THE CENTER FOR CLIMATE STRATEGIES

Developing and Assessing Economic, Energy, and Climate Security and Investment Options for the US

2012 International Energy Workshop Paper

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Abstract

The annual projection of business as usual US carbon dioxide emissions by the US Department of Energy *Annual Energy Outlook (AEO)* through the year 2020 shows a 23 percent drop in estimated future emissions between the 2005 to 2011 forecasting periods, and a 69 percent drop compared to 1990 levels – a dramatic narrowing of expected future emissions versus national climate policy goals. While many assume these forecast shifts are attributable to the economic downturn, state of the art decomposition analysis of AEO data indicate that 46 percent of the shift expected through 2020 can be attributed to eight sector-based policy actions instituted at the state and federal levels. Another 26 percent is attributable to additional policy actions and oil price changes. Only 22 percent of declining emissions forecasts result from changes in the economy by 2020, and eighteen percent by 2030. These shifts indicate a clear and progressive decoupling of carbon emissions and energy intensity from economic growth. In addition, 20 additional sector-based actions at the national and subnational levels can narrow remaining emissions gaps by 2020 and beyond while improving economic and energy security in every sector to expand decoupling. These actions also provide favorable returns on investment for job creation, energy savings, and energy security. Selection and design of these new actions is based on evaluation of hundreds of policy options derived from stakeholder and consensus-based comprehensive climate action planning in 20 states, combined with national energy and economic security considerations. They serve as drivers for new investment, collaboration, and governance structures needed to integrate economic, energy, and environmental security in the US. Multi-objective, fully integrated, and participatory systems of planning and analysis are critical to attaining simultaneous net positive outcomes in these areas, as is leadership at all levels of government, and a broadened view of national security that captures the dynamics between energy, economic, and environmental systems.

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Context

Research and practice on greenhouse gas (GHG) mitigation policy has identified options with potentially positive as well as negative impacts on economic, energy, and environmental security performance. Past research and policy development focused primarily on emissions reductions, direct economic impacts, and indirect economic impacts (Weyant, 1999; Barker et al., 2002; Rose and Dormady, 2011), but has progressively addressed a broader and more fully integrated set of policy objectives and impacts, as well as the interface between policy, markets and investment (Peterson, et. al., 2010). Policy analysis also began focusing on evidence and opportunity for decoupling of emissions reductions from economic growth and energy security. As a result, the range and design of policy options, their implementation mechanisms, and analytical techniques required for comprehensive analysis have grown and intensified. This paper provides a current assessment for the US.

Today, three principal drivers support this trend: 1) *market shift* -- the recognition of emerging sustainable global economies and related energy and industrial shift, and the potential for specific policy actions to capture and enhance emerging markets in particular locations; 2) *energy security* -- the importance of energy security and sustainability to national economic and environmental policy decisions, including national security; and 3) *investment* – the reality of significant limitations on public revenues to support policy, and the need for mobilization of private investment through new public-private partnerships.

This paper focuses on two important co-objectives of GHG mitigation. First are potential gains to the economy from investment in efficient, low polluting, and sustainable technologies and practices that are of global benefit. They stem from the fact that many climate mitigation options, such as energy and land use efficiency, can generate a net investment stimulus through net cost savings that frees up revenue for reinvestment, or they reconfigure infrastructure spending approaches to provide higher than average economic growth and employment returns. Second are the national security benefits stemming from reduced dependence on energy in general and fossil fuels, in particular, or in diversification of energy supplies toward more indigenous, reliable, and affordable supplies with lower environmental costs. Under certain conditions, these gains can include more secure supplies and decreased energy price volatility, as well as stimulus to the macro economy, while easing the strain on balance of payments. Done properly, they can also reduce health and environment costs.

The Center for Climate Strategies (CCS), in cooperation with the Johns Hopkins University Center for Advanced Governmental Studies/Global Security Center, launched *the Center for Climate Strategies' Security and Investment Project, Comprehensive Leadership Strategies for the Emerging Energy Economy*, in 2011 with a select group of policy makers and experts. This initiative builds upon the CCS/Johns Hopkins University 2010 report, *Impacts of Comprehensive Climate and Energy Policy Options on the US Economy*. This report is based on national-scale results of comprehensive state climate action plans developed through stakeholder based planning and analysis.

To support rapidly expanding interest in this area, and to incorporate new findings and dimensions on policy performance from its 2010 study, CCS expanded and updated its past framework and analysis. The new focus is to identify and design integrated "triple bottom line" policy actions at the local, state and national levels designed to simultaneously achieve net positive benefits of economic, energy and environmental security, and to identify investment requirements and potential sources of public and private financing for these actions. Baseline updates in the study reflect major shifts in US emissions and energy forecasts, and provide evidence of significant decoupling. The identification and assessment of additional stakeholder and expert-derived policy recommendations provides a comprehensive, empirical basis for future actions that can deliver even greater benefits.

Finding 1: State, Local, and National Policies Reduce Forecasted CO2 Emissions

Review of past energy, environmental, and economic policy activity in each of the economic sectors provides important insights into their evidence of success and potential in meeting future needs. As a first step, this paper examines changes in recent baselines for energy, economy, and emissions in the US, and the factors that drive them. In particular, Annual Energy Outlook (AEO) forecasts of US GHG emissions by the US DOE Energy Information Administration (EIA) have been in steady annual decline since 2005 and provide an important dataset for study (EIA AEO Archives).

Despite the lack of comprehensive national energy or climate policy or programs during this period, baseline CO_2 emissions expectations for 2020 in 2011 were 23 percent lower than those made in 2005. Specifically, the EIA's forecasts of US employment, Gross Domestic Product (GDP), oil imports and CO_2 emissions through 2020 and 2030 have been steadily declining since 2005 at markedly different rates, with CO_2 emissions showing the most significant decline. Many have assumed that these reductions are largely the result of the recession, but is this actually the case?

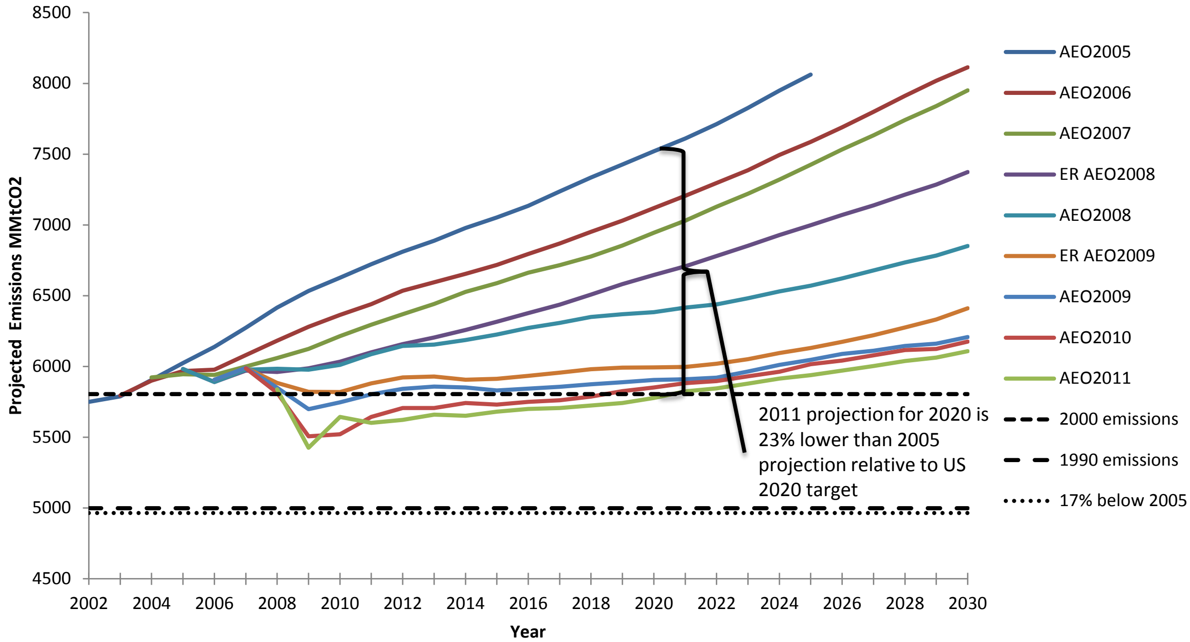
To help explain the primary drivers of the drop in expected GHG emissions projections, CCS conducted a state of the art decomposition analysis of EIA AEO projections to determine the relative contributions of the economy, specific sector-based policy actions and related market forces, and energy prices in the decline of baseline emissions expectations. CCS examined three potential methods for baseline decomposition, including two multivariate statistical approaches as well as the use of index number decomposition. A multivariate regression model chosen was based on best statistical and theoretical fit. External review was conducted by Dr. Hil Huntington of the Stanford Energy Modeling Forum to confirm use of standard statistical approaches and good practices for energy and economic modeling.

The economic downturn, sector based policy actions, prices, and other potential explanations for the decline in GHG emissions in the statistical analysis were selected either because: 1) they were explicitly modeled in AEO reference cases during 2008-2011, 2) are typically included in the energy economics literature (Marquez and Fuinhas, 2011; Marerro, 2010; Ang, 2007; Huntington, 2007; Casler and Rose, 1998), or 3) have been selected by the EIA (2011) as important sources of forecasting error in previous versions of AEOs. The CCS methodology separates the effects of the general economy from policy and prices, as well as the specific impacts of key sector-based policies and price impacts at the subnational and national levels. This regression modeling and policy analysis is further documented in the companion document, *Explaining the Decline in GHG Emissions Forecasts (CCS, 2012 b).*

Figure 1 shows the expectations of the AEO for US CO_2 emissions resulting from energy use between 2002 and 2030, with each line representing a different AEO reference case projection based upon the year the projection was made. In 2011, expectations for 2020 CO_2 emissions were 23 percent below those made just six years earlier, which represents 69 percent of the gap between expected 2020 emissions and the US goal of seventeen percent below 2005 emissions by 2020 (roughly equivalent to 1990 US emissions). In 2012, AEO projected emissions of CO2 dropped further. While surprising to some, considering the lack of comprehensive federal climate and energy action, it is not a surprise to those focused on the development of subnational and national actions within the each economic sector for multiple purposes and not necessarily driven by climate change objectives alone. These actions are drivers for the decoupling of emissions from economic growth and stronger energy security.

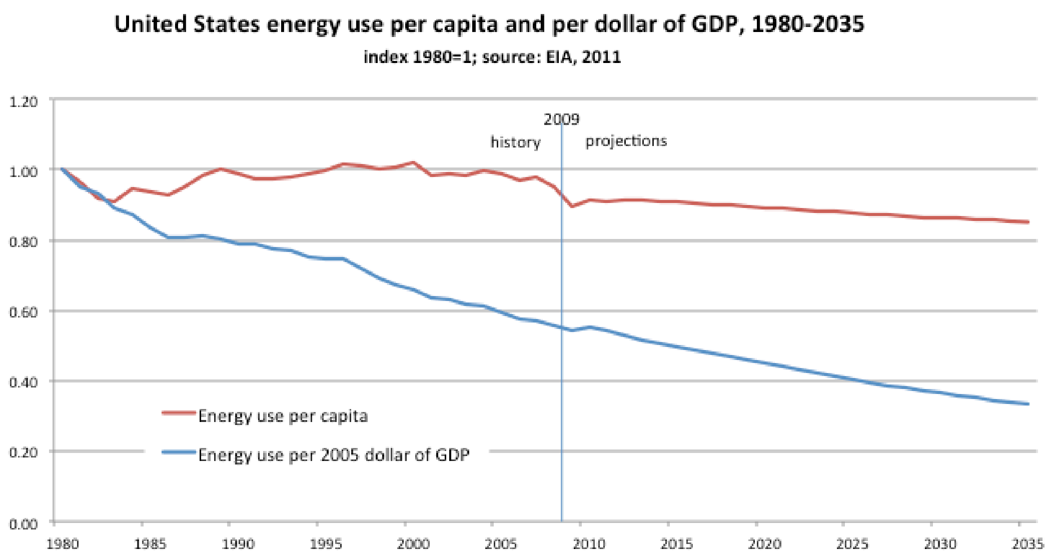
Figure 2 shows the decline in energy and CO_2 intensity from 1980 to 2010 as well as the AEO 2012 forecast through 2035. Note the decoupling between forecasted GDP, energy intensity, and CO_2 intensity in the forecast period that did not occur in the unique period of 2008 and 2009 when the economic downturn was acute, and a set of other major events coincided, including a spike in oil prices, precipitous drops in manufacturing orders and outputs, increased coal prices from health regulations, expanded low cost natural gas supplies, and a broad scale expansion of energy efficiency deployment.

Figure 1: AEO US CO2 Emissions by Projection Year



Source: U.S. EIA Annual Energy Outlook for listed years; ER = early release; MMtCO2e = million metric tons carbon dioxide equivalent; AEO= Annual Energy Outlook, US Energy Information Administration

Figure 2: Decoupling of Energy Intensity and Economic Growth



To determine the effect of the general economy on CO_2 emissions, this study used an autoregressive distribute lag (ADL 1,1) fixed-effects regression model that includes lagged values of GHGs and GDP

(Bentzen and Ensted, 2001). ADL models have a long history in energy and decomposition analysis. The ADL regression model performed well, explaining over 99 percent of the variation in GHG emissions. The model provided estimates of both short-term and long-term relationships between GHGs and GDP and indicates evidence that the short-run effect of the economy (particularly the 2008-2009 years) is much larger than the long-run effect (through 2020 and 2030). The former effect of GDP is larger than the latter because of long-term declines in the energy intensity of the economy, due to policy driven energy efficiency improvements and or structural changes in the economy away from energy intensive sectors. Results show that the recession is associated with a long-term decrease of about 420 MMtCO$_2$e emissions by 2030. This equals 22 percent of the downward shift in 2007 to 2011 emissions forecasts by AEO for 2020, and eighteen percent of the decline in projections to 2030.

The effects of the economy on GHG emissions are consistent with peer-reviewed energy economics literature for the effects of income on energy demand (Mahadevan and Asafu-Adjaye, 2007; Gately and Huntington, 2001). The robustness of these estimates of GDP effects on CO_2 emissions were also confirmed with tests of other regression model specifications and sample time periods, as well as factor decomposition analysis using marginal GHG/GDP intensity factors derived from AEO 2007, 2011 data. Following the estimation of the impacts of lower levels of economic activity on CO_2 emissions, the study used complementary analytical methods to explain other sources of decline in forecasted emissions based on policy, prices, and other factors. Our analysis included reports and analyses from EIA, the US Environmental Protection Agency, other studies, as well as our own supporting analyses using EIA data.

Figure 3 shows the contributions of the various factors to the projected declining emissions over the 2012 to 2030 period for the AEO 2007 and 2011 CO_2 projections.

Figure 3: Contributions to AEO projected emissions reductions

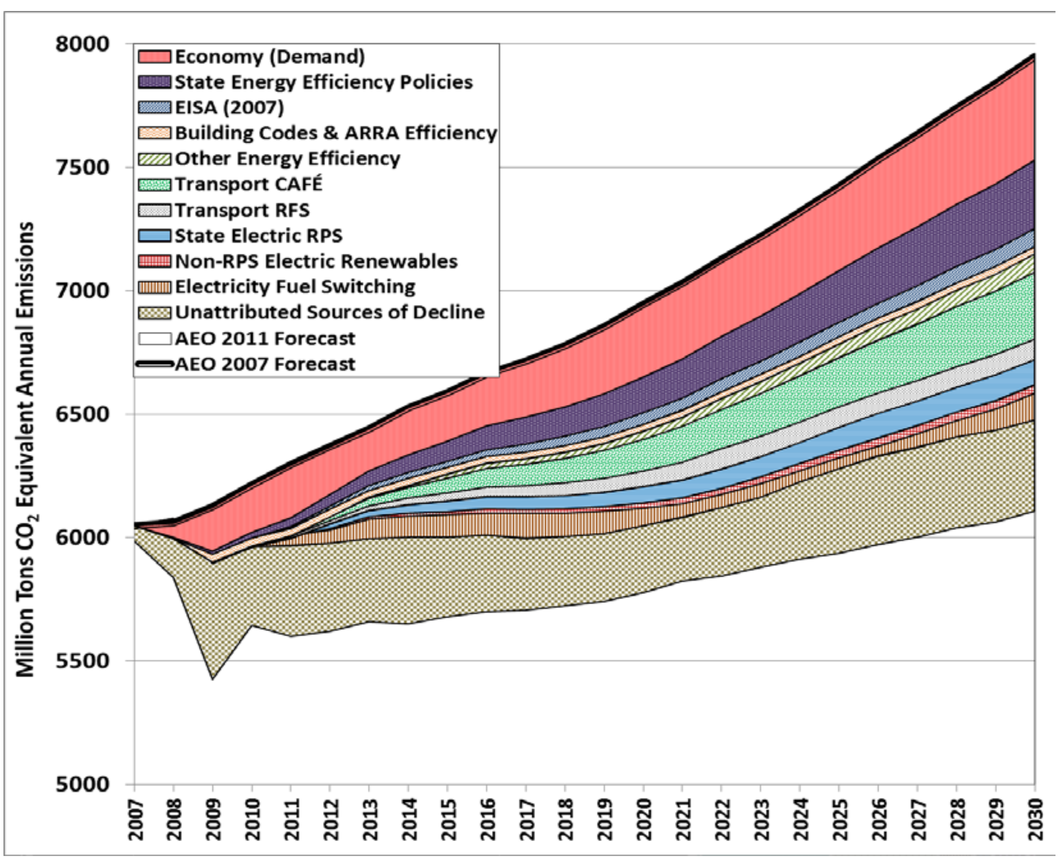


Table 1 shows the percent contribution of the major factors in the decline of expected US emissions for 2020 and 2030.

Table 1: Relative contributions to expected decline in US GHG emissions

Source	2020	2030
Economy (Demand)	22%	18%
Electricity Fuel Switching	6%	6%
State Electricity RPS	6%	5%
Non-RPS Electricity Renewables	2%	2%
Transport RFS	6%	5%
Transport CAFÉ	11%	15%
Building Codes & ARRA Efficiency	2%	2%
EISA	4%	4%
State EEPS	12%	15%
Other Energy Efficiency	3%	4%
Additional Sources of Decline	27%	26%

***** Abbreviations: RPS = Renewable Portfolio Standards, ARRA = American Recovery and

Reinvestment Act, EISA = Energy Independence and Security Act (of 2007), CAFE = Corporate Average Fuel Economy

The effects of major federal and state policy actions that occurred between 2008 and 2011 were also analyzed. To reduce the risk of double counting emissions, for each of the sources of declining GHGs forecasts not related to the economy that we analyzed, we modeled the effects of those factors taking into account the lower future economic activity and GDP growth that underlies later AEO forecasts.

Declines in forecast emissions are also due to differing assumptions between the two versions of the AEO with regard to market factors; especially the trends toward lower natural gas prices and higher coal prices. Fuel switching between coal and gas in the electricity sector explains approximately six percent of the decline in the 2030 emissions forecast. Increased renewable electricity generation from market-driven actions, as well as state renewable portfolio standards contribute an additional seven percent to the 2030 decline.

Additional sources of decline are estimated at about 26 percent of the total decline in 2030. This category includes a set of policy actions, such as health regulations, that go beyond changes in GDP and the other sources of change quantified directly in the analysis. This category also includes higher oil prices, which were shown to be important in the transportation sector, but not in the economy-wide effects shown in the analysis. The additional sources of decline demonstrate that the analysis is not overly deterministic in that it does not force attribution of the entire decline in GHGs emissions between forecasts to specific sources, and also verifies that emissions declines have not been double-counted in the analyses.

This analysis demonstrates that while lower economic growth forecasts played a significant role in the projections, more significant were the implementation of major sector-based policies, such as renewable fuel and CAFE standards, that have reduced fossil fuel consumption in the transport sector, as well state actions that have favored lower emitting heat and power generation technologies, more energy efficient equipment, as well as the recent increasing shift towards natural gas for electricity.

It is important to note the sector-based policies that have shifted emissions baselines downward were typically designed to achieve other important objectives as well, such as reducing fossil fuel imports, energy savings and diversification, resource conservation, system improvements, and economic stimulus. Their measureable past success in creating “win-wins” sheds important light on the potential for new policy actions going forward. For instance, energy efficiency improvements from market forces and policy actions in the buildings and industrial sectors together account for an additional 25 percent of the difference between forecasts by 2030, with over half of that total attributed to state actions.

Finding 2: New Actions Achieve Economic, Energy, and Environmental Benefits

In addition to the baseline decomposition results provided above, the policy analysis sought to identify a set of sector-based policies capable of achieving simultaneous net positive improvements for economic, energy and environmental security going forward. Twenty key actions were derived from a much longer list of specific policy actions recommended in a sample of 20 state climate action plans. These were screened and augmented by additional national economic and energy security considerations, in order to provide a final set of actions that were each net positive for economic, energy and climate security.

The set of 20 major polices that became the focus of this phase of the analysis comprise the majority of the national emissions reduction potential of several hundred sector-specific actions included and evaluated in state climate plans (typically state plans include up to 50 or more recommended actions). The actions in this sample do not fully address emissions reduction needs and opportunities from oil and gas production (such as methane release) or industrial process emissions. Both of these source categories have expanded recently and are the subject of new focus and action. Notwithstanding these two source areas, the set of 20 actions identified for future implementation represent the most critical opportunity and need in each sector through the 2020 period (the typical mid-term goal specified in state climate action plans, as well as the typical national goal index year).

The 20 policies were each designed with detailed, customized policy specifications (timing, level of effort, coverage of parties, etc.) and implementation instruments (financial incentives, agreements, codes and standards, etc.) derived from stakeholder recommendations and expert assistance to reach and be evaluated against three goals: 1) national economic security as measured by employment and GDP; 2) national energy security as measured by oil imports and indicators of fuel diversity, grid stability, energy intensity and energy system cost; and 3) national environmental benefits as measured by GHG emissions. Modeling included review and testing of multiple variations of policy designs and policy-combination scenarios in an effort to maximize the simultaneous net positive achievement of all three goals at the national level.

The level and kind of government program action was also critical to this optimization process, including assignment of local, state and federal program mechanisms and the use of existing or new authority to meet efficiency needs, stakeholder acceptance, and feasibility. The end results included a portfolio of policy actions that cover all economic sectors, a combination of national and subnational programs, a full range of implementation instruments, and both public and private investment driven outlays.

The analysis showed that these actions in aggregate offered sizable macroeconomic, energy security, and environmental benefits. In addition, the analysis showed that it is possible to identify a comprehensive set of actions in each sector that individually attain net positive results for economic, energy and environmental security through proper selection, design and implementation. The analysis was not able to fully capture interactive effects of policy actions at the macroeconomic level at this stage. Additional integrative analysis would likely demonstrate macroeconomic feasibility for a broader and more aggressive set of actions. As a result, these findings represent a lower bound to level of effort possible through actions that meet macroeconomic performance constraints.

The analysis shows that the 20 selected measures, when applied to all 50 states, achieve the three primary goals and could provide the benefits summarized below and in Figures 4 thru 7. Results for individual measures are available in Annexes 1-3 to this report.

a. Increase US employment by 1.24 million net new full-time jobs by 2020;
b. Grow GDP by $88 billion in 2020 and cumulatively by $1.11 trillion (in net present value) between now and 2030;
c. Provide a net societal savings of over $1.44 trillion between now and 2030;
d. Reduce US oil imports by 135 million barrels in 2020 and cumulatively by over 5billion barrels between now and 2030;
e. Increase US fuel diversity, reduce summer peak demand for electricity, generate direct societal cost savings and reduce US energy intensity (energy use per unit GDP);
f. Reduce GHG emissions by about 466 million metric tons of CO_2 equivalent in 2020, and cumulatively by about 13.5 billion metric tons of CO_2 equivalent between now and 2030.

Figure 4 shows the direct investment flow requirements and employment benefits of the policies by economic sector. Also shown is the direct investment cost per full time job (by employee-year) created between now and 2030. Investment in integrated economic, energy, environmental security investments creates jobs at favorable investment rates. The aggregate investment in all sectors would create jobs at the rate of about $24,000 each with the residential, commercial and industrial (RCI) sector policies being most cost-effective, followed by agriculture, forestry and waste (AFW) sector policies. The transport and land-use (TLU) policies are more expensive due to infrastructure costs required by some of the measures, and electricity and heat supply are higher than the average because of the high capital investments required by the renewable energy (biomass, geothermal, hydropower, solar and wind) power plants.

Figure 5 shows return on direct investment in terms of energy savings achieved by the 20 measures. Figure 6 shows the six energy security metrics used in the analysis. Figure 7 shows improvements in primary energy supply diversity across the economy from the 20 new measures. Figure 8 shows reductions in peak electricity demand driven by each of the 20 new measures from the study. Figure 9 shows aggregate sector level emissions reductions from the 20 measures; individual policy option results are provided in Annex 1 of the paper. Figure 10 shows the impact of the 20 new measures on attainment of national GHG goals by 2020.

Note, as indicated earlier, that the 20 measures do not fully include actions to reduce emissions associated with: 1) Industrial non-energy, which includes cement manufacturing and other industrial processes that release CO2, methane and other industrial gases that are GHG pollutants, and 2) Fossil fuel production, which includes coal mine methane emissions and emissions from oil and natural gas production, processing, transport, storage and distribution. These measures will be addressed in the next phase of this work.

Figure 4: Return on Investment for Job Creation

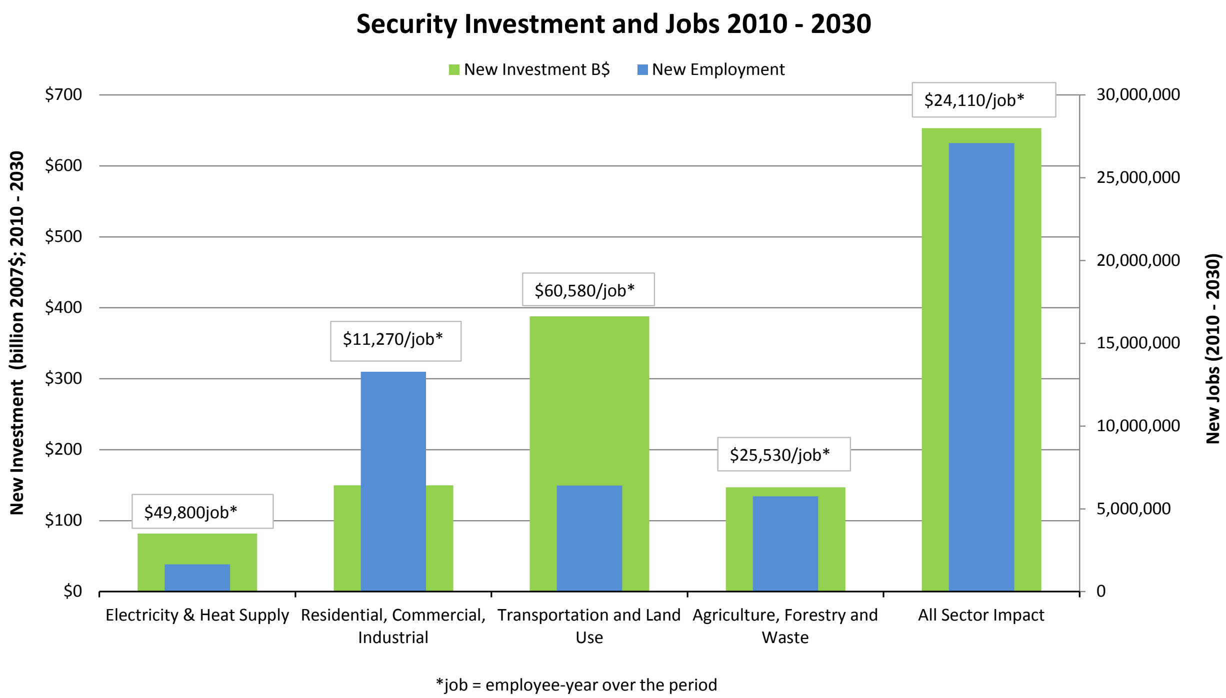


Figure 5: Return on Investment for Energy Savings

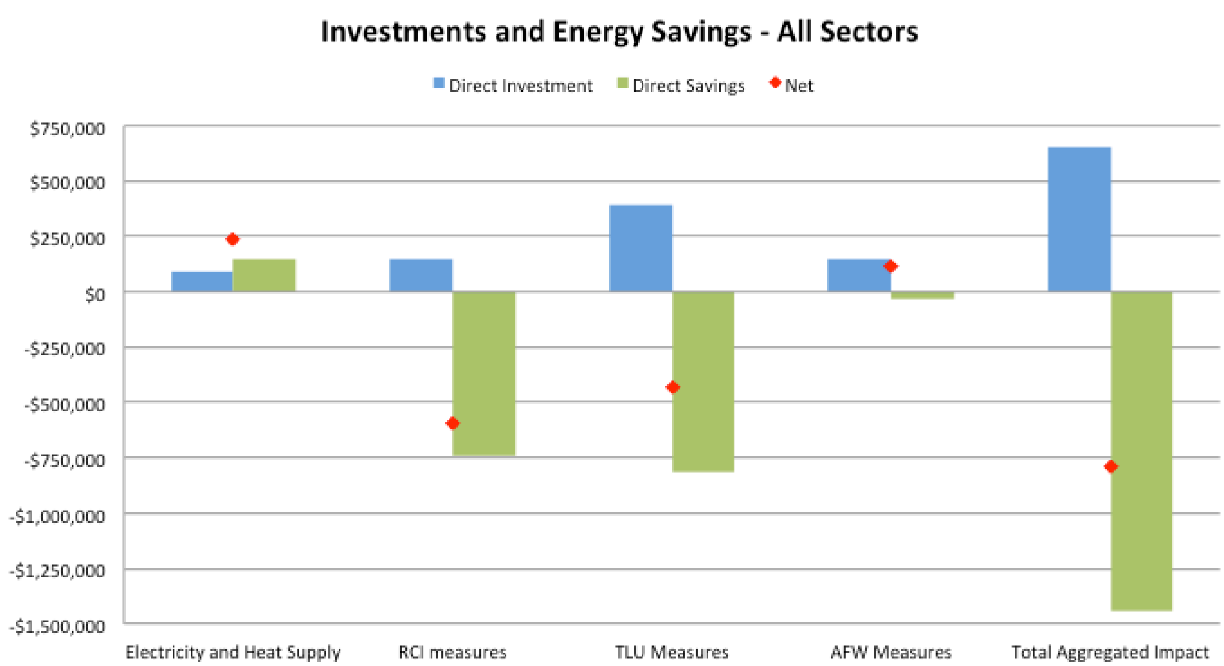


Figure 6: Energy Security Gains

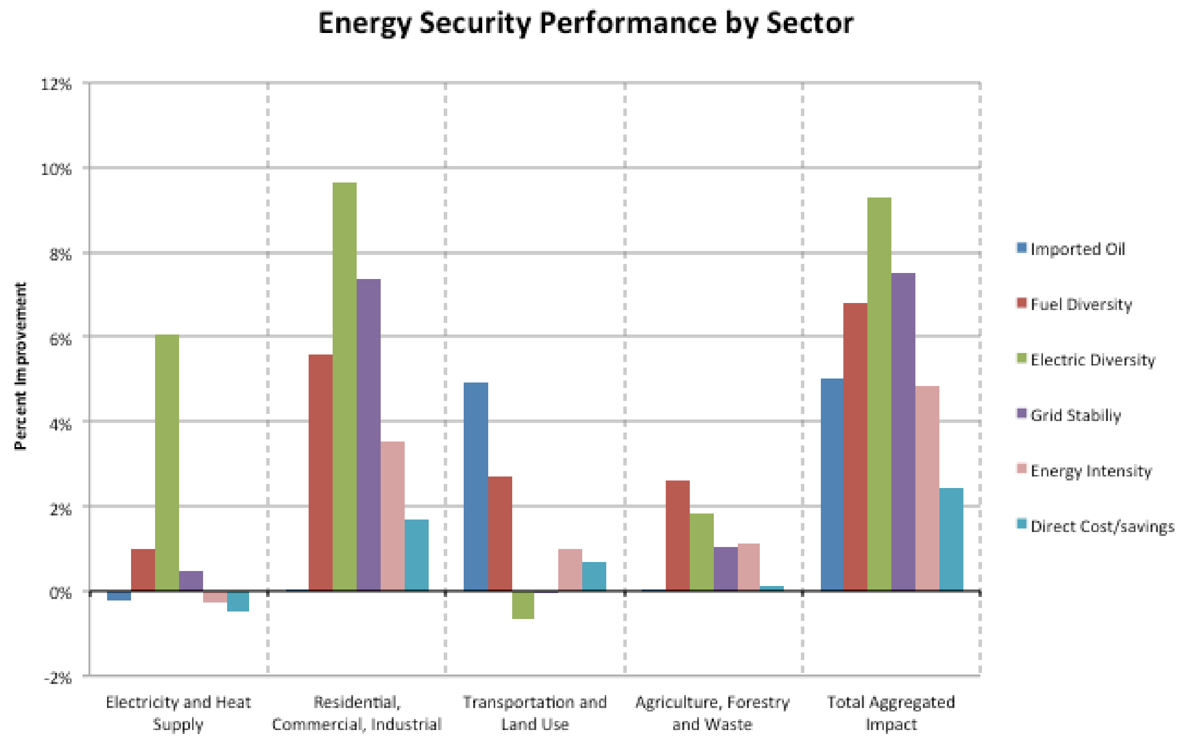


Figure 7: Impacts of New Measures on Energy Supply Diversity

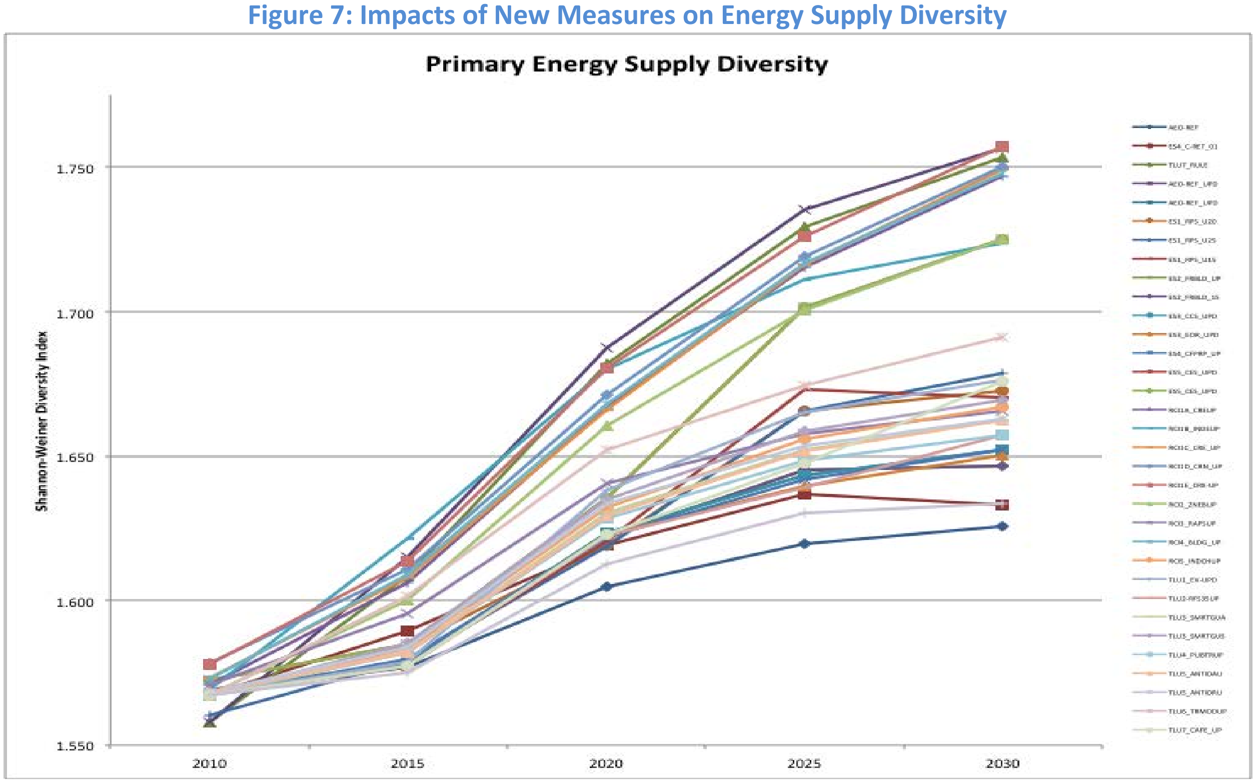


Figure 8: Impacts of New Measures on Electricity Peak Demand

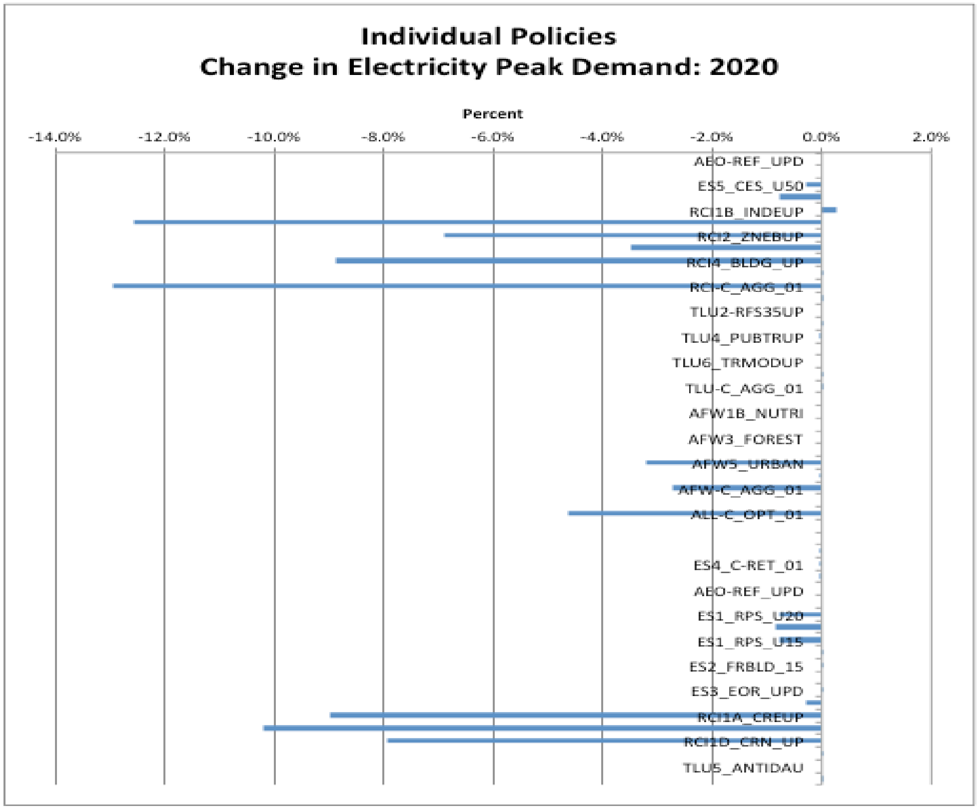


Figure 9: GHG Impacts

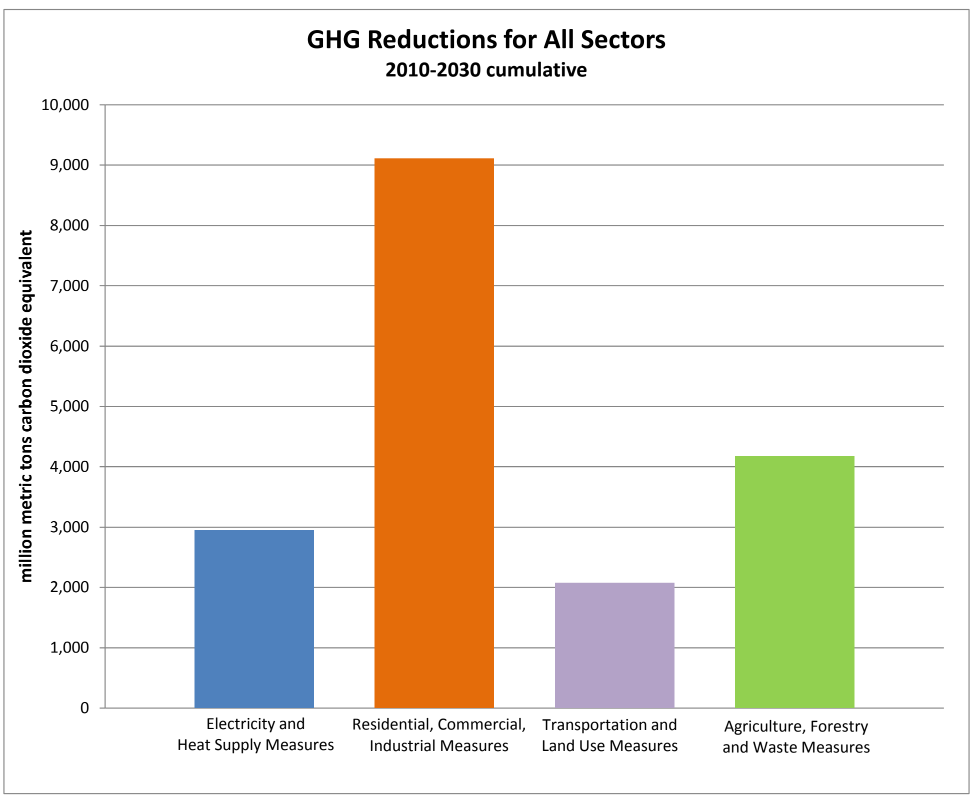
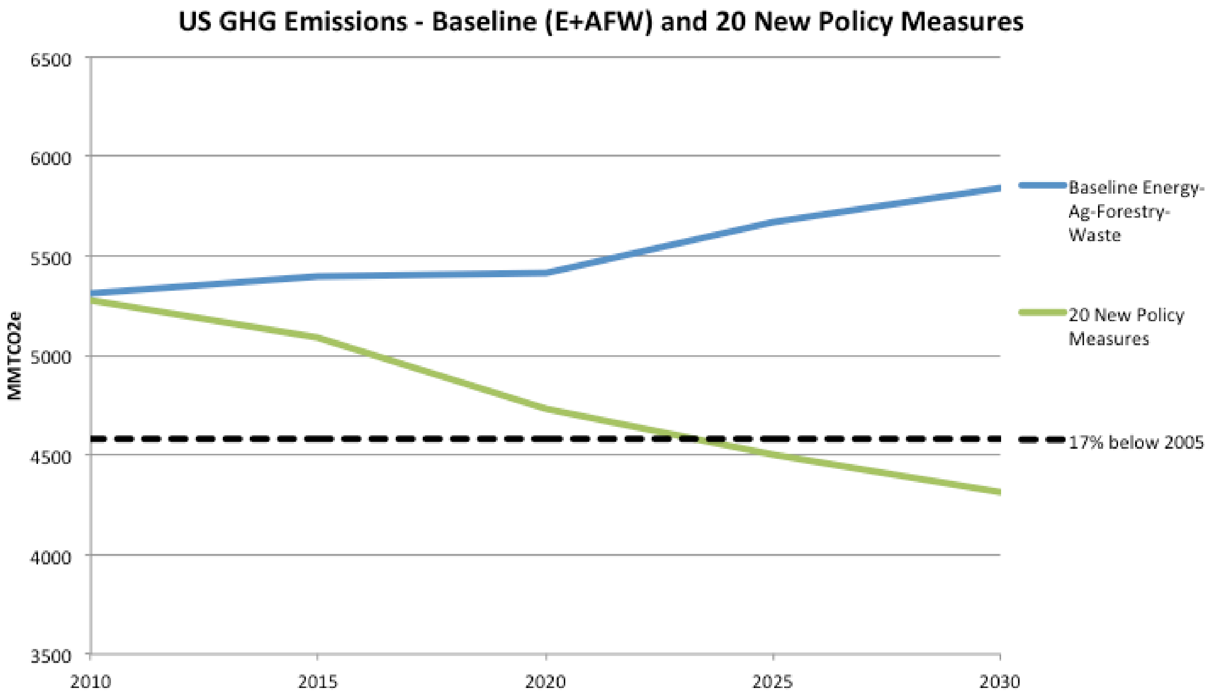


Figure 10: Impacts of New Measures on National GHG Goals



Finding 3: Targeted Actions and Instruments Drive Investment

Sector-based programs that advance multi-objective technologies and practices offer significant potential for the US to achieve greater economic stability, energy security and environmental benefits. To capture that potential, the US will need new financing models and better use of existing mechanisms that coalesce targeted public sector actions, willing investors, ample capital and a wide range of financing mechanisms and tools. The Security and Investment Project analysis focuses on determination of investment outlays needed for policy implementation, as well as specific outcomes of investment and optimal mechanisms and policies to support investment.

The US has a large population of potential investors who control an enormous pool of capital, yet the mobilization of these funds to meet public policy objectives often requires targeted public sector commitments tailored to the sector and action involved. The most significant members of this investor class are energy consumers and customers. In addition to paying for energy resources and technologies, they bear the ultimate financial risk involved in long-term development of energy supplies and infrastructure. Other significant capital communities range from investors seeking long-term, low-risk gains (pension funds) to those seeking higher risks and higher returns (equity funds and venture capitalists).

Significant barriers exist to the flow of funds from private sources to public goals, such as security. For instance, it is often the case that the people who bear the costs of a public policy or policy goal are not the same people who reap the benefits. As a result, there is no perceived economic benefit to those carrying the burden, so, absent government regulatory or financial intervention, the desired policy is not implemented (the phenomena of “split incentives”). Targeted public policy actions can be used, potentially, as a tool to overcome market barriers and imperfections and enable private investment flow in several ways. Some of the most prevalent of these are listed here:

- *Codes and Standards:* Regulations ranging from building standards to pollution control have historically driven investments by energy consumers and providers. Regulations can be prescriptive (requiring a specific action) or performance based (setting a standard and allowing the energy consumer or producer flexibility in how to meet it). Designed properly, they can increase the reliability of demand, reduce cost barriers, and or open the door to investments that require greater certainty, flexibility, or cost control.
- *Funding and Financial Mechanisms:* Government grants, loans, loan guarantees and special funds all are used to promote energy-related investments. An example is the public benefits funds typically created by levying a small fee or surcharge on customers’ electric rates. The funds are used by several states to finance energy efficiency, renewable energy and weatherization programs. Government subsidies to stir investment come in many forms, ranging from tax benefits and government cost sharing to tax-supported research and development. Subsidies can promote significant growth in a given industry or technology and encourage investments across a wide range of return and risk profiles. These pools of funds can provide anchor commitments that reduce private investment needs and enable matching flows from private sources, and they can enable longer-term commercialization pathways.
- *Price Mechanisms, including Carbon Taxes, Emissions Trading and other means:* For price-responsive GHG actions, emissions taxes or equivalent instruments stimulate decision-makers to undertake investment in mitigation to avoid paying the taxes and create revenue pools for reinvestment. Trading, for instance, sets a cap on emissions and allows polluters to buy and sell the rights to emit GHGs. For certain actions, those with high marginal mitigation costs can buy permits to reduce their costs, and those with low marginal costs will sell permits to make a

profit (they must also mitigate to back up each permit sold). The exchanges can shift the mitigation to the lowest-cost entities for certain actions for actions that are price responsive (due to market barriers such as split incentives, some actions are relatively insensitive to price signals). Government revenues collected from pollution taxes and the auction-based emission trading systems can be used to support various energy efficiency and clean energy programs.

- *Voluntary and Negotiated Agreements, Disclosure Mechanisms, Information and Education:* Like other mechanisms, these tools can be structured to reduce risk and uncertainly for demand or costs, bridge critical information gaps, or address other key investment criteria. They often are tailored to maximize flexibility and performance in lieu of, or as a part of regulatory approaches. As a result, they can increase investor certainty.
- *Pooled Market-Rate Capital Programs:* These include energy finance authorities or energy banks that help lower the cost of capital needed for capital-intensive investments. The aggregate size of markets impacts investment decisions with high transaction costs. By aggregating pools the relative impact of fixed transaction costs is reduced. Coordination by multiple jurisdictions to combine program demand can act in this fashion by consolidating markets. Cooperative multi jurisdictions are important tools to stimulating private investments in this manner.
- *Government Procurement:* Purchasing commitments by government can provide a large and sustained enough market for a product to spur private capital investment in plant and equipment that can lead to cost reductions and future market growth.

The objectives of public policies designed to leverage capital investment also can be diverse. For example, government incentives may be designed to produce jobs or tax receipts whose value exceeds the government's investment; to speed the development or market penetration of an energy resource or technology deemed to be in the national interest or that enhance our energy security; to help emerging technologies survive the "valley of death" that stands in the way of commercial competitiveness; to help clean energy technologies approach price parity with older, more polluting technologies by subsidizing some part of their cost; or by encouraging sufficient consumer interest, perhaps motivated by a call to "energy patriotism," to help a new technology achieve economies of manufacturing scale.

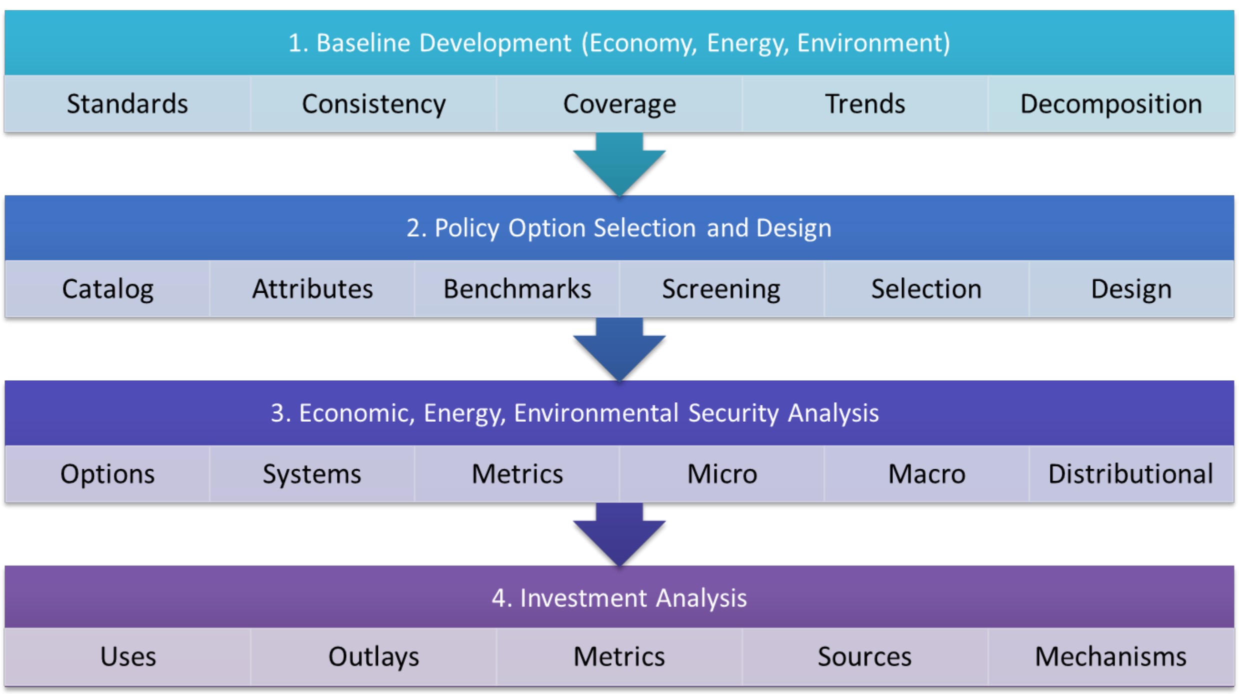
Study Methods

Full Spectrum Policy Design and Analysis

The *Security and Investment Project* analysis was possible due to the development of the Integrated Security Metrics (ISM) system derived from years of field application by CCS in the stakeholder and expert environment for comprehensive, multi objective decision-making. CCS previously used or developed widely-used and peer-reviewed models and modeling approaches that are linked in a comprehensive system to assess the environmental benefits, energy demand, costs or cost savings, fuel prices and macroeconomic impacts of proposed technologies and practices. The ISM system expands the analysis to include additional measures of energy security and of direct investment and financing, and to capture national energy system dynamics. The ISM system assembles all the tools and methods needed to generate security, economic, environmental and investment indicators into a single integrated framework.

CCS ISM modeling is part of a larger process that incorporates CCS facilitated stakeholder and policy maker deliberations into policy planning and analysis decisions. The policy development and evaluation process is shown schematically in Figure 11.

Figure 11: CCS ISM Policy Development Process



The CCS ISM system enables policy makers to identify, design and evaluate integrated measures that maximize economic, security and environmental benefits across all energy and economic sectors and using all policy instruments. In addition, the system provides policy makers with critical system cost and investment requirement information, allowing early consideration of financing measure implementation. These tools integrate the priorities of economic growth, energy security and environmental benefits into a single policy development process and analytical framework that addresses investment needs.

The ISM is broad and comprehensive in nature, combining the strengths of the MARKAL/TIMES least-cost energy system modeling platform, with detailed assessment of the Agriculture, Forestry, and Waste Management sectors and specific design and analysis of Heat and Power, and Residential, Commercial and Industrial and Transportation Sectors. Linkage with the econometrics is embodied in a reduced form Macroeconomic Screening Tool (CCS, 2012 a) based on the REMI PI+ Macroeconomic Model. Table 2 provides a brief listing of the key ISM components.

Table 2: ISM Components

Function	Module
Baseline analysis	Energy Sectors: AEO/NEMS (US DOE/EIA); Non-Energy Sectors: CCS modified EPA national inventory for agriculture, forestry, waste management, fossil fuel industries, and industrial process emissions; CCS forecast for each non-energy sector
Baseline decomposition analysis	CCS Baseline Regression Tool
Microeconomic and direct energy, resource and environmental impacts	Energy Sectors: MARKAL; Energy Sector CCS expert spreadsheet analysis for specific policy options; Non-Energy Sectors CCS expert spreadsheet analysis for agriculture, forestry, and waste management measures
National Energy security and systems impacts	MARKAL
Investment needs	MARKAL, CCS Macroeconomic Screening Tool, and REMI
Investment options	CCS Macroeconomic Screening Tool and REMI, CCS financing expertise
Macroeconomic screening and policy option design	CCS Macroeconomic Screening Tool, CCS sector based expertise
Macroeconomic impacts	REMI
Sectoral and small business distributional impacts	REMI, CCS small business tool
Personal Income Distribution	REMI; Multi-Sector Income Distribution Matrix
Multi-attribute screening	CCS Policy Options Matrix and benchmarking
Health module (air, water quality)	MARKAL

Modeling Steps

Out of its sample of 20 state climate action plans, CCS identified top measures in each sector with the greatest emissions reduction impact and highest economic and energy security potential. These policy measures were coupled with additional national measures to meet these criteria (see Appendix A) and input to the US MARKAL/TIMES model where they were assessed individually and in integrated clusters to identify their security, investment, and environmental benefits. Some sector-based policies from the sample pool were dropped at the national level because of poor performance against the three primary screening metrics, and a few were merged to improve their overall performance.

Specifically, measures such as a government policy to build fifteen GW of new nuclear power plants by 2030, incentives for converting existing coal power plants to natural gas combined cycle power plants, and a Clean Energy Standard of 60 percent by 2030, were dropped because they either reduced job growth, energy system diversity, or had negative or little impact on GDP growth. Other measures, such as integrated waste reduction, recycling and landfill gas utilization were combined into an integrated measure.

The analysis was performed using a combination of sector and options specific analysis and a full-sector US National MARKAL model (see below). It includes estimates of the expenditures necessary to implement the policies and bring the needed technologies to market, and the returns from investment in terms of expanded economic, energy and environmental security in the US. This information then served as the basis for our examination of policy and market financing needs and opportunities.

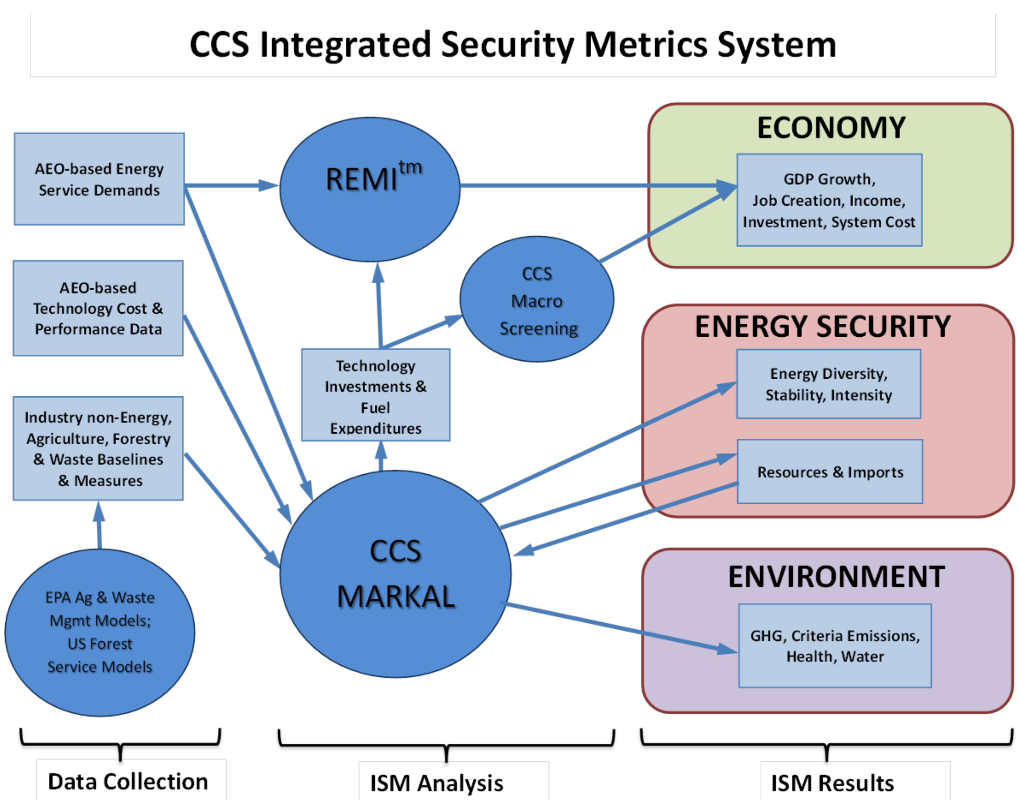
To analyze the microeconomic effects of each sector-based policy action, the MARKAL model evaluated all cost requirements and impacts, including new expenditures for plants, equipment, operations, maintenance, financing, etc., imposed by the policy. It then reduced these costs by any savings in fuel, labor, maintenance, and offsetting investments. This analysis provides net direct societal cost, which is important to policy makers who must judge the overall societal benefits of a proposed policy.

Investment flows and outlays were identified as needed to implement the policies. Estimates of these investment flows provide valuable information for policy makers seeking less intrusive means of leveraging public and private sector resources toward the effective implementation of a desired policy. The ties between investments and policy actions are described in more detail elsewhere in this paper.

A Macroeconomic Screening Tool, which is derived from full REMI macroeconomic studies for four US state climate action plans (see below), was used to estimate the macroeconomic impacts, particularly on employment and GDP, as an aide to policy selection and design.

The results of the analysis of the energy system response were then fed to the Macroeconomic Screening Tool to get the preliminary assessment on the jobs and GDP impact of each policy. [A full assessment of the macroeconomic impact of the nineteen measures is planned using the REMI PI+ model.] A snapshot of the framework is shown in Figure 12.

Figure 12: Comprehensive ISM Analytical Framework



The CCS ISM system also offers significant flexibility for the investigation of scenarios. For energy-related options, the system is built upon a least-cost platform, but it can also solve for environmental, security or alternative economic parameters. As examples, policy makers can test a series of GHG reduction targets, or establish limits on oil imports, or set a minimum reduction in grid summer peak demand, or a target a specific level of new investment, and the system will find the least cost set of policies, technologies and measures that satisfy these constraints. This comprehensive multi-objective capability gives policy makers dramatically enhanced opportunities to understand and fine-tune complex interactive policy scenarios.

Energy Sectors

Energy sectors were analyzed with the MARKAL Energy System Model, coupled with customized policy specifications and assumptions derived from the sample pool of policy actions. The main analytical engine in the ISM system is a full-sector US national MARKAL model (IRG, 2006). MARKAL/TIMES is an energy systems modeling platform that is a widely used and proven analytic framework for assessing a wide range of energy, economic and environmental planning and policy issues. The MARKAL/TIMES framework is developed, maintained and continually improved under the auspice of the International Energy Agency - Energy Technology Systems Analysis Programme (ETSAP, 2012). The US National MARKAL model used by CCS:

- Encompasses the entire US energy system from resource extraction through to end-use demands (thus “well-to-wheels”), as represented by a Reference Energy System network
- Employs least-cost optimization
- Identifies the most cost-effective pattern of resource use and technology deployment over time
- Provides a framework for the evaluation of mid-to-long-term policies and programs that can impact the evolution of an energy system
- Quantifies the costs and technology choices that result from adoption of the policies and programs

The starting point US National MARKAL model utilizes US DOE technology cost and performance data and assumptions as provided by the AEO2011 for national policy analysis. The CCS emission baselines also utilize AEO2011 projections, but the AEO and the starting point MARKAL model are limited to CO_2 emissions and system costs associated with energy use only. For a complete assessment of GHG emissions, non-energy use CO_2 emissions and non-CO_2 GHG emissions (methane, nitrous oxide, etc.) were added to the MARKAL model. Emissions sources and sinks in the agriculture, forestry and much of the waste sector are also not included in the AEO and the National MARKAL model. CCS resolved these limitations by incorporating the baseline emissions, policy analysis results and costs from these additional sectors and sources into the starting point US National MARKAL model to create an integrated MARKAL-CCS model, as discussed in the next section.

The results handling aspects MARKAL-CCS were enhanced to provide multiple Energy Security metrics. These include changes in the demand for imported oil, total fuel mix diversity, electric generation fuel mix diversity, electric grid stability as measured by changes in summer peak demand, and overall national energy intensity per unit of GDP.

Two important sources of emissions were not included in baseline or the analysis of potential mitigation options. They include: 1) upstream emissions from oil and gas extraction and production, such as methane release from wells, and 2) some industrial process emissions. Both are key areas of emission growth and the application of technology and best practices for additional study.

Non-Energy Sectors

Non-energy sectors were analyzed with customized spreadsheets and models using specifications and assumptions derived from the sample pool of policy actions. Historic inventory data (1990-2009) were taken from EPA's National GHG Inventory Report (EPA, 2011). Forecasts for each non-energy sector (Industrial Processes, Agriculture, Forestry, & Waste Management) were built from a combination of forecasted activity (e.g., US Department of Agriculture livestock operations) and historic trends (e.g., land use change from the USDA Natural Resource Inventory; landfill gas collection trends, US Bureau of Economic Analysis forecasts of personal consumption growth).

Non-energy sector measures selected for analysis under this project were a subset of those commonly selected within US state planning processes that tend to achieve positive micro- and macro-economic impacts, as well as energy and/or GHG reduction benefits. The following measures were addressed:

- Crop Production Practices: Soil Carbon Management
- Crop Production Practices: Nutrient Management
- Livestock Manure – Anaerobic Digestion & Methane Utilization (Dairy Sector)
- Forest Retention
- Reforestation/Afforestation
- Urban Forestry
- Municipal Solid Waste (MSW) Source Reduction
- Enhanced MSW Recycling
- MSW Landfill Gas Management

Note that although these measures are directed at sources considered to be in the "non-energy sector," there are energy impacts associated with most of the measures. These include fuel and electricity savings for crop production practices, urban forestry (shading and wind protection of buildings), and MSW source reduction and recycling. Other energy impacts include renewable energy generation from methane utilization (livestock and landfill gas) and increased biomass utilization under the forestry options. Full energy and non-energy related GHG reductions were captured in the analysis of each measure (e.g., energy use reductions, renewable energy generation, terrestrial carbon enhancements, and reduced methane and nitrous oxide emissions).

Macroeconomic Analysis

While the MARKAL-CCS model is capable of generating technology and policy-specific costs and savings for each measure, macroeconomic impacts, beyond the response of energy service demands to changes in energy price, are not available through this platform. To provide the critical GDP and employment results CCS has developed a Macroeconomic Screening Tool, which is derived from full REMI macroeconomic studies for four US state climate action plans (see, e.g., Rose et al., 2011; Rose and Wei, 2012). This tool provides fast and inexpensive predictions of impacts on employment and GDP as an aide to policy selection and design. It is described in greater detail in the *Macroeconomic Screening Tool* document (CCS, 2012 a). The tool covers energy and non-energy sectors.

The screening tool provides reliable guidance on the direction and relative magnitude of changes in employment and GDP, but it is only a placeholder for a full REMI macroeconomic impact analysis, which provides not only more accurate but much more detailed results. The CCS ISM links the MARKAL-CSS outputs to the reduced form economic platform, providing a comprehensive set of analyses through a single integrated system.

The CCS Macroeconomic Screening Tool is based on reduced form multivariate statistical models that examine the relationship between the macroeconomic impacts (GDP and employment) of the GHG mitigation options yielded by the REMI analyses and various microeconomic costs, structural linkages and other characteristics of these options. The two main explanatory variables in the regression models are the direct net cost and the investment requirements of the mitigation options. The models also include eight binary variables to help explain the option-specific characteristics, such as sectors, capital investment on construction vs. equipment, government subsidy, etc.

The models yield robust summary measures, as indicated by the multiple correlation coefficient (R-squared) values. The regression model for the GDP impacts has an R-squared of 0.71, while the model for the employment impacts has an R-squared of 0.82. These indicate that the models explain about 71 percent and 82 percent of the variance in the GDP and employment impacts across our pooled sample, respectively. The models also indicate that explanatory variables such as direct net costs and investment requirements have significant impacts on the overall GDP and employment impacts of the mitigation option.

This macroeconomic screening tool does not include analysis of the interactive and aggregate effects of individual policy actions at this stage. Interactive analysis would likely identify stronger aggregate economic benefits for actions that cross sectors. For instance, by combining energy savings and cost reductions for energy efficiency measures with positive cost options for renewable energy, the level of aggressiveness of both actions could be increased without reducing overall macroeconomic benefit. As a result, the findings of this analysis should not be taken as an upper limit to actions with positive net macroeconomic benefit, and instead should be viewed as a lower limit at this time. This is an important area for future study.

Conclusions

U.S GHG emission projections for 2020 and 2030 have fallen significantly in the past decade and the expected declines in emissions are only partially driven by economic recession. The majority of downward baseline shifts over this time frame are driven by specific sector based policy actions at the subnational and national levels that were implemented to achieve multiple goals, including economic, energy, health, and environmental improvement.

While revised economic expectations played a significant role in projected declines of future US CO_2 emissions, more significant were policy and market driven trends of energy use away from coal and toward natural gas for new electricity generators, recent CAFE regulations and other transportation improvements, and the array of state and federal actions that favor low emitting, sustainable energy supplies and efficiency measures in the energy, transportation, waste, and resource sectors.

State of the art baseline decomposition analysis of EIA emissions also demonstrates the importance of subnational actions within economic sectors toward the achievement of emissions reduction goals and national energy security, as several of key actions implement, at least partially, at the state and local level, or were originated at these levels prior to becoming national law or policy. Indeed, our regression analysis indicates that policies under state and local control are responsible for a significant portion of the decline in projected CO_2 emissions since 2007, and will be a significant factor in baseline emissions reductions and energy security improvements in the years ahead. They also serve as a platform for important new actions that tie economic, energy, and environmental security together in comprehensive fashion.

The combination of appropriate subnational and national action enables the achievement of national economic and energy security by expanding the range of low cost, high value options available, and the capacity for new levels of innovation and flexibility that will be needed to meet a combination of future goals at the same time. Not surprisingly, most of the national baseline policies identified in this study originated at the subnational level, and their continued evolution is critical to national attainment of economic, energy, and environmental security goals. Roughly two thirds of the nineteen sector based measures identified in this study involve primary or shared jurisdiction by states and localities with federal programs.

Analysis of nineteen new sector based actions indicate that the changes within sectors needed to reach national GHG goals by 2020 and simultaneously advance economic and energy security are not large in comparison to the total size of US economic and energy systems. However, the gaps and implementation barriers are significant and require a dedicated effort. If successful, as similar actions have ben in the past, they enable and accelerate significant new market and policy developments in sectors that will be important in future decades. And, they provide a comprehensive framework for sustainable economy, energy, and climate change mitigation actions that can be used in a flexible manner to support a variety of leadership needs. For instance, national policy makers may be most interested in energy security dimensions of action, while local, and state policy makers may be more interested in sustainable economic development. This framework accommodates both.

The findings of this study are consistent with many other economic and energy impact studies that find that properly selected and designed policies can generate net positive effects on the economy, energy security and sustainability, and pollution reduction. For instance, CCS has conducted a series of analyses of state level climate action plans using the REMI Policy Insight+ model that illustrate positive results for the majority of options in plans. Other studies document the growth of an emerging clean economy and clean energy market place at the global scale that is among the fastest growing market segments worldwide. Indeed, before the global recession many US states and other nations were enacting policies that reduced emissions concurrent with economic growth, and later as means to achieve economic stimulus during the recession. In addition, decoupling strategies are now becoming more common as a goal of national and subnational policy. For instance, under its most recent Five Year Economic Plan, China's national government has assigned dual goals for each of its provinces for economic growth and emissions reduction in an effort to foster both. Development banks are pursuing decoupling strategies to accelerate sustainable economic and energy development.

Finally, the US has a large population of investors who control an enormous pool of capital that could be used to implement many of the nineteen proposed policy measures in this study. However, numerous barriers exist to the use of private investment for these measures and will require collaborative responses that are tailor made to the policy and investment linkages for each measure, sector, and region. Cohesive leadership at all levels of government in all regions is critical to this success.

Appendix A: Summary of 20 Sector Based Policy Actions

The table below identifies the final set of 20 measures analyzed by sector.

Table 3: 20 Sector Based Measures

Sector	Policy	Policy Description
Electricity and Heat Supply	EHS-1	National Clean Electricity Standard
	EHS-2	Incentives for Combined Heat and Power
Residential, Commercial and Industrial	RCI-1	Industrial Process Efficiency and DSM Measures
	RCI-2	DSM Programs for COM & RES Electricity & Natural gas Use
	RCI-3	Zero Net Energy Buildings
	RCI-4	Appliance Standards
	RCI-5	Advanced Building Codes - Commercial & Residential
Transportation and land Use	TLU-1	Rebates for PHEVs and EVs
	TLU-2	National Renewable Fuel Standard - Post 2022
	TLU-3	Smart Growth - Land Use - Strong
	TLU-4	Public Transit
	TLU-5	Anti-Idling Technologies and Practices - Rapid response
	TLU-6	Mode Shift from Truck to Rail
	TLU-7	National CAFE Standard - Post 2025 targets
Agriculture, Forestry, and Waste	AFW-1	Crop Production & Nutrient Management Practices
	AFW-2	Agricultural Livestock Manure Management Practices
	AFW-3	Forest Retention Practices
	AFW-4	Reforestation Management Practices
	AFW-5	Urban Forest Management Practices
	AFW-6	Integrated Waste Reduction, Recycling and LGF Utilization

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Annex 1: Individual Policy Results: Economic Indicators

20 New Policy Measures		Net Direct Societal Cost M2007$		New Employment (person-years)		Change in GDP M2007$		Change in Societal Investment M2007$
Sector	**Policy Description**	**2020**	**2010-2030**	**2020**	**2010-2030**	**2020**	**2010-2030**	**2010-2030**
EHS-1	National Renewable Electricity Standard	$6,579	$162,323	12,523	991,393	-$6,425	-$165,734	$94,638
EHS-2	Incentives for Combined Heat and Power	-$2,388	-$16,349	40,364	652,658	$4,964	$57,667	$21,500
EHS-AGG	**Electricity and Heat Supply**	**$4,191**	**$145,974**	**52,887**	**1,644,051**	**-$1,461**	**-$108,067**	**$87,188**
RCI-1	Industrial Process Efficiency and DSM Measures	-$7,489	-$99,918	103,898	2,156,391	$6,926	$88,214	$45,188
RCI-2	DSM Programs for Building Electricity & Natural gas Use	-$1,335	-$112,010	54,177	2,659,139	$4,376	$106,641	$6,886
RCI-3	Zero Net Energy Buildings	-$17,161	-$194,131	164,335	3,132,090	$10,009	$118,852	-$34,940
RCI-4	Appliance Standards	-$17,566	-$156,890	130,965	2,122,703	$7,907	$82,653	-$26,054
RCI-5	Advanced Building Codes - Commercial & Residential	-$16,336	-$180,425	161,941	3,217,089	$8,664	$106,517	-$1,706
RCI-AGG	**Residential, Commercial, Industrial**	**-$59,887**	**-$743,374**	**615,316**	**13,287,412**	**$37,882**	**$502,877**	**$25,772**
TLU-1	Rebates for PHEVs and EVs	-$30,661	-$279,488	103,354	831,569	$11,016	$90,575	$32,745
TLU-2	National Renewable Fuel Standard - Post 2022	$153	$45,608	22,034	231,610	$1,902	$11,625	$8,977
TLU-3	Smart Growth - Land Use - Strong	-$19,443	-$237,576	73,644	1,446,169	$7,137	$87,404	-$127,432
TLU-4	Public Transit	$5,048	$32,784	32,365	658,515	$2,873	$42,016	$59,858
TLU-5	Anti-Idling Technologies and Practices - Rapid response	-$2,797	-$28,091	34,333	666,909	$2,878	$34,473	$1,788
TLU-6	Mode Shift from Truck to Rail	-$22,526	-$291,016	109,526	2,079,596	$10,538	$130,728	-$71,034
TLU-7	National CAFE Standard - Post 2025 targets	$2	$116,470	-4,184	-626,082	$249	-$29,332	$53,619
TLU-AGG	**Transportation and Land Use**	**-$70,225**	**-$641,310**	**371,071**	**5,288,285**	**$36,594**	**$367,488**	**-$38,338**
AFW-1	Crop Production & Nutrient Management Practices	$1,033	$11,265	20,476	350,753	$4,464	$56,987	$11,279
AFW-2	Agricultural Livestock Manure Management Practices	$254	$2,941	31,383	645,108	$3,880	$49,913	$1,284
AFW-3	Forest Retention Practices	$47	$576	18,903	395,316	$2,036	$26,223	$2,617
AFW-4	Reforestation Management Practices	$166	$1,768	21,023	428,171	$2,044	$26,271	$1,039
AFW-5	Urban Forest Management Practices	$4,853	$41,117	124,676	2,438,463	$2,106	$35,082	-$12,922
AFW-6	Integrated Waste Reduction, Recycling and LGF Utilization	-$7,706	-$89,707	69,932	1,495,543	$8,009	$98,542	$2,845
AFW-AGG	**Agriculture, Forestry and Waste**	**-$1,352**	**-$32,039**	**286,393**	**5,753,354**	**$22,539**	**$293,019**	**-$9,117**
ALL-AGG	**Total Aggregated Impact**	***-$127,273***	***-$1,270,749***	***1,325,666***	***25,973,101***	***$95,554***	***$1,055,317***	***-$72,798***

Annex 1: Energy Security Indicators (% change from reference)

20 New Policy Measures		Change in imported oil	Change in primary energy diversity	Change in electric generation diversity	Change in grid summer peak demand	Change in energy intensity
Sector	**Policy Description**	**2010-2030 levelized**	**2010-2030 levelized**	**2010-2030 levelized**	**2010-2030 levelized**	**2010-2030 levelized**
EHS-1	National Clean Electricity Standard	0.2%	0.5%	6.0%	-0.5%	0.4%
EHS-2	Incentives for Combined Heat and Power	0.0%	0.5%	-0.1%	0.0%	0.0%
EHS-AGG	**Electricity and Heat Supply**	**0.2%**	**1.0%**	**6.1%**	**-0.5%**	**0.3%**
RCI-1	Industrial Process Efficiency and DSM Measures	-0.1%	3.0%	1.0%	0.0%	-1.3%
RCI-2	DSM Programs for COM & RES Electricity & Natural gas Use	0.8%	3.6%	8.1%	-6.3%	-1.8%
RCI-3	Zero Net Energy Buildings	0.0%	2.3%	5.3%	-3.6%	-0.9%
RCI-4	Appliance Standards	0.0%	0.8%	2.4%	-2.5%	-0.3%
RCI-5	Advanced Building Codes - Commercial & Residential	0.0%	3.1%	7.0%	-4.5%	-1.4%
RCI-AGG	**Residential, Commercial, Industrial**	**0.0%**	**5.6%**	**9.6%**	**-7.4%**	**-3.5%**
TLU-1	Rebates for PHEVs and EVs	-1.0%	0.8%	-0.4%	0.0%	-0.2%
TLU-2	National Renewable Fuel Standard - Post 2022	-1.5%	0.0%	0.1%	0.0%	0.1%
TLU-3	Smart Growth - Land Use - Strong	-0.7%	0.6%	0.0%	0.0%	-0.2%
TLU-4	Public Transit	-0.3%	0.2%	-0.1%	0.0%	0.0%
TLU-5	Anti-Idling Technologies and Practices - Rapid response	-0.5%	0.5%	0.0%	0.0%	-0.1%
TLU-6	Mode Shift from Truck to Rail	-2.2%	1.5%	0.0%	0.0%	-0.5%
TLU-7	National CAFE Standard - Post 2025 targets	-0.7%	0.3%	-0.4%	0.0%	-0.1%
TLU-AGG	**Transportation and Land Use**	**-4.9%**	**2.7%**	**-0.6%**	**0.0%**	**-1.0%**
AFW-1	Crop Production & Nutrient Management Practices	0.0%	0.0%	0.0%	0.0%	0.0%
AFW-2	Agricultural Livestock Manure Management Practices	0.0%	0.0%	0.0%	0.0%	0.0%
AFW-3	Forest Retention Practices	0.0%	0.0%	0.0%	0.0%	0.0%
AFW-4	Reforestation Management Practices	0.0%	0.0%	0.0%	0.0%	0.0%
AFW-5	Urban Forest Management Practices	0.0%	0.3%	1.1%	-1.2%	-0.1%
AFW-6	Integrated Waste Reduction, Recycling and LGF Utilization	0.0%	2.5%	0.6%	0.0%	-1.0%
AFW-AGG	**Agriculture, Forestry and Waste**	**0.0%**	**2.6%**	**1.8%**	**-1.1%**	**-1.1%**
ALL-AGG	***Total Aggregated Impact***	***-5.0%***	***6.8%***	***9.3%***	***-7.5%***	***-4.8%***

Annex 1: Environmental Indicators

20 New Policy Measures		GHG emissions reductions MMtCO2e		Cost effectiveness $/tCO2e
Sector	**Policy Description**	**2020**	**2010-2030**	**2010-2030**
EHS-1	National Clean Electricity Standard	30.03	2,559	49.08
EHS-2	Incentives for Combined Heat and Power	9.02	236	-57.65
EHS-AGG	**Electricity and Heat Supply**	**44.26**	**2,947**	**39.08**
RCI-1	Industrial Process Efficiency and DSM Measures	127.09	2,773	-29.96
RCI-2	DSM Programs for COM & RES Electricity & Natural gas Use	160.28	4,869	-19.16
RCI-3	Zero Net Energy Buildings	73.65	2,329	-68.61
RCI-4	Appliance Standards	30.99	529	-253.93
RCI-5	Advanced Building Codes - Commercial & Residential	97.78	3,687	-40.22
RCI-AGG	**Residential, Commercial, Industrial**	**298.13**	**9,103**	**-46.08**
TLU-1	Rebates for PHEVs and EVs	8.06	351	222.02
TLU-2	National Renewable Fuel Standard - Post 2022	-1.94	629	54.63
TLU-3	Smart Growth - Land Use - Strong	14.23	339	-570.18
TLU-4	Public Transit	5.60	109	264.54
TLU-5	Anti-Idling Technologies and Practices - Rapid response	12.24	235	-98.53
TLU-6	Mode Shift from Truck to Rail	43.00	953	-252.55
TLU-7	National CAFE Standard - Post 2025 targets	3.06	184	447.17
TLU-AGG	**Transportation and Land Use**	**51.67**	**2,077**	**-80.93**
AFW-1	Crop Production & Nutrient Management Practices	19.18	495	5.64
AFW-2	Agricultural Livestock Manure Management Practices	5.79	198	12.03
AFW-3	Forest Retention Practices	4.00	100	4.62
AFW-4	Reforestation Management Practices	14.41	371	3.96
AFW-5	Urban Forest Management Practices	6.82	334	98.12
AFW-6	Integrated Waste Reduction, Recycling and LGF Utilization	106.69	2,622	-28.28
AFW-AGG	**Agriculture, Forestry and Waste**	**156.57**	**4,175**	**-6.49**
ALL-AGG	***Total Aggregated Impact***	***465.66***	***13,448***	***-44.61***