Impacts of Greenhouse Gas Regulations on the Industrial Sector:

Summary and Key Results

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While the regulatory approach to reducing greenhouse gas (GHG) emissions in the United States has largely focused on the power and transportation sectors, it's clear that substantial reductions by the industrial sector would be needed to meet President Obama's pledge under the Paris Agreement. This report summarizes a study conducted by NERA Economic Consulting[1] on the potential impacts to the U.S. economy of regulating industrial sector GHG emissions.

Introduction

In 2013, President Obama announced his Climate Action Plan (CAP) to address climate change through a series of executive actions. CAP included a broad suite of regulations and policies implemented by several federal agencies. A central component of CAP directed the U.S. Environmental Protection Agency (EPA) to establish restrictions on carbon dioxide emissions from the electric power sector, triggering development of what became known as the "Clean Power Plan" (CPP). Additional key aspects of CAP were stricter fuel economy standards for light-duty vehicles and heavy trucks, reduced emissions of methane and hydrofluorocarbons (HFCs), and the promulgation of new efficiency standards for appliances and federal buildings.

CAP also sought international agreement by the end of 2015 for the creation of a global framework for reducing GHG emissions.

Total U.S. Economic Impacts in 2025

- **GDP loss:** $250 billion
- **Household income:** reduced by $160
- **Manufacturing job losses:** 440,000
- **Total job losses:** **2.7 MILLION**

1 The full study, "Impact of Greenhouse Gas Regulations on the Industrial Sector," can be accessed at http://accf.org/2017/03/16/accf-nera-report/. This short special report summarizes the key findings of the full the study.

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This was accomplished at a December 2015 meeting of the United Nations Framework Convention on Climate Change (UNFCCC) in Paris. The Paris Agreement requires signatory nations to submit, and periodically update, voluntary "Nationally Determined Contributions" to reducing GHG emissions.

In its initial NDC, the United States pledged to reduce emissions 26% to 28% below 2005 levels by 2025. However, as the 2016 Second Biennial Report of the United States of America (USSBR 2016) and many independent analyses show, estimates of the reductions from existing U.S. regulations fall well short of the targets agreed to in Paris by the Obama Administration.

This gap between existing policy and ambition—which only increased once the U.S. Supreme Court placed a stay on the CPP and President Trump announced his intention to withdraw the regulation —amounts to nearly two-thirds of the total emission reductions needed to meet the Paris NDC target. Even with CPP in place, the United States would still fall short of its pledge by roughly 50%. It's clear that President Obama's pledge to reduce GHG emissions by as much as 28% cannot be met without additional steep cuts on the industrial sector.[2]

The American Council for Capital Formation Center for Policy Research contracted with NERA Economic Consulting to estimate the potential economic impact of regulating industrial sector GHG emissions sufficient to close the Paris NDC gap. The study analyzes various emission reduction scenarios and reports the results both at the macro and industry levels.

Core Scenario:

Scenario 1, the core scenario, examines a broad sectoral cap. Four broad sectors (electricity, transportation, industry, and other) face individual targets to meet the U.S. NDC target. By applying the cap to a broad industrial sector that includes all the targeted subsectors (including cement, iron, and steel), we assume that regulators succeed in identifying the least costly mitigation options within each broad sector. No trading is allowed between broad sectors (such as between electricity and transportation), but subsectors may trade emissions allowances with the other members of their sector.

The USSBR 2016 report on actions to reduce GHG emissions includes high and low estimates for sequestration of GHGs due to changes in land use and forestry that are uncertain and difficult to estimate. Using the trend lines in this report and data on sequestration in the EPA's 2016 GHG inventory, two different offset potentials (average and high) were developed that are counted toward emission reduction targets for each scenario.

2 Consistent with this view, a recent EPA budget proposal requested funding to begin considering new GHG regulations on the refining, paper and allied products, iron and steel, livestock, and cement sectors. (United States Environmental Protection Agency, Fiscal Year 2015, Justification of Appropriation Estimates for the Committee on Appropriations, EPA-190-R-14-002, pg. 2013.)

Table 1: Key results for the core scenario under both average and high sequestration.

	2025	2040	2025	2040
	Average Sequestration		High Sequestration	
Percentage Change in Gross Domestic Product (%)	-1%	-9%	-1%	-8%
Change in Gross Domestic Product (2015$ Bil.)	-$250	-$2,900	-$180	-$2,500
Change in Income per Average U.S. Household (2015$/Household)*	-$160	-$7,000	-$60	-$5,900
Change in Manufacturing Sector Jobs (Thousands)	-440	-3,100	-280	-2,800
Change in Total Industrial Sector Jobs (Thousands)	-1,060	-6,500	-760	-5,800
Change in Total Economywide Jobs (Thousands)	-2,700	-31,600	-1,900	-27,900
Percentage Change in Industrial Sector Output (%)				
Paper and Allied Products	-4%	-12%	-3%	-10%
Cement	-21%	-23%	-13%	-21%
Bulk Chemicals	-5%	-12%	-3%	-10%
Iron and Steel	-19%	-38%	-12%	-35%
Coal	-20%	-86%	-18%	-82%
Natural Gas	-11%	-31%	-8%	-29%
Petroleum Products	-11%	-45%	-7%	-41%

**Change in income per average U.S. household is expressed as a dollar value relative to current average income levels.*

Key Results:

Impact on U.S. Economy: In the core scenario, depending on the sequestration assumption, the loss of U.S. GDP could range between $180 and $250 billion in 2025, increasing to $2.5 to $2.9 trillion in 2040 relative to the baseline levels in the respective years. The GHG regulations will have a ripple effect by first increasing energy costs, decreasing the sectoral output, and then ultimately decreasing income and consumption at the household level. Investment and exports of goods and services are lower, leading to lower GDP. This loss of economic output due to the GHG regulations intensifies in the long run as the "mid-term" deep decarbonization target constrains the economy significantly. This translates into an average annual GDP loss of 6% between 2034 and 2040, amounting to a loss of greater than $2 trillion annually and a cumulative loss of $16 trillion over the period.

Household Income: The cost of compliance with GHG regulations and higher costs for energy lead directly to reductions in household purchasing power. In 2025, a typical U.S. household's real annual income will decline between $60 and $160 relative to today's income level. The average annual loss in income increases to about $510 to $720 per household between 2022 and 2031. In 2040, the range is between $5,900 and $7,000.

Manufacturing Sector Jobs: Energy costs make up a large share of the total cost of production of manufacturing goods. A restriction on carbon emissions means that the total cost of fossil fuel increases leading to higher costs of production. This cost increase leads to the closing of facilities that cannot compete on a cost basis. The increasing stringency of GHG policy leads to more closures in the manufacturing sectors over time, resulting in fewer manufacturing jobs. In 2025, the manufacturing sector alone could potentially lose 440,000 job-equivalents relative to the baseline job projections and about 3.1 million in 2040.[3]

Total Industrial Sector and Economy-wide Jobs: Taking into account the loss in employment in other, non-manufacturing sectors, the impact for the overall industrial sector could be about 1.1 million job-equivalents in 2025 and 6.5 million in 2040 under average sequestration. A large share of this job loss occurs in the construction sector which employs a significant portion of the overall industrial labor force. Total economy-wide employment losses amount to about 2.7 million in 2025.

Energy-Intensive Sectors: The most energy and carbon intensive sectors experience the greatest impacts. As a result of the GHG policy, these sectors face higher costs and reduced competitiveness, resulting in lower demand for their goods.

3 We represent jobs impacts as "job-equivalents." The number of job-equivalents equals total labor income change divided by the average annual income per job. This does not represent a projection of the numbers of workers that may need to change jobs and/or be unemployed, as some or all of the loss in labor income could take the form of lower wages and would be spread across workers who remain employed.

Production in the iron and steel, refined petroleum products, and cement sectors are the most impacted. Under the core scenario, their 2025 output declines by about 19%, 11%, and 21%, respectively, and their 2040 output declines by about 38%, 45%, and 23% respectively. Bulk chemicals and paper and allied products output declines by about 5% relative to the baseline in 2025 and by 12% in 2040.

Since the regulatory program represented by a carbon price has a direct impact on the cost of using fossil fuels, fuel demand is reduced and production of natural gas and crude oil declines. The production of natural gas declines by 31% and refinery output by 45% by 2040. Coal production declines by 20% relative to the baseline production in 2025 and by 86% in 2040 as the electric sector decarbonizes significantly.

Marginal Costs of Reducing Carbon: Under the core scenario, the caps for each sector are set separately and no emission trading is allowed between the four broad sectors: Industry, Transportation, Electric Power, and Other. As a result, there will be a suboptimal allocation of emissions reduction effort across these sectors. The carbon price reveals that the power sector experiences the lowest price to meet its targets as the lower natural gas price helps to meet the CPP target. The industrial sector faces a carbon price of $200 per metric ton[4] of CO2 (TCO2) in 2025 and rises over time to about $400/TCO2 in the long run. The other two broad sectors (Transportation and Other) face no carbon price until the year 2028 since their emissions caps are met by demand response. However, the carbon price in the transportation sector rises significantly over time. The ranges of carbon prices for the four broad sectors for the different levels of sequestration in the model are shown in Figure 1.

Emissions Leakage: Leakage in emissions occurs when reductions in one region employing a policy are offset by an increase in emissions in another region. In particular, for this study, U.S. emission reductions are offset by increases in emissions in the rest of the world, which do not employ a

Figure 1. Carbon Prices (2015$ per metric ton of CO2)[5]

4 Throughout the remainder of this report, CO2 is reported in metric tons and for brevity referred to as tons.

5 IND - Manufacturing sectors, TRN - Transportation sector, ELE - Electric sector, and OTH - Rest of the economic sectors, see Section III.

GHG reduction policy[6] beyond the programs that are already incorporated in the baseline.[7] Leakage offsets a large share of the emission reductions from the most energy-intensive and heavily impacted sectors. For every ton of CO2 emissions reduced in the U.S., 0.3 tons of CO2 emissions increase from energy-intensive sectors elsewhere around the world, as manufacturing and industrial activity (and the emissions associated with them) moves to countries that do not impose similarly stringent restrictions. Hence, from a global perspective the overall effectiveness of the U.S. policy is undermined by leakage. Moreover, the high costs borne, especially by the energy-intensive sectors, produce even less emission reduction when viewed from a global basis.

Alternative Scenario Descriptions

The study considers four other scenarios, excluding the Broad Sectoral Cap, that include direct sectoral regulations as well as a nationwide cap and trade program combined with a regulatory program to meet the U.S. NDC target (see **Table 2** for a brief summary of the alternative scenarios considered).

These alternative scenarios are:

Scenario 2. ***Industrial Sector Cap Only:*** In order to isolate the direct cost of industrial sector emission reductions, we impose a cap only on the Industrial sector and impose no additional regulations on other sectors of the economy (for example no CPP on electric sector). This scenario, when compared to Scenario 1, highlights the effect of having a broader cap and its effect on the trade-off with the demand for manufacturing goods. As with Scenario 1, we allow trading between industrial sub-sectors but not across sectors.

Scenario 3. ***Direct Measures:*** This scenario aims to mimic a regulatory approach system. Direct measures are applied to all sectors to the extent deemed feasible based on EIA's estimates using the Annual Energy Outlook's side cases. The direct measures could be quite costly, but any measure that would automatically force a shut down in production are excluded (e.g., direct measure that mandate reductions beyond what is technologically achievable). This scenario applies specific direct measures to each subsector. For example, we impose regulatory measures that require the process industries to improve their energy intensity, fuel economy standards for light duty vehicles and heavy duty trucks, increase CPP stringency, a more stringent renewable portfolio standard on the electric sector, and reduction in building sector energy consumption. Achievement of the NDC target is not forced in this Scenario.

Scenario 4. ***Subsector-Specific Regulation:*** In light of the results of Scenario 3, we find that identifiable direct measures are insufficient to achieve the required reduction in emissions for the industrial sector and for the overall economy to meet the NDC target. In Scenario 4, we introduce direct measures on each industrial subsector at levels that would achieve the NDC target. Each subsector of industry is assigned the same percentage reduction that is applied to the broad industrial sector in Scenario 1. The other broad sectors also follow the Scenarios 1 emission reduction pathway. Under this Scenario, there is no trading across subsectors. This approach intends to capture a CPP like regulation for the industrial sector under Section 111(d).

Scenario 5. ***Economy-Wide Trading with Direct Measures:*** This scenario assumes that EPA will depart from its existing authorities under CAA and claim broad authority to create an economy-wide cap and trade program. While the legality of such an action is up for debate, numerous stakeholders have suggested that an argument for such authority could be made under CAA Section 115. If EPA were to attempt to do so, it is likely that they would be required to instruct states to include GHGs in State Implementation Plans (SIP). In this scenario, we assume that all states and sectors trade carbon allowances in a single nationwide market while meeting the direct measures identified in Scenario 3. Each state is assigned a cap in 2025 equal to 27% of its 2005 emissions, declining linearly to 80% below 2005 levels by 2050. To be consistent with the timing and carbon prices of the regulatory scenarios, we assume no banking is allowed. We also assume that all the direct measures included in Scenario 3 would remain in force.

The full NERA report has further discussion of the alternative scenarios. However, given that only alternative scenarios 4 and 5 actually reach the U.S. NDC target, we limit discussion in this report to the key results for these two scenarios under average sequestration. (See **Table 3**)

6 Since the intensity pledge of China, a major contributor of global emissions, does not deviate significantly from the current outlook (http://www.energyxxi.org/china%E2%80%99s-indc-significant-effort-or-business-usual), we did not consider the potential effects of other regions taking on their respective NDCs in this study.

7 The leakage rate would be mitigated if other regions of the world also undertook policies to reduce carbon emissions.

Table 2: Scenario descriptions and policies applied to each broad sector

Scenario No.	Scenario Description	Regulation	Industry (IND)	Electric (ELE)	Transportation (TRN)	Other (OTH)	Trading among broad sectors	Trading among industrial sub-sectors	Sequestration
0	Baseline	Consistent with AEO 2016's Reference Case without CPP							
1	Broad Sectoral Cap	Broad sector specific cap to meet NDC target	NDC	CPP	NDC	NDC	No	Yes	Average and High
2	IND Sector Cap Only	NDC cap on the industrial sector	NDC	None	None	None	No	Yes	Average
3	Maximum Direct Measures	Command and Control	Energy Intensity Improvements	Extended CPP	CAFE Standards and Efficiency Improvements	Building Energy Efficiency	N/A	No	None
4	Sector Specific Cap	NDC sector specific cap to meet the NDC target	NDC by Sub-Sector	CPP	NDC	NDC	No	No	Average
5	Cap & Trade Approach with regulatory programs	Cap and Trade + Command and Control	Energy Intensity Improvements	Extended CPP	CAFE Standards and Efficiency Improvements	Building Energy Efficiency	Yes	Yes	Average

Key Results

Comparing Scenario 4 to the baseline gives an estimate of the cost of meeting the NDC targets with regulations sufficient to bring each subsector into compliance with its sectoral NDC targets on its own. We believe this is still an underestimate of the true cost of a full regulatory approach that purports to regulate at a facility level because scenario 4 assumes perfect trading among establishments within the subsector and no other costs arising from the distorted incentives created by regulations. Furthermore, this scenario still applies emissions targets at a broad sub-sector level.

Comparing Scenario 5 to the baseline provides estimates of the lower cost that might be achieved with a full economy-wide cap and trade system in conjunction with Scenario 3 regulatory measures that impose a cap and trade system. We offer no opinions on the legality of such an approach, but note that working through State Implementation Plans poses a significant risk of introducing barriers to trading and inefficiencies into the system.

Impact on U.S. Economy: In Scenario 4, U.S. GDP losses could range between $270 billion in 2025 to $3,100 billion in 2040 due to significant cutbacks in investment in the industrial sector resulting from the sector specific caps. Although the impacts are smaller, Scenario 5 still shows reductions in GDP of $110 billion in 2025 and rising to $950 billion in 2040.

Household Income: The cost of compliance with GHG regulations and higher costs of using energy lead directly to reductions in household purchasing power. In 2025,

Table. 3. Scenarios 4 and 5: Impact on Key Variables Relatives to Baseline (Average Sequestration)

	Scenario 4		Scenario 5	
	2025	2040	2025	2040
Percentage Change in Gross Domestic Product (%)	-1.2%	-9.8%	-0.5%	-3.0%
Change in Gross Domestic Product (2015$ Bil.)	-$270	-$3,100	-$110	-$950
Change in Income per Average U.S. Household (2015$/Household)*	-$480	-$7,000	-$1,250	-$2,400
Change in Manufacturing Sector Jobs (Thousands)	-450	-3,500	-12	-430
Change in Total Industrial Sector Jobs (Thousands)	-1,100	-7,300	-200	-1,740
Change in Economywide Jobs (Thousands)	-3,400	-33,500	-2,300	-8,700

** Change in income per average U.S. household is expressed as a dollar value relative to current average income levels.*

a typical U.S. household's real annual income would decline between $480 and $1,250 relative to today's income level under Scenarios 4 and 5, respectively. The reason that the income impact is higher under Scenario 5 is due to the combined effect of direct measures and cap-and-trade in a hybrid of carbon reduction regimen in which consumers feel the drag of regulations, such as CAFÉ standards, on their income.

Impact on Jobs: As the comparison of scenarios 1 and 5 shows, broadening the cap reduces the economic impacts relative to the baseline. Whereas the differences in impacts between scenarios 1 and 4 were relatively small but the differences in impacts between scenarios 1 and 5 are larger driven primarily by an economy-wide trading assumption. Under Scenario 4, job losses in manufacturing sector ranges between 450,000 and 3.5 million job-equivalents in 2025 and 2040 respectively. This impact is much smaller under Scenario 5, amounting to 12,000 in 2025 and 430,000 in 2040. When we compare the economy-wide job losses in Scenarios 1, 4 and 5, the difference gets larger in the long run as the stringency of the policy increases and the efficiency gain from additional flexibility in the form of cap-and-trade that mitigates the overall costs. The Scenario 4 economy-wide job loss is 33.5 million job-equivalents in 2040 whereas Scenario 5 experiences 8.7 million job losses for the same year.

Conclusions

This study highlights the fact that regulatory measures are an inefficient way to achieve climate goals. While all examined scenarios resulted in significant job and economic impacts, scenarios that allow more flexibility achieve the same or greater emission reductions at a lower economic cost. The analysis also shows that in the next 10 years, regulating the industrial sector to achieve NDC goals would be responsible for most of the overall impact on the economy. Additionally, the study illustrates that electric sector reductions are relatively less expensive than reductions from the industrial sector, which generally is comprised of far smaller emissions sources. It would be much less costly to allow other sectors to purchase credits from the electric sector for emission reductions than to meet NDC targets on their own. The study also illustrates the challenges associated with emissions leakage. Regardless of which regulatory scenario is pursued, substantial leakage is likely to undermine environmental goals unless other countries impose similarly stringent emissions restrictions.