial output quantities are generally small across all industries for 15/35, while there are slightly larger effects in a limited number of industries for 14/35. Outside of the energy-intensive sectors (EIS), estimated changes in output of manufactured goods are less than five one-hundredths of one percent (0.05%). Effects on energy producers are also of a similar magnitude, aside from electricity generation and coal under 14/35, which limits any spillover effects to other businesses and households.

As described in Chapter 6, selected control options for the 14/35 standard involve additional actions by electric utilities, influencing U.S. coal consumption. Other energy industries also engage in additional measures, which can affect energy users such as the EIS sectors. Cement, aluminum and paper production are influenced by direct control costs on their respective industries and any changes in energy markets. Note, however, that even across the energy-intensive industries, output quantities decline on average by less than a quarter of a percent.

Figure 7-3b shows how these changes in output quantities (or units) compares to changes in gross output revenues, where revenue changes include the effects of changes in both quantity and output prices (which reflect changes in production costs). While additional gross revenues may not imply that net revenues have increased for a given industry, Figure 7-3b is useful in illustrating the overall changes occurring in the economy in dollar terms. The first set of results to note across the two figures are the differences between the slight decline in electricity output and a small increase in output revenues for the electricity industry, which are the result of changes in production costs that lead to slightly higher electricity prices. Also, across the economy as a whole, although there is almost no change in the quantity of services produced, in revenue terms the changes in energy-related industries are much smaller than in services due to the overall size of the service industry in the U.S. economy.

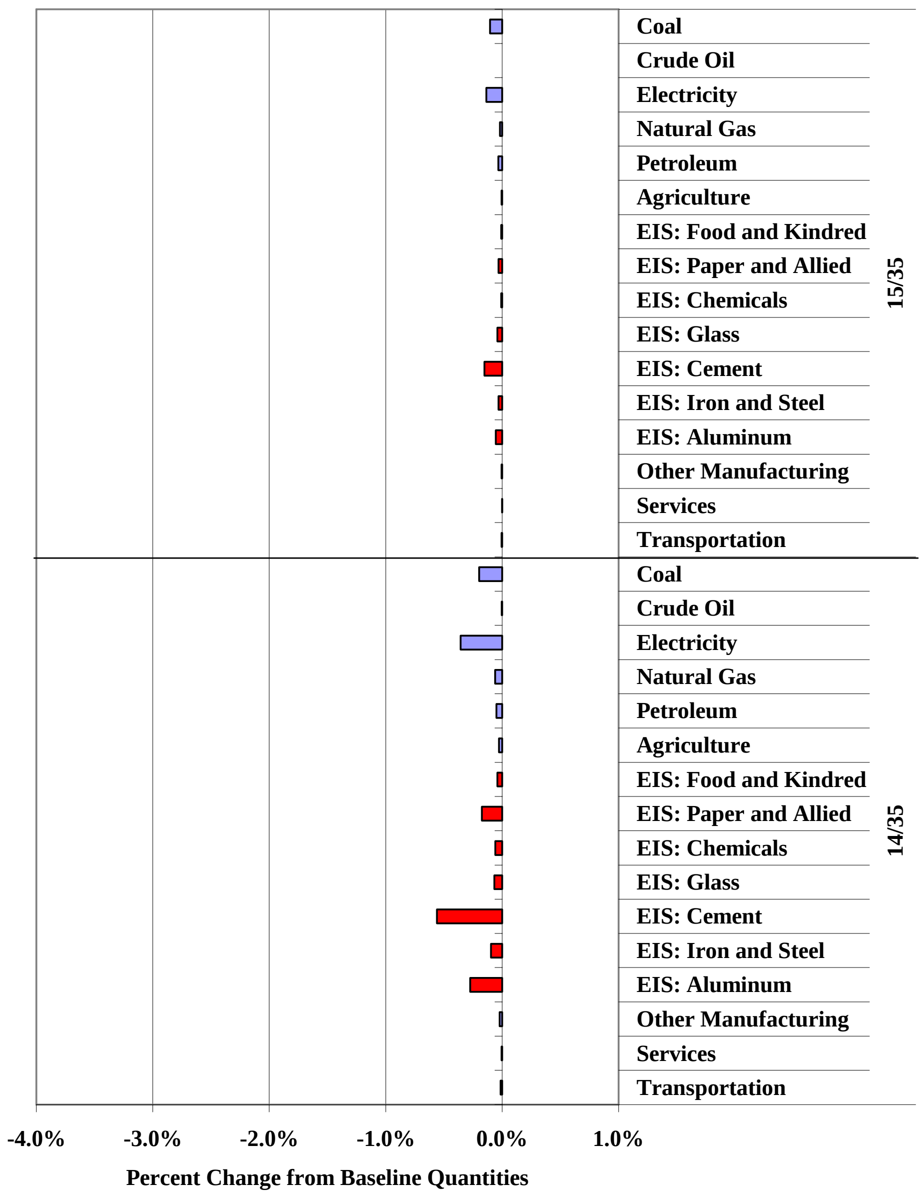

Figure 7-3a. $PM_{2.5}$ NAAQS 15/35 and 14/35 Impacts on U.S. Domestic Output Quantity, 2020

Source: EMPAX-CGE

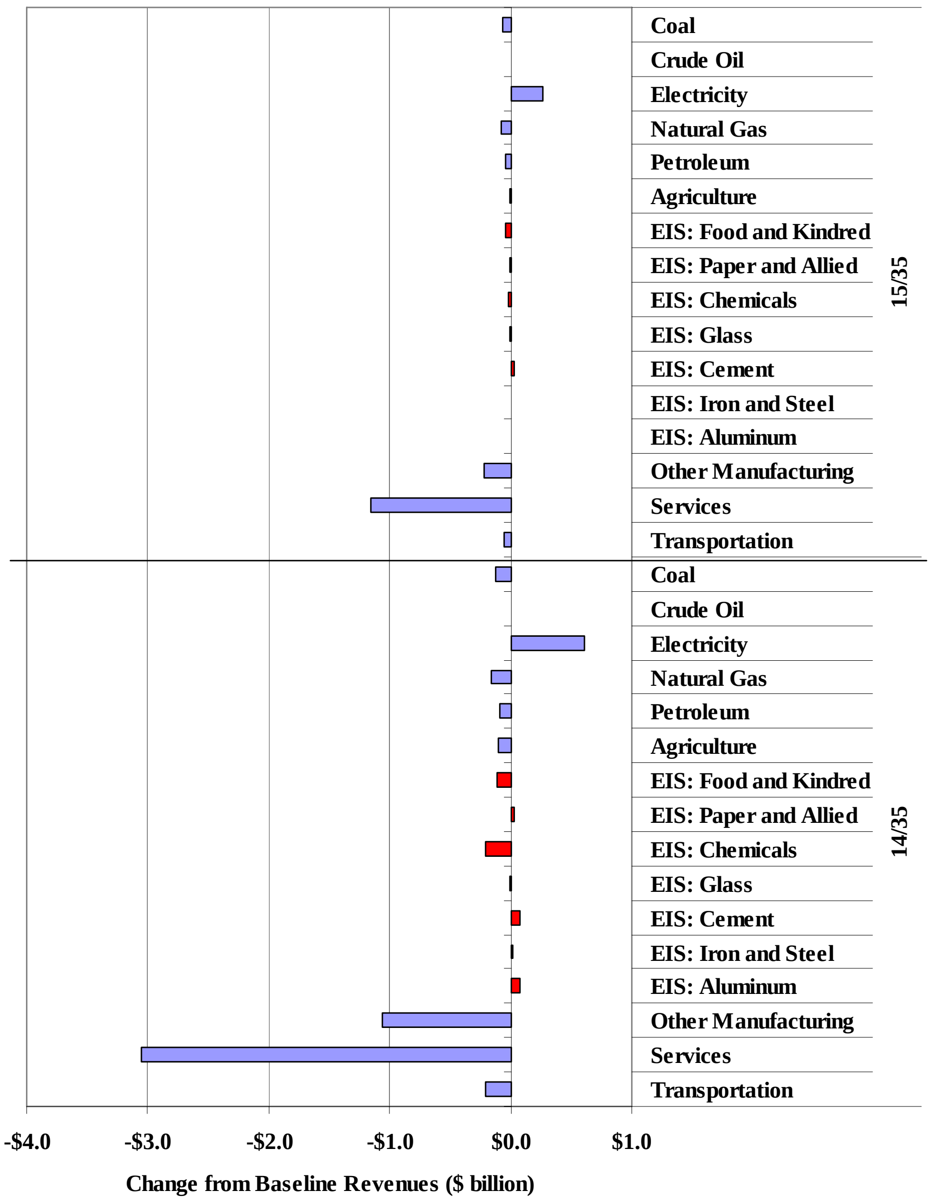

Figure 7-3b. $PM_{2.5}$ NAAQS 15/35 and 14/35 Impacts on U.S. Domestic Output Revenues, 2020

Source: EMPAX-CGE

7.4.2 Projected Impacts on Regional Energy-Intensive Industries

Regional effects will tend to show variation that does not appear at the national level. To examine how such variations might occur in response to the two alternative $PM_{2.5}$ NAAQS standards, this analysis presents findings for an East-West split of the United States (see Section

7.3.1 for a definition)[11]. Since changes in output for most industries are essentially unaffected, Figures 7-4 and 7-5 focus on regional results for the energy-intensive industries in EMPAX-CGE.

As with the U.S. average results from Figure 7-3a, even though the energy-intensive sectors show more regional variation, based on differences in production methods and changes in manufacturing costs, the majority of the impacts are less than one tenth of one percent. However, for each scenario, there are one to two industries that demonstrate measurable, but still relatively small, impacts. Under 15/35, energy-intensive output tends to be redistributed slightly from West to East as decreases in cement and aluminum manufacturing output in the West are offset by increases in the East.[12] For the 14/35 results shown in Figure 7-5a, this finding is reversed for cement in the East, which is projected to be offset by an increase in output quantities in the West, giving an end result of a one-half of one percent decrease in cement output for the U.S. In revenue terms, the changes in Figure 7-4b are generally similar to the quantity changes in Figure 7-4a. For some industries such as cement and aluminum, gross revenues are somewhat higher while output quantities have declined slightly as the result of changes in production costs. A similar story holds true for the 14/35 standard in Figure 7-5b.

When examining such findings, however, it is important to note that these impacts and redistributions are directly related to the specific control options assumed in this illustrative analysis. As previously stated, these results represent the impact of an approach presented by EPA that could meet attainment under the alternative standards. While EPA is providing this analysis as guidance for States, it is expected that States will evaluate the best strategies for achieving compliance and may choose options that could significantly alter these regional effects. Therefore, SIPs will most likely be different than the strategies developed in this RIA and could be designed to alleviate any disproportionate impacts on sensitive industries. For example, given the impact on aluminum and cement production, as well as paper manufacturing, assumed with the two scenarios, affected States may well design SIP strategies that mitigate the impact on these particular industries, perhaps distributing costs more uniformly among all sectors.

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[11] For more detailed regional impact figures, in accordance to the EMPAX-CGE regions shown on Figure 7-2, please see Appendix F.

[12] Redistribution of production will also tend to occur among states in each region, with some states' increasing output to offset any declines in neighboring states.

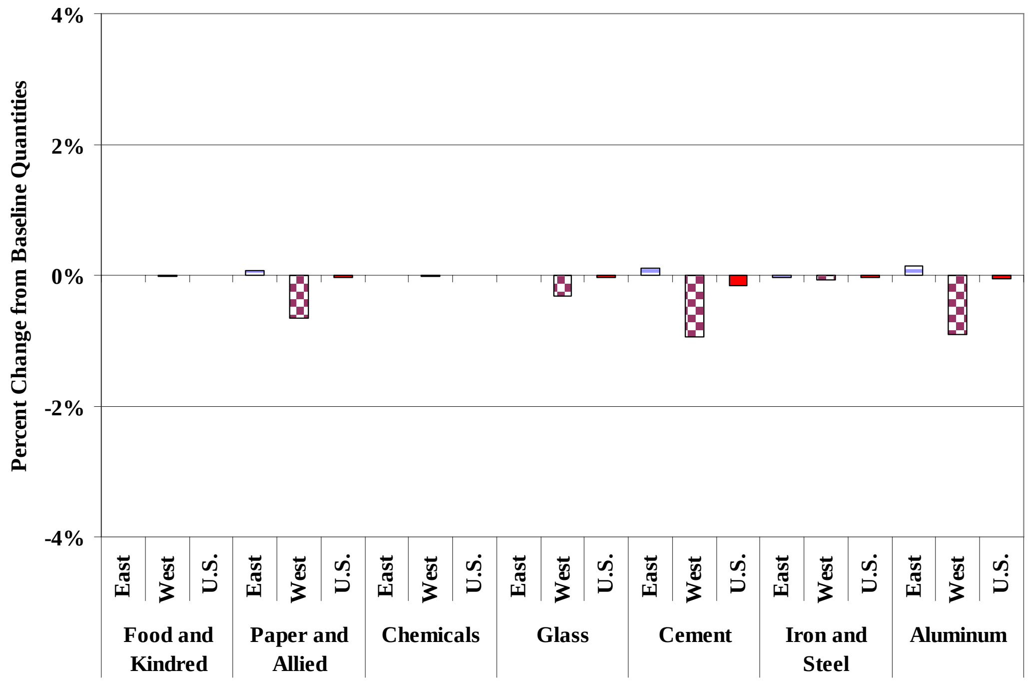

Figure 7-4a. $PM_{2.5}$ NAAQS 15/35 Impacts on Regional Energy-Intensive Output Quantities, 2020

Source: EMPAX-CGE

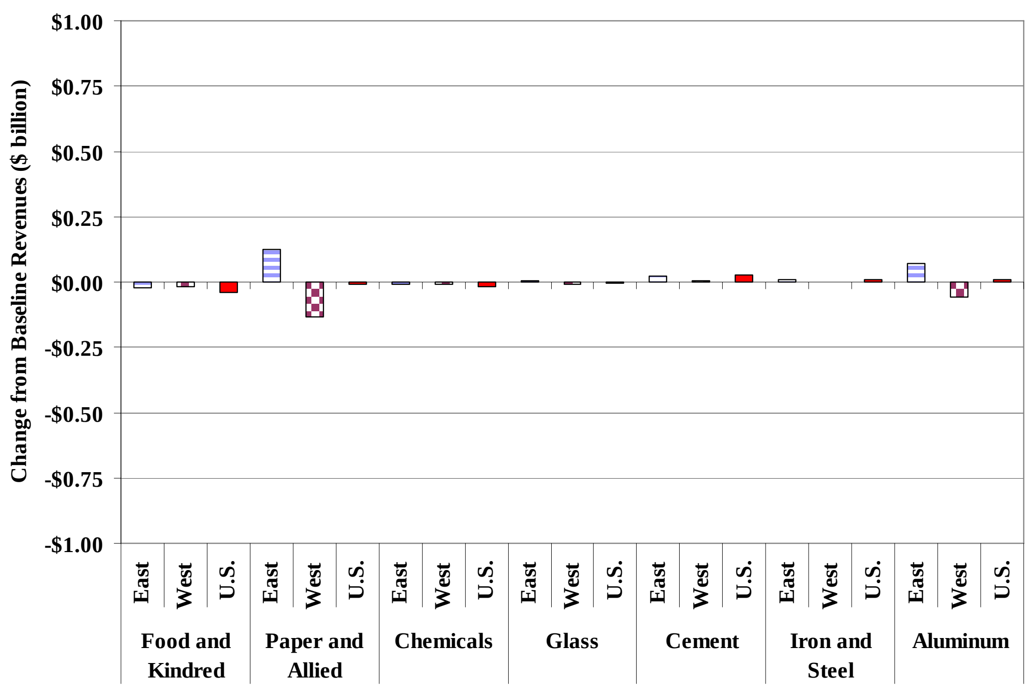

Figure 7-4b. $PM_{2.5}$ NAAQS 15/35 Impacts on Regional Energy-Intensive Output Revenues, 2020

Source: EMPAX-CGE

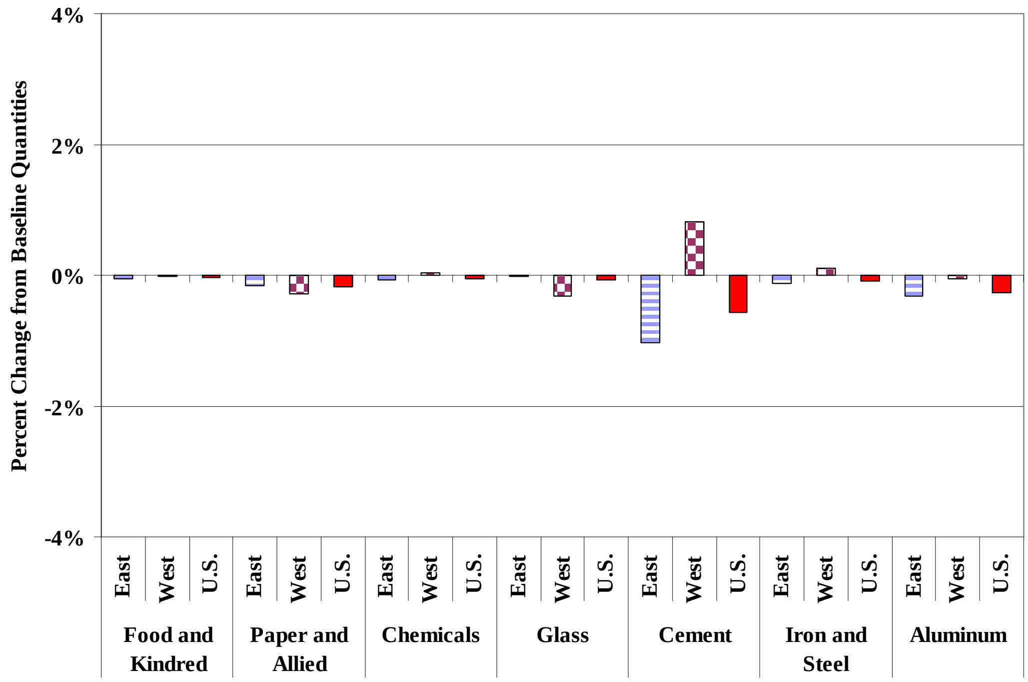

Figure 7-5a. $PM_{2.5}$ NAAQS 14/35 Impacts on Regional Energy-Intensive Output Quantities, 2020

Source: EMPAX-CGE

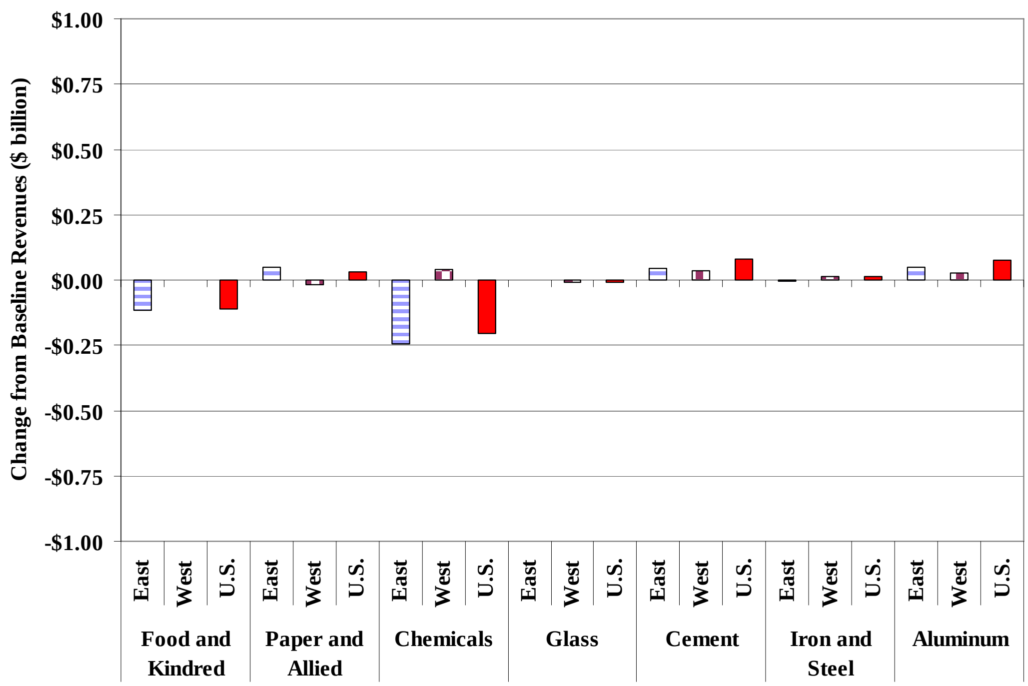

Figure 7-5b. $PM_{2.5}$ NAAQS 14/35 Impacts on Regional Energy-Intensive Output Revenues, 2020

Source: EMPAX-CGE

7.4.3 Projected Impacts on GDP

The combination of economic interactions affecting business and household behavior will be reflected in the changes in GDP estimated by a CGE model. Given that this cost-based approach to analyzing the $PM_{2.5}$ NAAQS standard does not reflect its benefits to the environment, public health, and labor productivity, CGE models (including EMPAX-CGE) will tend to over estimate declines in total production in the United States. Potentially offsetting these benefits are attainments costs that have not been included in this analysis mainly due to their lack of direct industry cost information (See Section 7.1 (b)). Consequently, these results can be considered incomplete because they do not reflect potential productivity benefits of the $PM_{2.5}$ NAAQS or the full cost of attainment. The impacts on GDP should be viewed as an approximation of the costs of the $PM_{2.5}$ NAAQS and are provided here for illustration.

Figure 7-6 illustrates GDP in the EMPAX-CGE model's baseline forecast and the two $PM_{2.5}$ NAAQS policy cases. As shown, the estimated GDP impact is negligible and, in fact, it is not possible to adjust the scale of the graph to the point where the two lines do not overlap. Projected decreases in GDP for the $PM_{2.5}$ NAAQS 15/35 and 14/35 standards of roughly 0.01 and 0.02 percent, respectively, for the year 2020. This is equivalent to a \$1.15 billion decrease in GDP for 15/35 and a \$3.54 billion decrease for 14/35 during the implementation year. In absolute terms, these estimated implications for U.S. GDP are extremely small relative to the total size of the economy. Even these small costs could be negated if the CGE analyses were extended to include benefits associated with the $PM_{2.5}$ NAAQS standard such as improvements in labor productivity from environmental improvements.

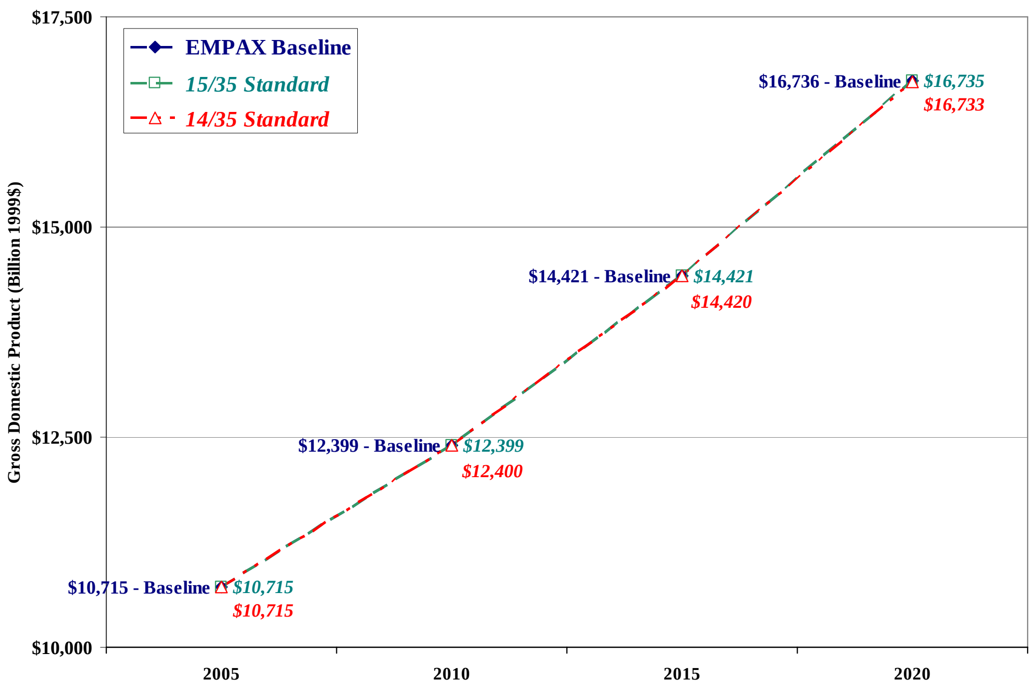

Figure 7-6. Change in U.S. GDP Compared to EMPAX-CGE Baseline

Source: Department of Energy, Energy Information Administrations; EMPAX-CGE

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