Gobierno del Estado de
Coahuila
Secretaría de Medio Ambiente

Plan Estatal Contra Cambio Climático de Coahuila

Final Report

of the

Coahuila Phase 2

State Climate Action Plan

Submitted to:

the Secretaria de Medio Ambiente (SEMA),

Border Environment Cooperation Commission (BECC), and the Mexico Low Emissions Development Program (funded by the U.S. Agency for International Development (USAID) and represented by the World Wildlife Fund (WWF)

By the:

Center for Climate Strategies (CCS)

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Acronyms and Abbreviations

\$/kWh	pesos per kilowatt-hour
\$/MM	millions of pesos
\$/MWh	pesos per megawatt-hour
\$/t	pesos per metric ton
\$/tCO_2e	pesos per metric ton of carbon dioxide equivalent
%	per cent
AFOLU	Agriculture, Forestry, and Other Land Use
AG	Advisory Group
BAU	business as usual
BC	Baja California
BECC	Border Environment Cooperation Commission
BRT	bus rapid transit
Btu	British thermal unit
CAFE	corporate average fuel economy
CCC	Council on Climate Change
CCI	Cross-Cutting Issues
CCS	Center for Climate Strategies
cf	cubic feet
CH_4	methane
CHP	combined heat and power
CI	custom industry
CNG	compressed natural gas
CO	Coahuila
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CRF	capital recovery factor
CY	calendar year
DG	distributed generation
DOE	[United States] Department of Energy
DOT	[United States] Department of Transportation
DSM	demand-side management
EIA	Energy Information Administration [US DOE]
EO	Executive Order
EPA	[United States] Environmental Protection Agency
EPS	environmental portfolio standard
ES	Energy Supply
EU	European Union
FS	fuel supply
FIT	feed-in tariff
FOLU	Forestry and Other Land Uses
ft	foot
FY	fiscal year

gal	gallon
GHG	greenhouse gas
GJ	gigajoule
GREET	Greenhouse Gases, Regulated Emissions and Energy Use in Transportation [model]
GSP	gross state product
GTL	gas to liquid
GWh	gigawatt-hour [one million kilowatt-hours]
GWP	Global Warming Potential
HDV	heavy-duty vehicle
HFC	hydrofluorocarbon
HOV	high-occupancy vehicle
HVAC	heating, ventilation, and air conditioning
I&F	Inventory and Forecast
IECC	International Energy Conservation Code
INEGI	Mexico National Institute of Statistics and Geography
I-O	Input-Output
IPCC	Intergovernmental Panel on Climate Change
IPP	independent power producer
IRP	integrated resource planning
ITS	intelligent transport system
kg	kilogram
km	kilometer
km/L	kilometer/ liter
kV	kilovolt
kW	kilowatt
kWh	kilowatt-hour
LandGEM	Landfill Gas Emissions Model [US EPA]
LARCI	Latin American Regional Climate Initiative
lb	pound
LDV	light-duty vehicle
LCOE	levelized cost of energy or electricity
LED	light-emitting diode
LEED	Leadership in Energy and Environmental Design [Green Building Rating System™]
LFG	landfill gas
LFGcost	Landfill Gas Cost model [US EPA]
LFGTE	landfill gas-to-energy
LNG	liquefied natural gas
LPG	liquefied petroleum gas
m^2	square meter
ME	macro-economic
metric ton	1,000 kilograms or 22,051 pounds
MJ	megajoule
MLED	Mexico Low Emissions Development
MM	million

MMBtu	millions of British thermal units
MP	mathematical programming
mpg	miles per gallon
MSW	municipal solid waste
MW	megawatt [one thousand kilowatts]
MWh	megawatt-hour [one thousand kilowatt-hours]
N	nitrogen
NAMA	nationally appropriate mitigation action
N_2O	nitrous oxide
N/A	not applicable
NF_3	Nitrogen triflouride
NG	natural gas
NGCC	natural gas combined cycle
NGCT	natural gas combustion turbine
NGO	nongovernmental organization
NOx	oxides of nitrogen
NPV	net present value
O&M	operation and maintenance
ODS	ozone-depleting substance
PACE	Property Assessment for Clean Energy
PBF	Public Benefit Fund
PE	Panel of Experts
PFC	perfluorocarbon
PHEV	plug-in hybrid electric vehicle
PM	particulate matter
PM10	particulate matter less than 10 microns
POD	policy option document
PS	power supply
PV	photovoltaic
R&D	research and development
RCII	Residential, Commercial, Institutional and Industrial
RFS	renewable fuel standard
RPC	regional purchase coefficient
RPS	renewable portfolio standard
SBC	systems benefit charge
SCAP	State Climate Action Plan
SEMA	Secretaria de Medio Ambiente
SF_6	sulfur hexafluoride
SO_2	sulfur dioxide
SOx	oxides of sulfur
SOV	single-occupant vehicle
sq ft	square foot/feet
SUTs	supply and use tables
t	metric ton
Tg	teragram [million metric tons]
$TgCO_2e$	teragrams of carbon dioxide equivalent

T&D	transmission and distribution
tC	metric tons of carbon
tCO_2	metric tons of carbon dioxide
tCO_2e	metric tons of carbon dioxide equivalent
tCO_2e/MWh	metric tons of carbon dioxide equivalent per megawatt-hour
TDM	transportation demand management
TLU	Transportation and Land Use
TOD	transit-oriented development
TSM	transportation system management
TWG	Technical Work Group
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
VHT	vehicle hours of travel
VKT	vehicle-kilometers traveled
VMT	vehicle miles traveled
VOC	volatile organic compound
WIOD	World Input-Output Database
WM	Waste Management
WTE	waste to energy
WW	wastewater
WWF	World Wildlife Fund
yr	year

Executive Summary

Background

In June 2010 with funding from the Border Environment Cooperation Commission (BECC) the Center for Climate Strategies (CCS) completed an Inventory and Forecast (I&F) of Greenhouse Gas emissions in the State of Coahuila (CO) and several other northern border states of Mexico. Findings of this report are summarized in Chapter 2.

In 2011 BECC and CCS worked closely with the state of Coahuila Secretary of Environmental Protection (Secretaria del Medio Ambiente (SEMA) to conduct a Phase 1 State Climate Action Plan (SCAP) process in Coahuila. This Phase 1 process resulted in development of a set of catalogs of 337 potential state climate action policies and a priority list of 56 policies drawn from the catalogs for further analysis in Phase 2. The Phase 1 process is summarized in Chapter 1.

The policies developed during the course of the Phase 1 process in 2011 were reviewed and considered in the early stage of the Phase 2 process which commenced at the beginning of 2015. From the 56 policies identified at the end of the Phase 1 process SEMA and a local Panel of Experts (PE) selected 17 policies to focus on in the Phase 2 process for Coahuila.

For the Phase 2 process the following entities came together as Partners in this collaborative effort:

- The Secretaria de Medio Ambiente (SEMA) is the state environmental agency for the state of Coahuila for whom the SCAP has been prepared;
- The Border Environment Cooperation Commission (BECC) is a sponsoring organization which provided significant funding for the project;
- The U.S. Agency for International Development (USAID)'s Mexico Low Emission Development (MLED) Program is a second sponsoring organization which provided significant funding for the effort;
- The Center for Climate Strategies (CCS) is a non-profit entity that was contracted by BECC and the MLED Program to perform technical, facilitative and project management services in developing the Coahuila SCAP.

The objectives for the Coahuila Phase 2 SCAP process were established in the Scope of Work (SOW) for CCS by BECC and the MLED Program at the outset of the process and are summarized in Chapter 3. The primary objective was to enhance state capacity in climate planning and analysis through a "learn by doing" approach directed by CCS. Another key objective was to develop an initial SCAP for Coahuila that can be used to commence the state's GHG mitigation efforts by targeting the 17 climate mitigation policies selected for initial detailed analysis. This secondary objective recognized that additional measures or strengthened versions of the initial measures will likely be needed over time in pursuit of achieving the global, national and state GHG reductions necessary to realize the GHG reduction levels anticipated in the recent Paris Accord.

The multi-phase approach to developing the SCAP follows CCS' step-wise approach to action planning showed in Figure Ex-S-1 below. This step-wise process and the analytical toolkit that supports its implementation are described in more detail in Chapter 1.

Figure ExS-1. Step-Wise Action Planning Approach

Step 1	**Organization and Goals**
Step 2	**Baseline Development**
Step 3	**Policy Options Identification**
Step 4	**Policy Screening & Prioritization**
Step 5	**Initial Policy Option Design Specifications**
Step 6	**Direct (Micro) Impacts Assessment**
Step 7	**Policy Options Integration and Overlap**
Step 8	**Indirect (Macro) Impacts Assessment**
Step 9	**Final Recommendations & Report Transmittal**
Step 10	**Monitoring, Reporting, Evaluation, & Updating**

Through Phase 1 of the project, Steps 1 through 4 had been completed which included a GHG baseline and a set of priority policies for inclusion in the CO SCAP. Phase 2 initiated work on Step 5 and included the work through Step 9 to develop this final report on the SCAP.[1] Work is now underway on Step 10 which will involve the development of detailed implementation plans for a sub-set of high priority policies selected by SEMA from the 17 SCAP policies analyzed in Phase 2.

SEMA, BECC and MLED agreed early in the process that SEMA would be the entity to host the Panel of Experts (PE) for the project, all who are associated with the Universidad Autónoma de Coahuila in Saltillo. The PE was the entity designated to receive CCS's training in policy design and analysis. The capacity building process was designed from the outset to be a learn-by-doing effort in which CCS trained the PE in the various technical analysis functions and then shared the workload of actually conducting the technical analysis on the selected policy recommendations. Chapter 3 includes a list of the Members of the PE and their sectors of expertise. It also includes a summary of the training sessions provided to the PE and the Partner organizations.

Following completion of the Phase 2 Final Report, CCS will team up with SEMA and the Partners on Step 10 of the planning process to conduct a detailed assessment of 3-5 of the

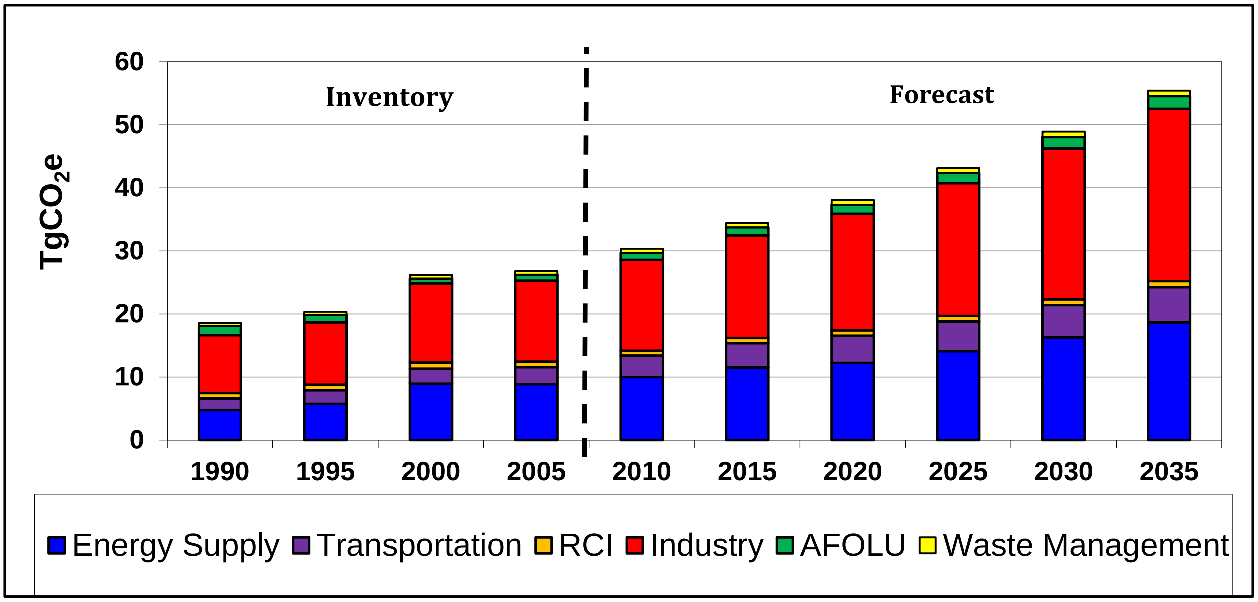
[1] Note that a macroeconomic analysis of CO GHG mitigation policies was not included in this SCAP.

selected policies to chart out a more detailed implementation plan for these selected policies using the SCAP as a foundation.

Coahuila GHG Emissions Inventory & Forecast

The inventory and business as usual (BAU) forecast (or "baseline") of GHG emissions was constructed primarily from the 2010 GHG I&F prepared by CCS.[2] As summarized in Figure ExS-2 below, the baseline is economy-wide and includes annual emissions data for all sectors. "Net" emissions indicate that these estimates include both sources and sinks of GHGs (e.g. carbon sequestration in the Forestry sector).

Figure ExS-2. Coahuila's Net GHG Emissions by Sector



All sectors of Coahuila's economy were addressed in the baseline (see the materials provided in Chapter 2 and Appendix A for more details). These follow the common categorization used in national GHG reporting:

- Energy Supply (ES): for Coahuila, this mainly addresses the Power Supply (PS) subsector;
- Residential, Commercial & Institutional (RCI): this covers emissions from fuel combustion in buildings;
- Industry (I); this sector includes emissions from fuel combustion for industrial processes and buildings, as well as non-combustion emissions that occur from industrial processes;
- Transportation: most importantly fuel combustion in on-road vehicles, but also including air, rail and marine vessels;

[2] *Greenhouse Gas Emissions in Coahuila and Reference Case Projections 1990 – 2025*, the Center for Climate Strategies, June 2010. As discussed in further detail in a technical memorandum appended in Appendix A, the 2010 CCS baseline was extended to 2035. Therefore, the reader should expect some differences in the baseline values shown in the body of this report as compared to the values shown in 2010 report provided in Appendix A.

- Agriculture, Forestry & Other Land Uses (AFOLU): the agricultural subsector covers fuel combustion and non-combustion emissions associated with crop production and livestock management; the forestry and other land use sector primarily covers carbon sequestration; and
- Waste Management (WM): this includes the solid waste management and wastewater treatment subsectors.

The baseline estimates are presented in units of teragrams (Tg) of carbon dioxide equivalent (CO_2e) emissions (1 Tg is equal to 1 million metric tons). These estimates include all GHG emissions within each sector and put them in common units based on their global warming potential (GWP). For this study, GWP's from the IPCC's Second Assessment Report (SAR) were used. As noted below, emissions for all GHGs required for reporting by the Intergovernmental Panel on Climate Change (IPCC) were addressed; however, sources for all GHGs were not identified:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous oxide (N_2O);
- Hydrofluorocarbons (HFC);
- Sulfur hexafluoride (SF_6);
- Perfluorocarbons (PFC); and
- Nitrogen trifluoride (NF_3).

As shown in Figure ExS-2, as well as Figure ExS-3 below, emissions are expected to double from the year 2005 (27 $TgCO_2e$) to the end of the planning period in 2030 (55 $TgCO_2e$). The emissions are shown on a "net" basis, meaning that carbon sinks have been subtracted from the overall emissions totals (these carbon sinks occur in the AFOLU and WM sectors). As indicated in the results shown in Figure ExS-3, the Energy Supply and Industry sectors are expected to contribute to most of the emissions growth in Coahuila during the forecast period.[3]

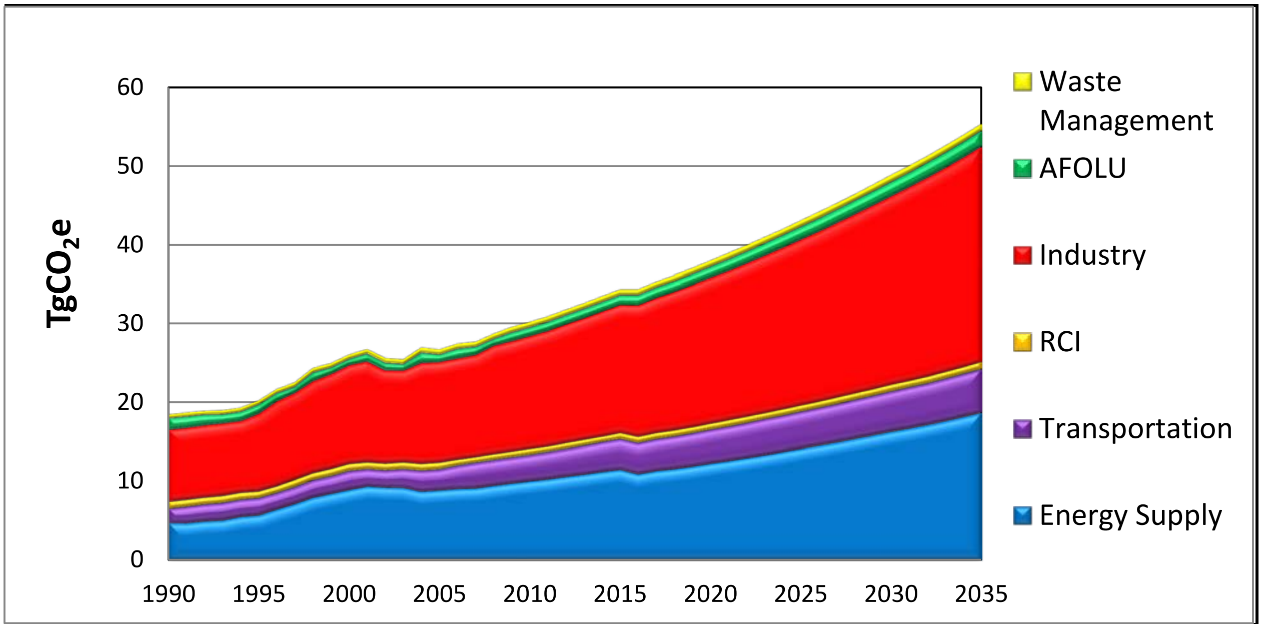
Figures ExS-4 and ExS-5 provide GHG emissions normalized to population and economic output ("carbon intensities"). On a per capita basis, due to a relatively low population and the presence of heavy industry in the State, CO's emissions are above the national levels. This difference is expected to grow over time based on population and economic growth, industry structure, and an electricity system with substantial coal-based generation. Net intensities include an accounting of carbon sinks, while gross intensities exclude these.

On the basis of economic output, due to the presence of heavy industry and the carbon intensity of the electricity system in CO, the carbon intensity for the State is again higher than national levels. Over time, the carbon intensity of Mexico's economy is expected to decline slightly,

[3] Note: the Federal government has recently indicated that it is studying the potential for decommissioning one of the coal-fired power plants in the State. If this were to occur, there would be a significant impact on Coahuila's baseline, since any new generation to make up for this loss in capacity would most likely come from much cleaner sources.

while Coahuila's is expected to continue to increase due to both industrial growth and the carbon intensity of electricity supply.

Figure ExS-2. Coahuila Net GHG Emissions Baseline by Sector



A more detailed break-down of Coahuila's 2005 GHG emissions, as well as the overall GHG baseline can be found in Chapter 2 and Appendix A.

Figure ExS-4. CO and National Carbon Intensities, per capita

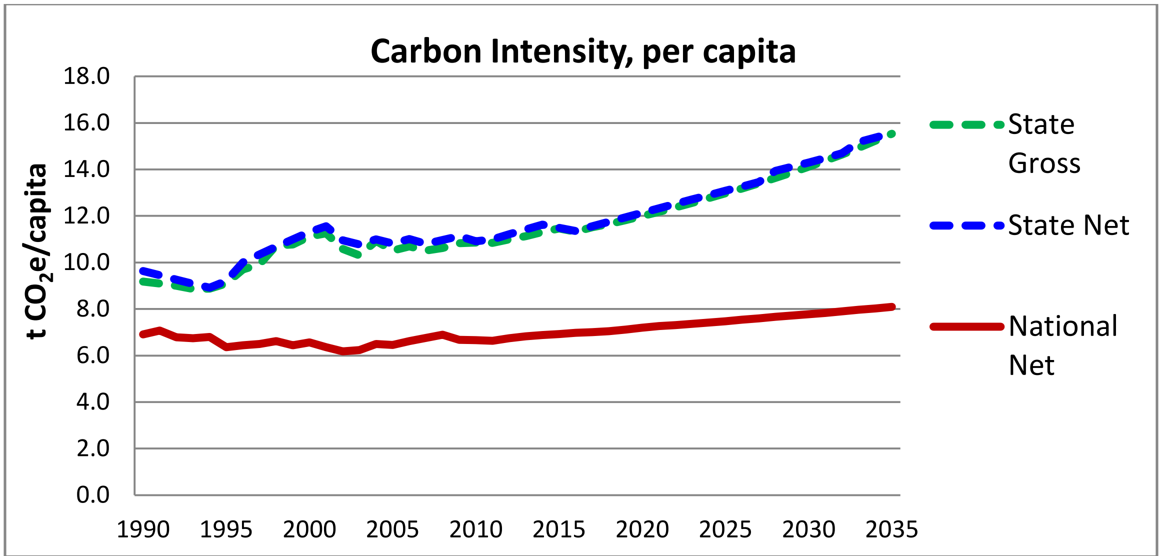
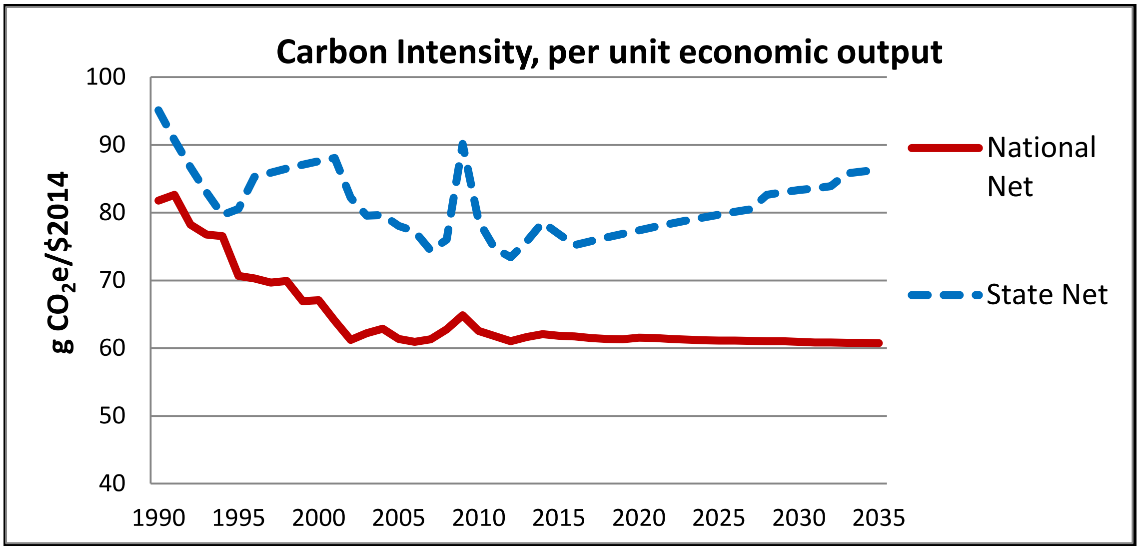


Figure ExS-5. CO and National Carbon Intensities, per unit economic output



Selection and Design of SCAP Policies

To initiate work under Phase 2 of the SCAP, policy designs were developed for each of the 17 priority policies selected at the beginning of Phase 2. The work was completed by three sector-based teams:

1. Energy Supply (ES) and Residential, Commercial, Institutional & Industrial (RCII) sectors: while the baseline breaks out Industry as a separate sector, it was included within a broader RCII sector during policy design and analysis;
2. Transportation & Land Use (TLU): covering transportation sector GHG sources, as well as urban land issues that tie into urban mobility systems;
3. Agriculture, Forestry & Other Land Use (AFOLU) and Waste Management (WM): while agriculture is a separate sector within the baseline, the work under Phase 2 of the SCAP project combines it with the Forestry and other land use sector. WM policies were also developed and analyzed within this technical team.

A policy design includes: a brief description of the policy and its intended GHG impacts, a causal chain showing the primary policy effects and their associated GHG impacts, numeric goals for the policy, timing to achieve goals, and the parties involved in policy implementation. Brief descriptions of the CO SCAP policies are provided below:

- **ES-1. Electricity production through renewable energy technologies (photovoltaic panels, wind generators) in Central Station Power Supply** - The purpose of this policy is to take advantage of low carbon energy resources in Coahuila to contribute to the national GHG reduction target (Objective 3)[4] through the strategy of diversification of

[4] Objective 3: Reduce emissions of greenhouse gases to move to a competitive economy and low emissions development (Special Climate Change Program Promotion Version 2014-2018, 2014-2018 PECC Government of the Republic.)

the energy matrix production in the country (Strategy 3.2.1).[5] This includes reducing dependence on fossil fuels with high carbon content in electricity generation by promoting installation of power plants that use renewable energy sources, specifically wind and sun, thereby helping to reduce GHG emissions per megawatt (MW) generated. This strategy is consistent with the State's resources, as Coahuila receives a high level of solar radiation (2.9 to 6.7 kWh/m^2) with high potential for energy conversion. The state can support diversification of electricity supply options by providing siting and construction of new facilities and generation operations with primary renewable energy.

- **ES-2. In-situ electricity generation in residential buildings with photovoltaic panels** - Towards 2020, the residential sector will be the eighth largest greenhouse gas emitter and the second largest in black carbon. These emissions are associated with electricity consumption of households. The costs of small-scale generation with photovoltaic panels are lower than domestic rates without access to the government electric subsidy (e.g. Mexico's PROSOLAR Program).[6] Also, the territory of Coahuila receives high levels of solar radiation. Therefore, the implementation of economic and financial incentives will boost the self-generation of solar photovoltaic electricity in the residential sector. The implementation of this policy contributes to the reduction of GHG emissions related to the consumption of electricity produced from fossil fuels. Similarly, it supports the national strategy for distributed power generation in the domestic, commercial and industrial sector (Strategy 3.4.3).
- **ES-3 In-situ electricity generation in public buildings with photovoltaic panels** - Electrical energy used in public buildings comes largely from fossil fuels with high global warming potential. Therefore, the objective of this policy is to increase energy efficiency in the institutional sector, taking advantage of the high incidence of solar radiation of the entity, promoting the installation of photovoltaic panels in public buildings in Coahuila to meet their electric energy requirements electric. With this measure, besides reducing operating costs in the public sector, GHG emissions are mitigated using cleaner and more efficient technologies to replace fossil fuels for power generation.
- **ES-4. In-situ electricity generation in commercial and industrial buildings with photovoltaic panels** - The commercial and industrial sectors have increasingly contributed to the increase of GHG emissions that alter the energy balance of the climate system. Therefore, it is appropriate to move towards an energy model that considers the consumption of electricity in commercial and industrial buildings by harnessing solar energy. The auto-consumption of electricity produced by photovoltaic technologies will contribute to savings in operating costs in commercial and industrial buildings, and

[5] Strategy 3.2.1: Promote the diversification of the energy matrix with public and private investment in generation through clean energy (Special Climate Change Program Promotion Version 2014-2018, 2014-2018 PECC. Government of the Republic).

[6] Electricity generated from solar photovoltaics costs less than the MX tariff (electricity rate) for larger consumers. For residential customers that use more than 300 kWh per 2 month billing cycle, the electricity tariff is $MX 2.86 kWh ($US 430/MWh) less the subsidy, and for those residential customers classified as High Consumption Domestic (Domèstico de Alto Consumo-DAC) the electricity tariff is $MX 3.1 kWh and they don't have access to any subsidy due to the average monthly consumption recorded is above the high consumption limit defined for each location. These tariffs are more expensive than the estimated levelized costs of solar PV generation used in the ES analysis. For more information about the domestic tariffs access the CFE website (http://app.cfe.gob.mx/Aplicaciones/CCFE/Tarifas/Tarifas/tarifas_casa.asp) or read Prosolar Program.

contribute to mitigation of GHG emissions, both by reducing dependence on non-renewable fuels, and avoiding energy losses during transport and distribution of electrical energy required in the commercial and industrial buildings of Coahuila.

- **ES-5. Encouragement of efficient cogeneration of electricity in industry** - Electricity cogeneration systems reach a much higher efficiency than conventional systems by leveraging untapped waste heat and reducing unnecessary energy losses, enabling considerable medium and long term savings (CONUEE and CRE, 2013). In Mexico, regulation has been developed considering energy efficient cogeneration projects. In most companies in the industrial sector, heat and electricity are essential inputs. When these two forms of energy are required together in a production process, it is an opportunity to implement cogeneration systems, which leads, simultaneously, to achieve greater efficiency in the use of fossil fuels and produce less pollutant emissions per unit of useful energy. This policy considers the promotion of efficient cogeneration systems according to the productive structure of the state, where the impulse for cogeneration is concentrated in the following sectors: Cement industry, steel industry and mining sector. Cogeneration mode represents a viable option to contribute to energy sustainability by increasing energy and economic efficiency of the company.
- **RCII-1. Increasing energy efficiency in new and existing construction buildings- Building codes and standards** - Construction and design modifications of a building can contribute to increase energy efficiency, reducing energy demand to satisfy thermal conditioning and lighting needs, improving inhabitants' comfort, thus contributing to mitigate deterioration of the environment. Within the framework of energetic sustainability, this policy covers regulation of design, construction and major remodeling of buildings, with the objective of building low carbon footprint "green buildings". All of this through enhancement, improvement, and adoption of regulations and standards that promote thermal isolation technologies, installation of low-power consuming lighting systems: halogen, compact-fluorescent (LFC) and light-emitting diode (LED) lamps, and carbon sequestration activities (such as green roofs, vertical gardens, and urban gardens) in new residential, commercial, institutional, and industrial buildings.
- **RCII-2. Increasing energy efficiency in new construction- Equipment (Appliances, solar water heaters, flow water heaters) -** Part of the emissions of GHG in the residential, commercial, and institutional sectors (RCII) comes from the consumption of electricity to satisfy the needs of lighting, water heating, thermal conditioning and appliance operation. The goal of this policy is to increase energy efficiency in the RCI sectors by reducing the energetic demand, supporting a decrease in GHG emissions from generation, distribution and consumption of energy. (Note that industrial building appliance efficiency is addressed in RCII-4). This policy promotes the following measures specifically:
    - Use of solar energy through installation of solar water heaters in households, thus reducing consumption of liquefied petroleum gas (LPG), natural gas (NG) or electricity for water-heating purposes.
    - Encourage the use of flow water heaters, with the purpose of reducing the use of LPG and NG.
    - Acquisition of energy efficient appliances.
    - Use of more energy efficient thermal conditioning equipment (e.g. mini-split inverter).

This policy is complementary to policies 2, 3 and 4 of the Energy Sector, which consider the installation of photovoltaic panels for in situ generation in residential, commercial, industrial and institutional buildings.

- **RCII-3. Increasing energy efficiency in existing construction, excluding the industrial sector - Equipment (Appliances, lighting, solar water heaters, flow water heaters) -** In this policy, GHG mitigation strategy is oriented to satisfy energetic needs of existing buildings of RCI (Residential, Commercial, Institutional) sectors by replacing high-energy-demanding technologies (electricity and gas) with more efficient ones. This policy specifically promotes the following measures:
    - Use of solar energy through installation of solar water heaters in households, thus reducing consumption of liquefied petroleum gas (LPG), natural gas (NG) or electricity for water heating purposes.
    - Use of flow water heaters, with the purpose of reducing the use of LPG and NG.
    - Acquisition of energy efficient appliances.
    - Replacement of incandescent bulbs for efficient lighting systems: halogen, compact-fluorescent (LFC) and light-emitting diode lamps (LED).
    - Replacement of standard air-conditioning equipment for more energy efficient thermal conditioning equipment (e.g. mini-split inverter).
- **RCII-4. Stimulating energy efficiency in the industrial sector with energy efficient equipment and industrial process improvements** - The Special Climate Change Program (PECC, 2014) anticipates that for 2020, the industrial sector will be the third GHG emission generator at a national level. The main polluting sources of this sector come from the consumption of fossil fuels during manufacturing processes, especially in the iron, steel and cement industries. Due to the presence of heavy industry in the economy of Coahuila (including cement production and iron & steel industries) and relatively high carbon content electricity production, the Industrial sector in the State generates about 29% of the total GHG emissions. The purpose of this policy is to implement regulations and incentives to decrease potential global warming through greater energy efficiency of the industrial sector, through improvements in operation processes, replacement and acquisition of low-energy consuming machinery and equipment, as well as replacement of high-energy demanding technologies for industrial operation (electricity and gas) for more efficient technologies (e.g. efficient motors, sensors, controls and other electrical components, as well as efficient process-heat and water-heating equipment).
- **TLU-1. Urban density index –** Increase the urban density index (inhabitants/ hectare) of the major metropolitan zones in the State. By 2035, the following increases in the urban density index are targeted: Saltillo-Arteaga-Ramos Arizpe - 36%; La Laguna – 31%; Monclova-Frontera – 25%; and Piedras Negras-Nava – 27%.
- **TLU-2. Sustainable urban mobility –**Restructure the demand for the various modes of transportation, that is, reduce the percentage of private passenger car use and increase the relative participation in the use of mass public transportation, bicycling and walking. Coahuila will join the national strategies that seek to design and implement a policy of sustainable mobility for cities of 500,000 or more inhabitants, which aim to promote key transportation projects that exhibit transit travel time reduction, socio-economic profitability and improved environmental impact

- **TLU-3. Energy efficient government fleet** - Increase participation of hybrid, pluggable hybrid and electric vehicles in the State and local government fleet. This policy seeks to: provide individuals who acquire them, tax incentives upon purchase and possession (e.g. value added tax exemption) as well as special privileges for parking; support, together with manufacturers of electric and hybrid cars with plants in the State, the development of a network of charging stations.
- **AFOLU-1. Dairy cattle manure management -** This policy proposes using manure generated in the dairy farms of the state of Coahuila for the production of bio-fertilizer and electricity, thus supporting the reduction in the use of fossil fuels in energy generation. The focus will be in the Laguna Region, where under BAU conditions, it is expected that only about 7% of dairy manure will be managed using anaerobic digestion (AD) technologies that reduce methane emissions and produce renewable electricity. Through implementation of this policy, 40% of dairy manure will be managed via anaerobic digestion by 2025. The policy will target implementation of AD technology at both large dairies (>1,500 head of cattle; 60% of targeted population) and medium-sized dairies (500 – 1,500 head of cattle; 40% of targeted population).
- **AFOLU-2. Increase and maintenance of urban vegetation -** Urban reforestation includes complete restoration and maintenance of green areas with emphasis in rescuing and preserving native species. This supports conservation and protection of the wide genetic biodiversity in the State. Also, strategically-planted urban trees provide shade and/or wind protection for buildings and thus can generate benefits in energy savings (in CO, mostly lowering summer air conditioning costs). Additionally, urban trees capture rain water, which reduces the amount of storm-water that ends up at water treatment plants in areas with combined sewerage systems. The policy addresses incremental urban tree plantings of 5,000 trees per year beginning in 2016 all the way through the planning period of 2035. This results in a total expansion of the urban forest of the State of 100,000 trees (the equivalent of about 240 hectares of rural forest for the State). Further, most of these new plantings (65%) will be strategically-sited to achieve energy savings benefits.
- **AFOLU-3. Increase and conservation of vegetation in rural areas -** Reforestation and conservation of these forested lands promotes an increase in carbon dioxide sequestration above the levels expected for the BAU landcover (e.g. grassland or brushland). Additional benefits of reforestation include greater potential for the rescue of native species, protection of biodiversity, and enhancement of water resources. Through property acquisition or the establishment of conservation easements with property owners, the goals of the policy are to reforest approximately 3,200 hectares per year during the 20 year CO SCAP planning period (nearly 64,000 hectares total). Lands targeted for conservation and reforestation will be at the rural-urban interface which will indirectly influence more efficient land use and “smart growth”. Thus, this policy is complementary to TLU-1 which seeks to achieve higher urban densities.
- **WM-1. Landfill methane utilization -** This policy promotes the expansion of landfill methane energy capture and utilization in the State. The policy expands the use of this technology beyond BAU conditions which include the existing 1 mega-watt (MW) methane collection and utilization project in Saltillo. Under the policy, the methane collection and electricity generation capacity at Saltillo will be doubled to 2 MW by 2020. Also, by 2025, a 1 MW system will be constructed at the Torreon landfill. The

renewable electricity generated by methane from Coahuila's landfills will be supplied to the Federal Electricity Commission's (CFE) public grid. Landfill gas capture and utilization reduces direct CH_4 emissions, and indirectly reduces fossil fuel use to produce electricity for the public grid. It also generates local income and employment for landfill operators.

- **WM-2. Water sanitation and reclamation for industrial processes and irrigation -** This policy promotes both an increase in the amount of wastewater (WW) collected for centralized treatment, as well as increasing percentages of reclamation of wastewater for industrial processes and irrigation of urban green areas and agricultural crops. The policy will then: reduce the amount of GHG emissions and water pollution resulting from not sanitizing wastewater under BAU conditions; reduce the amount of water consumed from primary sources (e.g. surface or groundwater); and reduce the overall amount of energy required for water use in industrial processes and irrigation purposes. Since the extension of wastewater treatment collection and centralized treatment services will require an increase in energy consumption as compared to BAU conditions, the policy will also promote the application of renewable energy (photo-voltaic electricity generation) at levels that will offset the increase in energy requirements (because of the expansion of centralized treatment services and the associated energy use, without this aspect of the policy, there would not likely be a net GHG benefit). Usage of reclaimed water for urban green areas allows savings in consumption of water from aquifers, at the same time that green areas in cities are preserved (see AFOLU-2). Drinking water supplies for the population are also conserved.

Summary of Micro-Economic Analysis Methodology and Results

After a policy design had been completed, the information from that design was used as the initial starting points for micro-economic analysis. Changes brought on by policy impacts can include energy production, reduction in consumption of energy or materials, change in natural resource management, industrial process changes, and changes to other activities that relate to GHG emissions.

Micro-economic analysis of each policy involves two main components: net GHG and energy impacts; and net direct societal costs. Estimates are prepared for each year of the planning period. For the CO SCAP, the planning period extends from the first year of implementation (generally 2016) to 2035. For net GHG impacts, analysts quantify the business as usual (BAU) GHG emissions for the activity targeted by the policy (e.g. fossil fuel use, electricity use, landfill methane generation). Then, estimates are prepared for the same activity, but with the impacts expected through implementation of the policy. The net GHG emissions are then determined for each year by subtracting the BAU emissions from the policy scenario emissions (a negative value indicates a net reduction in GHGs).

Net direct societal costs are estimated in a similar manner as are net GHG impacts. BAU costs are estimated for the activities affected by the policy. Then, the costs for implementing the policy are determined. These typically include initial investment costs (e.g. capital expenditures for new facilities or equipment), operations and maintenance costs, energy costs, materials costs, government subsidies, and other costs. Net costs are determined by subtracting BAU costs from the policy scenario costs. Chapter 3 and Appendix B provide much additional detail in the methods used to conduct micro-economic (direct impacts) analysis.

Key results from the micro-economic analysis phase are summarized in Table ExS-1. Note that these results have been adjusted to account for interactions and overlaps between policies in different sectors (e.g. between electricity supply and demand policies). For that reason, the results will not match those estimated on a policy-specific basis (as shown in the sector chapters to this report and the sector appendices). Key results for the Coahuila SCAP include:

- Net GHG reductions in 2025, 2035, and cumulative through the planning period. Figure ExS-6 is a chart of cumulative GHG reductions estimated for each of the SCAP policies. Policies ES-1 (renewable electricity generation at central power stations) and RCII-2 (energy efficiency in existing buildings) were found to have the highest cumulative reduction potential);
- Net present value of policy implementation costs (cumulative through the planning period);
- Cost effectiveness: this metric allows for direct comparisons of policy performance across policies and is determined by dividing the NPV by the cumulative GHG reductions through the planning period, providing pesos spent per metric ton of carbon dioxide equivalent GHGs reduced ($/tCO_2e$). Figure ExS-7 provides a summary of the cost effectiveness estimates for the SCAP policies; most showed a net savings on a societal basis; and
- Net changes in activity: changes in electricity consumption, fossil fuel use, renewable power generation, etc. Documentation of these results can be found in the direct impacts analyses for SCAP policies located in each sector appendix to this report.
- Figure ExS-8 provides the marginal abatement cost curve (MACC) for the CO SCAP policies. Policies are ranked by their cost effectiveness along the Y-axis. The length of the line for each policy indicates its contribution to reductions in 2035 BAU emissions (on a percentage basis). As shown at the far right of the chart, the total reductions for the SCAP policies are estimated to be about 8% of BAU emissions in 2035.

  The primary use of a MACC curve is to summarize the results of the microeconomic impacts analysis. The graph depicts all of the 2035 impacts shown in the summary data of Table ExS-1, but it helps give a sense of the amount of 2035 emissions that can be achieved at a net savings to society and a net cost to society. Reductions achieved at a net savings are represented by the area between the X-axis and the negative cost effectiveness for the policy. Reductions achieved at a net cost are represented by the area between the X-axis and the positive cost effectiveness for a policy. For the CO SCAP, there is much more emissions reduction area below the X-axis than above it, which means that overall, the SCAP policies can be implemented at a net societal savings. Indeed this is shown in the values at the bottom of Table ExS-1, which indicate a net savings of over $70 billion pesos ($2014) for implementing all SCAP policies.

  While it is tempting to view a MACC curve and to focus attention on or prioritize policies that achieve only the greatest emission reduction potential with net direct savings to society, these results don't provide the full story of cost/benefit analysis. Some policies, regardless of their net direct cost effectiveness may produce indirect (macroeconomic) impacts that aren't shown here. These could include positive employment, income or gross state product impacts. Other non-monetary co-benefits could include improvements in air quality, water conservation, water quality, storm water management, and quality of life (e.g. commute time, aesthetic improvements).

Table ExS-1. Summary of CO SCAP Micro-Economic Analysis of Policies and Results (Part 1)

Policy ID	Policy Name	2025 In-State Annual Reductions ($TgCO_2e$)	2035 In-State Annual Reductions ($TgCO_2e$)	Cumulative In-State 2016-2035 ($TgCO_2e$)	Cumulative Total 2016-2035 ($TgCO_2e$)	NPV Costs / Savings 2016-2035 ($2014MM)	Cost Effectiveness ($2014 / tCO_2e)
ES-1.	Electricity production through renewable energy technologies in Central Station Power Supply	(0.92)	(1.31)	(18.5)	(25)	($2,179)	($89)
ES-2.	Photovoltaic energy in residential buildings	(0.034)	(0.054)	(0.64)	(0.82)	($304)	($369)
ES-3.	Photovoltaic energy in public buildings	(0.015)	(0.021)	(0.27)	(0.35)	($124)	($352)
ES-4.	Photovoltaic energy in commercial and industrial buildings	(0.078)	(0.15)	(1.6)	(2.1)	($983)	($458)
ES-5.	Cogeneration in the industrial sector	(0.12)	(0.22)	(2.4)	(2.4)	($1,614)	($670)
Energy Supply Sector Totals		**(1.2)**	**(1.8)**	**(23)**	**(30)**	**($5,203)**	**($172)**
RCII-1.	Building Codes and Standards	(0.025)	(0.049)	(0.51)	(0.65)	($855)	($1,311)
RCII-2.	Increasing energy efficiency in new construction - Equipment (Appliances, solar water heaters, flow water heaters).	(0.014)	(0.029)	(0.29)	(0.38)	($601)	($1,590)
RCII-3.	Increasing energy efficiency in existing construction, excluding industrial sector - Equipment (Appliances, lighting, solar water heaters, flow water heaters).	(0.72)	(1.2)	(14)	(18)	($21,262)	($1,206)
RCII-4.	Energy Efficient Equipment and Processes in the Industrial Sector	(0.18)	(0.54)	(4.3)	(5.5)	($7,200)	($1,307)
Residential, Commercial, Industrial & Institutional Sector Totals		**(0.94)**	**(1.8)**	**(19)**	**(24)**	**($29,918)**	**($1,238)**

All values adjusted for intra- and inter-sector policy overlaps and interactions

Table ExS-1. Summary of CO SCAP Micro-Economic Analysis of Policies and Results (Part 2)

Policy ID	Policy Name	2025 In-State Annual Reductions ($TgCO_2e$)	2035 In-State Annual Reductions ($TgCO_2e$)	Cumulative In-State 2016-2035 ($TgCO_2e$)	Cumulative Total 2016-2035 ($TgCO_2e$)	NPV Costs / Savings 2016-2035 ($2014MM)	Cost Effectiveness ($2014 / tCO_2e)
TLU-1.	Urban Density Index	(0.068)	(0.12)	(1.3)	(1.7)	($3,025)	($1,776)
TLU-2.	Sustainable Urban Mobility	(0.19)	(0.35)	(4.3)	(5.6)	($30,201)	$(5,428)
TLU-3.	Energy Efficient Government Fleet	(0.000051)	(0.000088)	(0.00095)	(0.0012)	$3.7	$3,004
	Transportation & Land Use Sector Totals	**(0.26)**	**(0.47)**	**(5.6)**	**(7.3)**	**($33,222)**	**($4,572)**
AFOLU-1.	Dairy Cattle Manure Management	(0.026)	(0.055)	(0.74)	(1.8)	$285	$159
AFOLU-2.	Urban Forestry	(0.0024)	(0.0066)	(0.058)	(0.061)	$7.9	$130
AFOLU-3.	Rural Forestry	(0.042)	(0.084)	(0.88)	(0.88)	$115	$131
	Agriculture, Forestry and Other Land Use Sector Totals	**(0.071)**	**(0.15)**	**(1.7)**	**(2.7)**	**$408**	**$150**
WM-1.	Landfill Methane Gas	(0.13)	(0.13)	(2.1)	(2.2)	($153)	($71)
WM-2.	Water Sanitation and Reuse for Industrial Processes and Irrigation	(0.037)	(0.051)	(0.76)	(0.98)	($2,082)	($2,133)
	Waste Management Sector Totals	**(0.17)**	**(0.19)**	**(2.9)**	**(3.1)**	**($2,235)**	**($712)**
	Total Integrated Plan Results	**(2.6)**	**(4.4)**	**(53)**	**(68)**	**($70,171)**	**($1,039)**

All values adjusted for intra- and inter-sector policy overlaps and interactions

Figure ExS-6. Cumulative GHG Reduction Potential by SCAP Policy

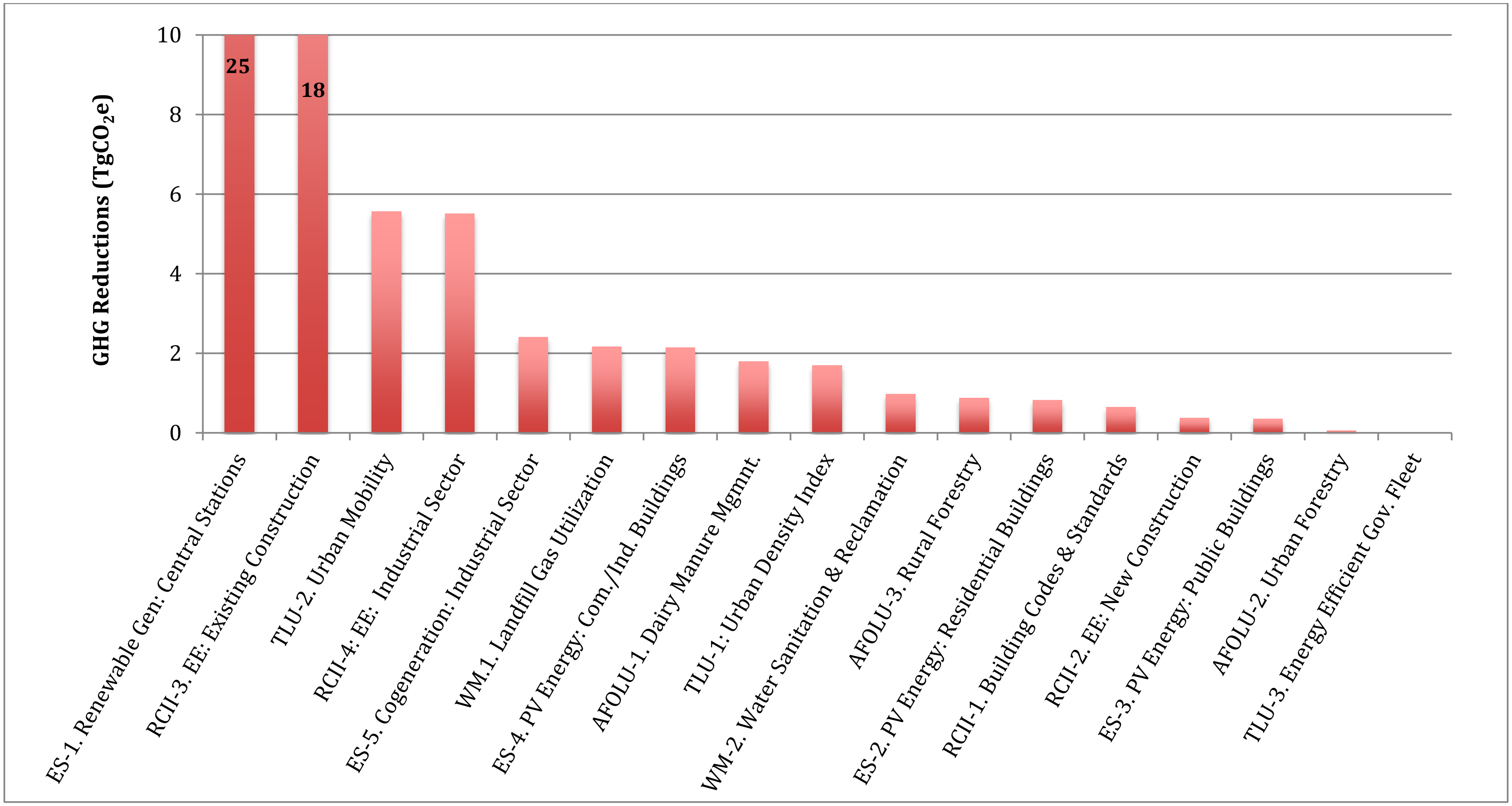


Figure ExS-7. Cost Effectiveness of each SCAP Policy

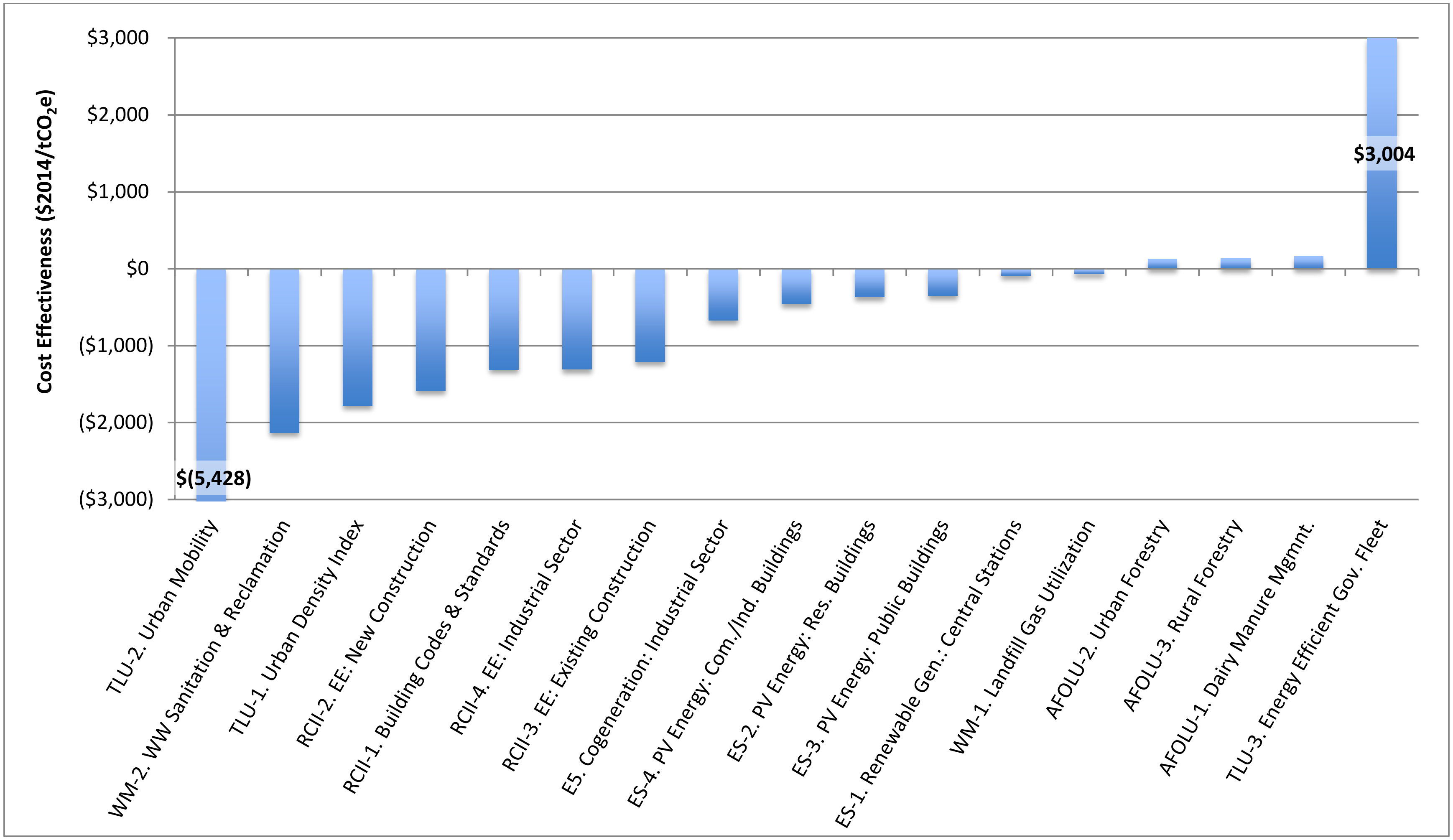
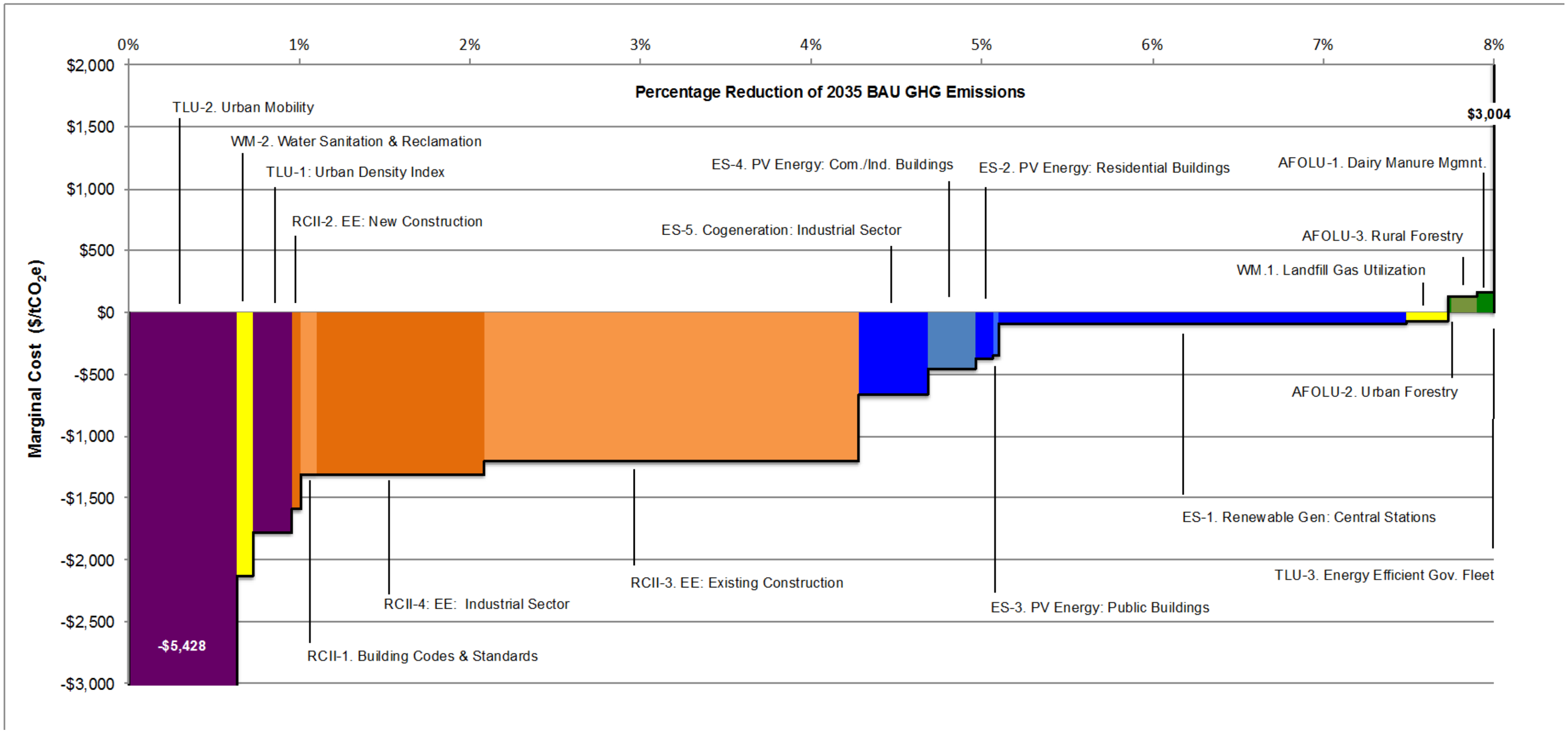


Figure ExS-8. Marginal Abatement Cost Curve for the Coahuila SCAP



Key Findings and Recommendations

The PE, in consultation w/ the project Partners, developed the proposed priority policy recommendations for detailed analysis in Phase 2. The Coahuila Climate Advisory Group (CAG) endorsed these policies at their first meeting in July, 2015. These recommendations are presented later in this summary and presented in more detail in the subsequent chapters and appendices. They also determined that there would not be a policy recommendation for a proposed state GHG reduction goal at this time. Some of the key results and highlights are:

- As summarized above in Table ExS-1, there are 17 multi-sector policy recommendations that were analyzed and which are included in this proposed SCAP;
- As shown below in Table ExS-2, these policies were analyzed quantitatively and, if all are implemented in a timely manner, are projected to result in a reduction of GHG emissions in Coahuila of 4.4 $TgCO_2e$ in 2035 (8% of BAU forecasted emissions);
- These policies are projected to have a net direct societal savings of over 70 billion pesos ($2014) cumulatively during the period of 2016 - 2035. The weighted-average cost-effectiveness of these policies is expected to be -$1,039 ($2014/tCO_2e);
- During the course of the Phase 2 SCAP process, the CCS 2010 GHG Inventory and Forecast was extended from 2025 to 2035 using simple trend analysis. These adjustments were factored into the CAP baseline during the course of the quantification process for the policy options (as a result, some minor differences in results as compared to those shown in the original 2010 baseline provided in Appendix A should be expected). The current GHG baseline indicates that the State's net emissions will increase by over 80% between 2010 and 2035 under business as usual conditions. Key sectors contributing to this growth are ES (almost all of this from the power supply subsector), and Industry (primarily, from the cement and iron & steel subsectors); and
- An annual economy-wide GHG reduction of over 4 $TgCO_2e$ in 2035 seems like a reasonable start towards GHG management in Coahuila (as compared to current emissions levels of around 34 $TgCO_2e$). However, due to expected steep emissions growth, these reductions fail to bend the expected BAU emissions curve of the State. This is shown graphically in Figure ExS-9 below. Additional work to update/refine the BAU forecast is warranted, since in many cases, the emissions are forecasted using simple techniques, including extrapolation of historic trends.[7] However, strengthening of these initial CAP policies and additions of others will certainly be needed in order to change the future GHG trajectory in a more sustainable direction, as well as support Mexico to meet any national commitments that come from the recent Paris Accord.

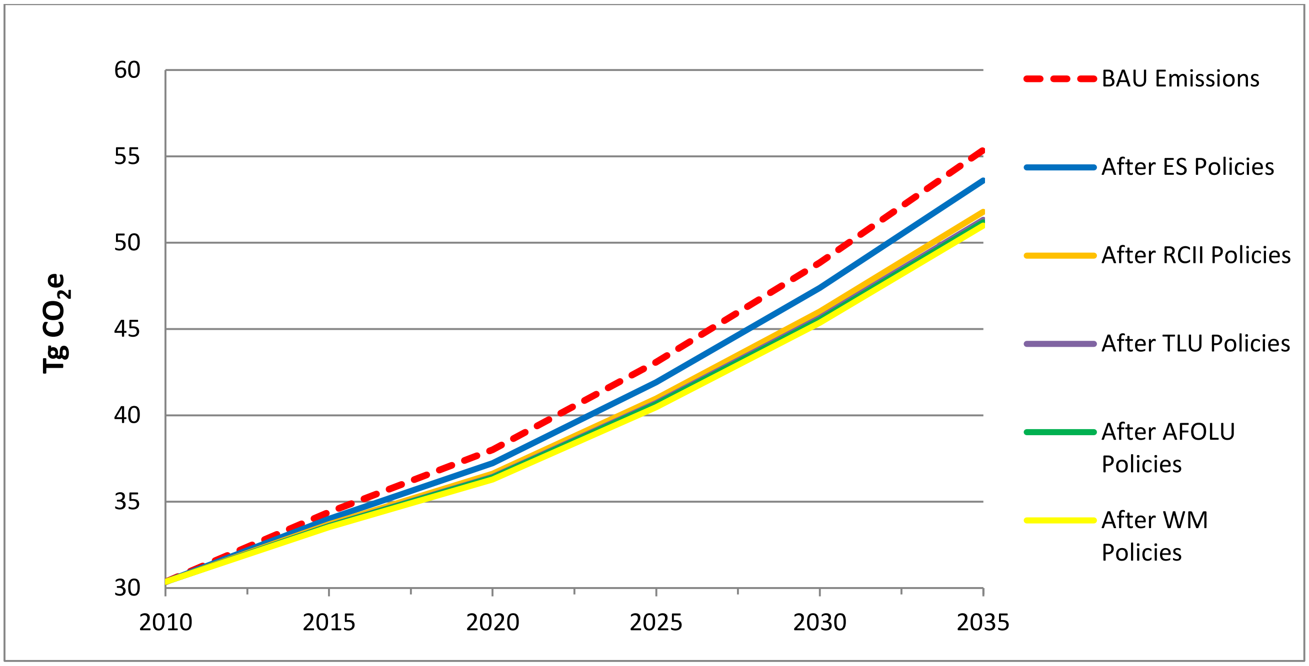
[7] There have been recent discussions about the timing for decommissioning the two coal plants in the State. This has not been factored in to the CO GHG baseline for this SCAP, and would have a significant impact on the overall size of the State's emissions pending an understanding of what types of generation would be used to make up for the lost capacity.

Table ExS-2. Sector-level GHG Reductions for the CO SCAP

Net Emissions ($TgCO_2e$)										
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Projected GHG Emissions	19	20	26	27	30	34	38	43	49	55
Reductions from Recent Actions[a]	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.07	0.07	0.07
Projected GHG Emissions After Recent Actions	19	20	26	27	30	34	38	43	49	55
Plan Reductions: ES Sector					0.0	*0.4*	*0.8*	*1.2*	*1.5*	*1.8*
Projected Emissions with ES Policies					30	34	37	42	47	54
Plan Reductions: RCII Sector					0.0	*0.3*	*0.6*	*0.9*	*1.4*	*1.8*
Projected Emissions with ES/RCII Policies					30	34	37	41	46	52
Plan Reductions: TLU Sector					0.00	*0.1*	*0.2*	*0.26*	*0.4*	*0.47*
Projected Emissions with ES/RCII/TLU Policies					30	34	36	41	46	51
Plan Reductions: AFOLU Sector					0.0	*0.0*	*0.0*	*0.07*	*0.1*	*0.15*
Projected Emissions with ES/RCI/Industry/TLU/AFOLU Policies					30	34	36	41	46	51
Plan Reductions: WM Sector					0.00	*0.1*	*0.1*	*0.17*	*0.2*	*0.19*
Projected Emissions with All Policies					30	34	36	40	45	51
Total GHG Reductions from Plan Policies					*0.0*	*0.9*	*1.7*	*2.6*	*3.5*	*4.4*
Emissions After Quantified Plan Policies	**19**	**20**	**26**	**27**	**30**	**33**	**36**	**40**	**45**	**51**

Values in red are interpolated from micro-economic analysis results.
[a] These reflect expected reductions in methane emissions from landfills and dairies that were not addressed in the 2010 inventory and forecast report.

Figure ExS-9. Sector-level GHG Reductions for the CO SCAP



Additional opportunities for reductions in the ES and RCII sectors are expected to be key areas to begin bending the GHG emissions curve for Coahuila. A combination of approaches addressing energy efficiency and renewable energy (both electricity and fuels) will be needed, which could build off of this initial SCAP policy set. Other policies should also be considered, including process input substitution in the cement and iron & steel sectors. Additional mitigation opportunities in other sectors could also be explored, especially in Transportation & Land Use. More details on the CO GHG emissions baseline, SCAP policies, and the direct impacts analysis can be found in Chapters 2 through 9 of the report.

- Following completion of the Phase 2 SCAP Report, 4 of the 17 policies analyzed will receive a more detailed assessment to formulate specific implementation strategies, including financing options, in a follow-up initiative by the Partners. For the balance of policies, SEMA will be responsible for determining how to prioritize, finance and promote their implementation.

Mexico's Intentional Nationally-Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC) includes an unconditional commitment to reduce BAU GHG and black carbon (BC) emissions by 25% by 2030.[8] This commitment implies a 22% GHG reduction and a 51% BC reduction. The INDC is consistent with Mexico's intent to reduce GHG emissions by 50% by 2050 relative to a year 2000 baseline.

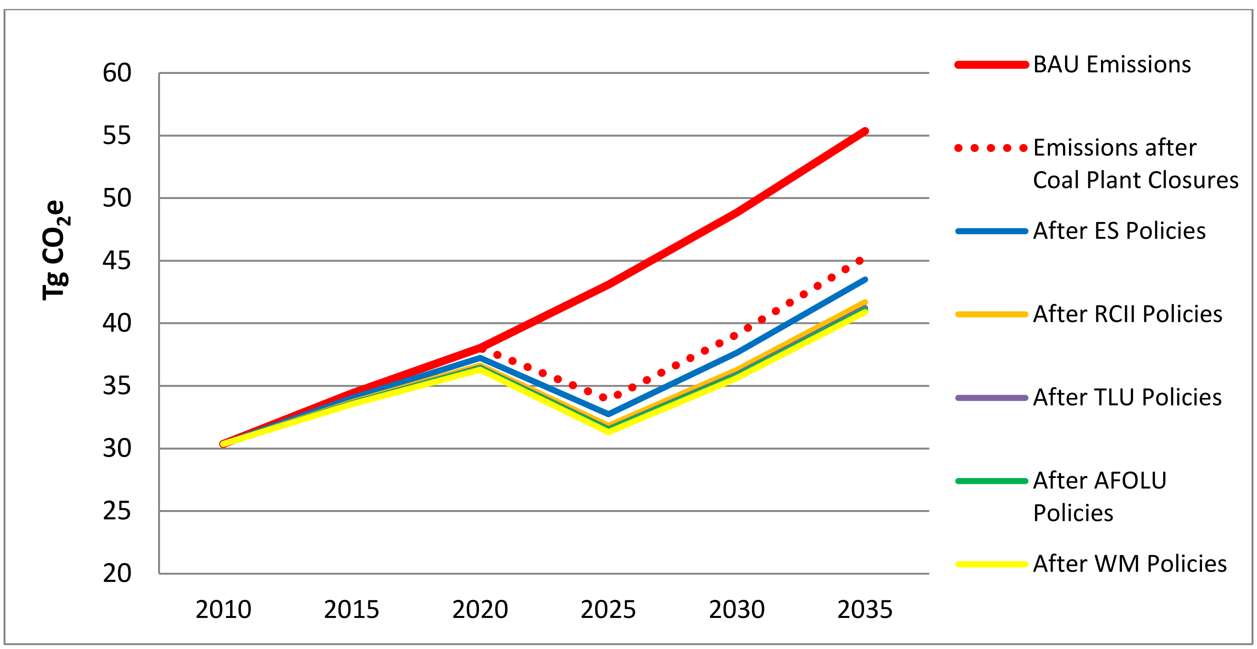
8 http://www4.unfccc.int/submissions/INDC/Published%20Documents/Mexico/1/MEXICO%20INDC%2003.30.2015.pdf. (Mexico indicates that the commitments are subject to support from developed countries).

At the December 2015 Paris climate conference (COP21), 195 countries agreed that GHG mitigation should reduce the expected increase in globally-averaged temperature to well below 2 degrees Celsius (ºC) and to aim for an increase of not more than 1.5 ºC, since this would significantly reduce the risks and impacts of climate change.[9] Collectively to date, the INDCs submitted by all nations are not expected to keep temperature rise below the 2 ºC threshold.

Significant GHG reductions will be needed from each of Mexico's states in order for the nation to achieve its intended reduction targets. The carbon intensity charts provided in Chapter 2 (Figures 2-4 and 2-5) indicate that Coahuila's emissions intensities (both per capita and per unit of GDP) are higher than the nation as a whole. This implies that emission reductions in Coahuila may need to be higher than for other states so that national commitments are met. Within this context, this initial SCAP for Coahuila sets the stage for future development of additional mitigation policies and potential strengthening of the policies adopted in this plan.

Regarding the potential closure of the two coal-fired power plants in the State, the potential impacts in relation to the SCAP final results presented in Figure ExS-9 above are shown in Figure ExS-10 below. This chart shows a substantial downward shift in BAU emissions (about 10 $TgCO_2e$) following closure of both plants in 2025 before emissions growth (in all sectors) pushes emissions higher in the following years. The impacts of SCAP policies are still similar to those shown in Figure ExS-9, since the electricity expected to be offset by RE/EE policies hasn't changed (i.e. still expected to be mostly natural gas combined-cycle generation). So, bending the emissions curve will still require additional or strengthened SCAP policies.

Figure ExS-10. Sector-level GHG Reductions for the CO SCAP with Coal Plant Closures in 2025



[9] European Commission: http://ec.europa.eu/clima/policies/international/negotiations/future/index_en.htm.

A State-level policy to work with the Federal government on a plan for coal plant closures could therefore reduce Coahuila's carbon intensity of electricity supply and its overall emissions substantially. The impacts shown in Figure ExS-10 assume that new generation in the form of natural gas combined-cycle plants would be constructed to make up for lost production only to the level needed by Coahuila's electricity demand. Therefore, other states that rely on imported electricity from Coahuila should also be involved in the development and implementation of a policy of this type.

Chapter 1
Background

Summary of Coahuila State Climate Action Plan – Phase 1

In June 2010 with funding from the Border Environment Cooperation Commission (BECC) the Center for Climate Strategies (CCS) completed an Inventory and Forecast (I&F) of Greenhouse Gas emissions in the state of Coahuila and several other northern border states of Mexico. Findings of this report are summarized in Chapter 2.

Following the I&F report, the State of Coahuila Secretary of Environmental Protection [Secretaria del Medio Ambiente (SEMA)] convened Phase 1 of the State Climate Action Plan (SCAP) process for Coahuila. The Secretary of SEMA formed the Coahuila Climate Advisory Group (CAG) to help guide the Phase 1 CAP process. A key objective of the Phase 1 process was to identify a broad range of potential state climate actions and to narrow that broad list into a set of high priority potential state GHG reduction policy actions for further detailed analysis in Phase 2.

The objectives for the Coahuila Phase 2 SCAP process were established in the Scope of Work (SOW) for CCS by BECC and the MLED Program at the outset of the process and are summarized in Chapter 3. The essence of the objectives was to develop a SCAP for Coahuila and to enhance State capacity in climate planning and analysis through a "learn by doing" approach directed by CCS. The multi-phase approach to developing the SCAP follows CCS' step-wise approach to action planning showed in Figure 1-1 below. This step-wise process and the analytical toolkit that supports its implementation are described in more detail in Chapter 3.

Through Phase 1 of the project, Steps 1 through 4 had been completed which included a GHG baseline and a set of priority policies for inclusion in the CO SCAP. Phase 2 initiated work on Step 5 and included the work through Step 9 to develop this final report on the SCAP.[10] Work is now underway on Step 10 which will involve the development of detailed implementation plans for the first set of SCAP policies.

Initial meetings of the CAG were held in 2011. CCS assisted the CAG and SEMA in developing the Coahuila Catalogs of Potential State Climate Action Policies.[11] They contained 337 potential policies for consideration in Coahuila. The CAG then set about the process of prioritizing the policies for potential further detailed analysis in a Phase 2 climate planning process, to come later. A total of 56 policies were selected by the CAG for further analysis.

The 10-Step Planning Process is supported by an Analytical Toolkit depicted in Figure 1-2 below. Components 1 (Baseline Tools) and 2 (Policy Catalogs) were developed and reviewed

[10] Note that a macroeconomic analysis of CO GHG mitigation policies was not included in this SCAP.
[11] "Catalogo De Politicas Publicas Para La Mitigacion Del Cambio Climatico" - Febrero 2011.

during Phase 1 of the SCAP development process. Component 3 (Policy Screening & Selection) began during Phase 1 with the selection of the initial list of 56 priority policies for consideration. Phase 2 of the SCAP process began with a further refinement of the policy priorities to focus on 17 key policies for detailed analysis in Phase 2. The focus of the work in Component 4 (Policy Design & GHG Target Setting) was on establishing initial policy designs and GHG reduction goals for each policy.

Figure 1-1. Step-Wise Action Planning Approach

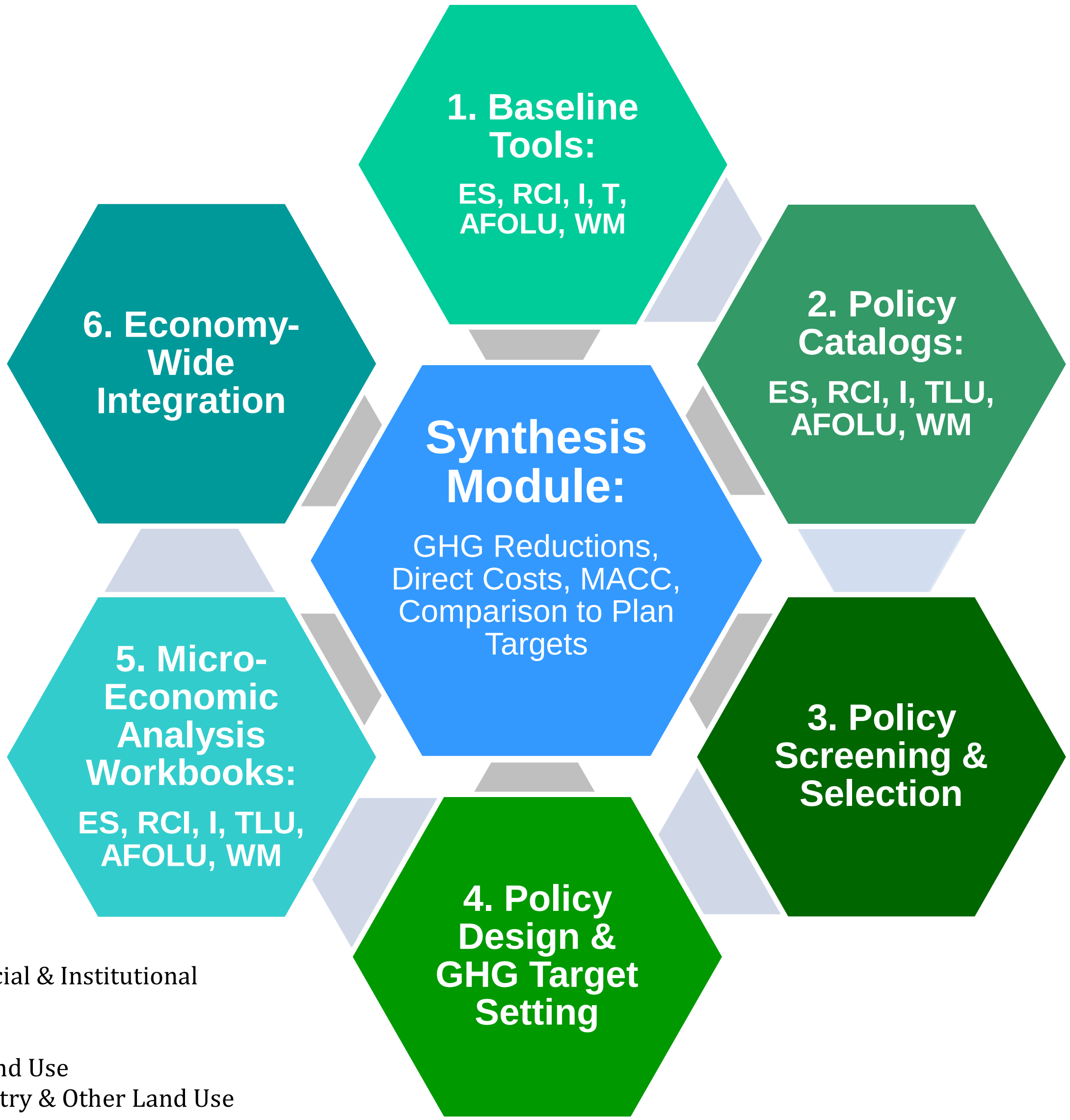
Step 1	**Organization and Goals**
Step 2	**Baseline Development**
Step 3	**Policy Options Identification**
Step 4	**Policy Screening & Prioritization**
Step 5	**Initial Policy Option Design Specifications**
Step 6	**Direct (Micro) Impacts Assessment**
Step 7	**Policy Options Integration and Overlap**
Step 8	**Indirect (Macro) Impacts Assessment**
Step 9	**Final Recommendations & Report Transmittal**
Step 10	**Monitoring, Reporting, Evaluation, & Updating**

Once the Coahuila Climate Advisory Group endorsed the 17 policies the direct impacts analysis using Component 5 of the Toolkit (Micro-Economic Analysis Workbooks) proceeded. This work was conducted in a learning-by-doing approach using sector-level experts provided by CCS and their PE counterparts. CCS then completed the direct impacts assessment work of integrating the results across policies into a set of economy-wide results (described in Chapter 3 of this report). That work, as well as the economy-wide baseline data, was all completed within the Toolkit's Synthesis Module.

Following the CAG meetings CCS and SEMA concluded the Phase 1 work in Coahuila by presenting the Final Report on the Coahuila Phase 1 SCAP process.[12] All of these priorities developed during the course of Phase 1 in 2011 were reviewed and considered as the Phase 2 Coahuila CAP process commenced in 2015. Following completion of the Phase 2 Final Report, CCS will team up with SEMA and the Partners on Step 10 of the planning process to conduct a detailed assessment of several selected high priority policies to chart out a more detailed implementation plan for these selected policies using the SCAP as a foundation.

[12] *Plan Estatal Contra el Cambio Climatico de Coahuila*, Agosto 2011.

Figure 1-2. Action Planning Analytical Toolkit



ES – Energy Supply
RCI – Residential, Commercial & Institutional
I – Industry
T – Transportation
TLU – Transportation & Land Use
AFOLU – Agriculture, Forestry & Other Land Use
WM - Waste Management

Chapter 2
Inventory and Forecast (I&F) of GHG Emissions

2.1 GHG I&F Overview

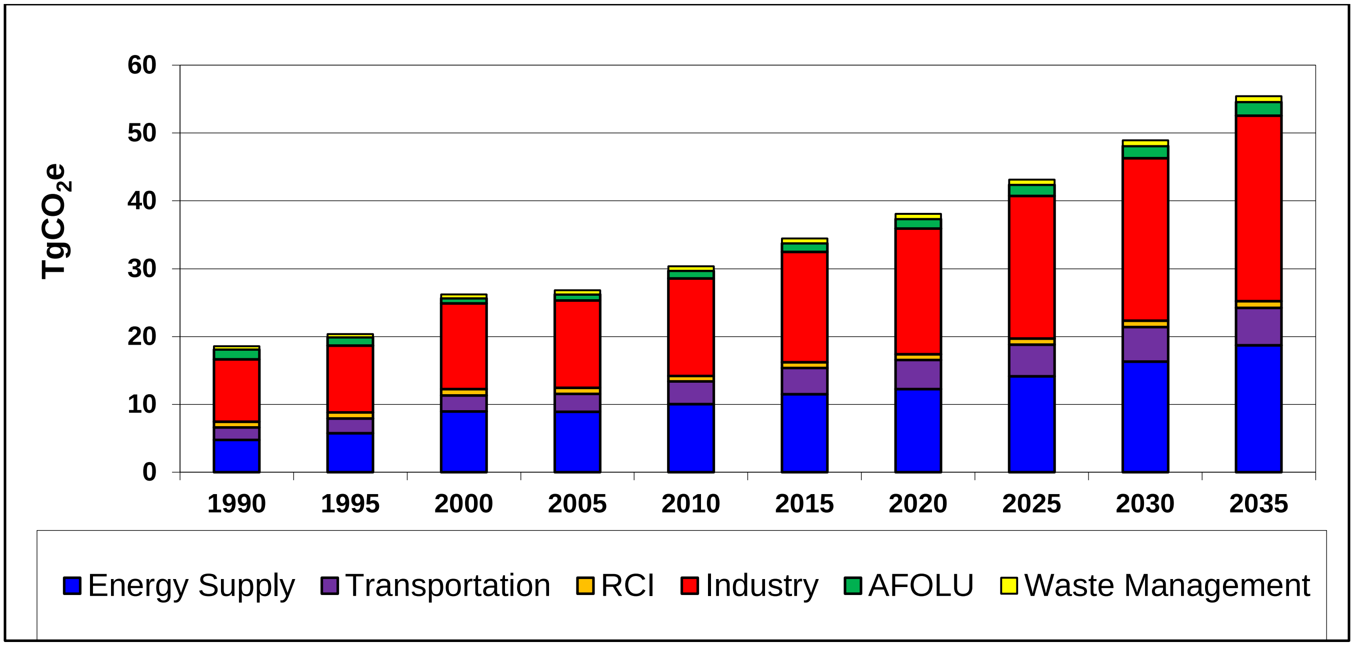
The inventory and business as usual (BAU) forecast (or "baseline") of GHG emissions was constructed primarily from the 2010 GHG I&F prepared by CCS.[13] As summarized in Figure 2-1 below, the baseline is economy-wide and includes annual emissions data for all sectors.

All sectors of Coahuila's economy were addressed in the baseline (see the materials provided in Appendix A for more details). These follow the common categorization used in national GHG reporting:

- Energy Supply (ES): for CO, this mainly addresses the Power Supply (PS) subsector; all emissions estimates for the PS subsector shown here and used for SCAP analysis purposes are provided on a *consumption* basis, rather than a direct (*production*) basis. This means that only emissions associated with electricity consumed within the State are included. Coahuila is a net exporter of power. Emissions associated with these power exports are not included in the consumption-based estimates.
- Residential, Commercial & Institutional (RCI): this covers emissions from fuel combustion in buildings in all three subsectors;
- Industry (I); this sector includes emissions from fuel combustion for industrial processes and buildings, as well as non-combustion emissions that occur from industrial processes;
- Transportation: most importantly fuel combustion in on-road vehicles, but also including air, rail and marine vessels;
- Agriculture, Forestry & Other Land Use (AFOLU): the agricultural subsector covers non-energy emissions associated with crop production and livestock management; the forestry and other land use sector primarily covers carbon sequestration; due to data limitations, emissions from fuel combustion in these sectors is included in the other energy end use sectors above (most of this use is likely aggregated with the Transportation sector); and
- Waste Management (WM): this includes the solid waste management and wastewater treatment subsectors; as with AFOLU, due to data limitations, emissions from fuel combustion in these sectors is included in the other energy end use sectors above (most of this use is likely aggregated with the Transportation sector).

[13] *Greenhouse Gas Emissions in Coahuila and Reference Case Projections 1990 – 2025,* the Center for Climate Strategies, June 2010. As discussed in further detail in a technical memorandum appended in Appendix A, the 2010 CCS baseline was extended to 2035. Therefore, the reader should expect some differences in the baseline values shown in the body of this report as compared to the values shown in 2010 report provided in Appendix A.

Figure 2-1. Coahuila's GHG Baseline



Sector	$TgCO_2e$									
	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
Energy Supply	4.8	5.7	8.9	8.9	10	12	12	14	16	19
Transportation	1.8	2.2	2.4	2.7	3.4	3.9	4.3	4.7	5.1	5.5
RCI	0.88	0.89	0.94	0.87	0.79	0.82	0.85	0.89	0.94	0.99
Industry	9.2	9.9	13	13	14	16	19	21	24	27
AFOLU	1.5	1.2	0.79	0.93	1.1	1.3	1.4	1.6	1.8	2.0
Waste Management	0.45	0.50	0.54	0.59	0.64	0.69	0.73	0.77	0.82	0.87
TOTAL NET Emissions	**19**	**20**	**26**	**27**	**30**	**34**	**38**	**43**	**49**	**55**

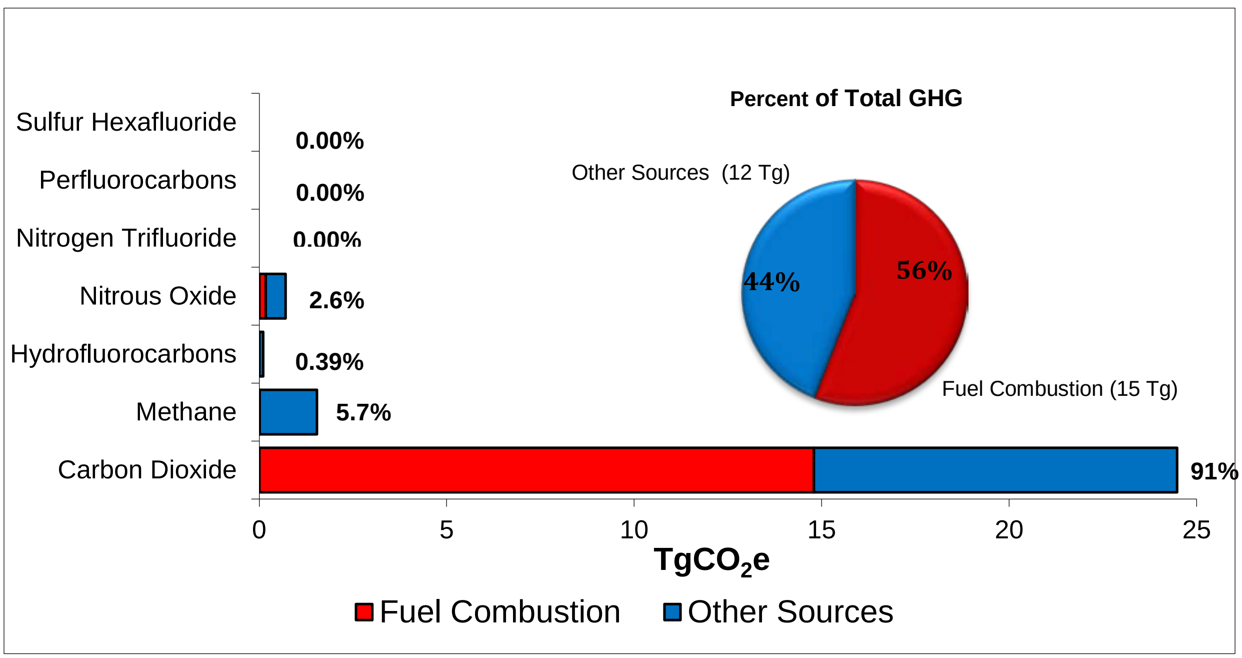
The baseline estimates are presented in units of teragrams (Tg) of carbon dioxide equivalent (CO_2e) emissions (1 Tg is equal to 1 million metric tons). These estimates include all GHG emissions within each sector and put them in common units based on their global warming potential (GWP). For this study, GWP's from the IPCC's Second Assessment Report (SAR) were used. As noted below, emissions for all GHGs required for national reporting by the Intergovernmental Panel on Climate Change (IPCC) were addressed; however, sources for all GHGs were not identified in Coahuila:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous oxide (N_2O);
- Hydrofluorocarbons (HFC);
- Sulfur hexafluoride (SF_6);[14]
- Perfluorocarbons (PFC);[15]
- Nitrogen trifluoride (NF_3).[16]

2.2 Additional GHG Baseline Details

Data to support historical (inventory) estimates varied by sector; however, data were generally available through 2008 when the baseline was originally constructed. Figure 2-2 below provides a summary of the contribution of each gas to the total 2005 GHG emissions for CO. As shown, CO_2 is the dominant GHG contributing over 90% of the total emissions on a CO_2e-weighted basis. The chart also shows contributions of each gas from fuel combustion or non-combustion sources. Fuel combustion emissions tend to dominate GHG baselines in most jurisdictions. While these are also the majority in Coahuila (56%), non-fuel combustion emissions contributions from industrial processes are key contributors (iron & steel, cement, and use of carbonates).

Figure 2-2. 2005 Combustion and Non-Combustion Emissions by GHG

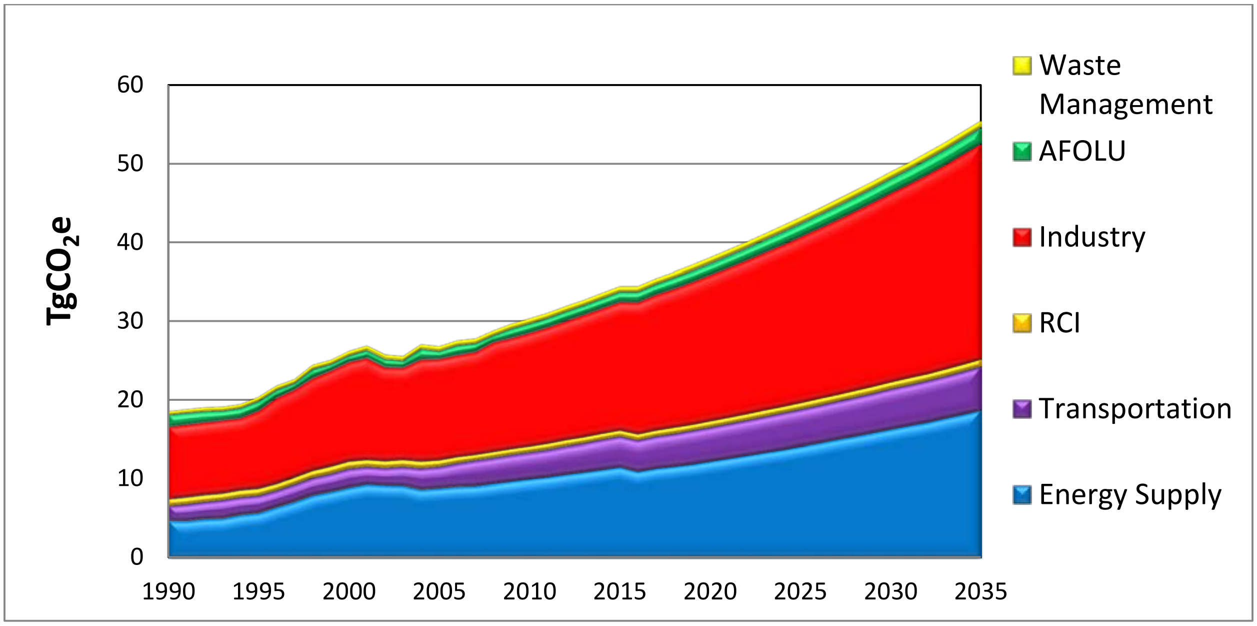


[14] Although emissions would be expected to occur from electrical systems equipment that use this compound as an insulator, no data were identified to generate emissions estimates.
[15] No emissions sources were identified: e.g. electronics manufacturing that would use this compound as a cleaning agent.
[16] Same as for PFC above.

SF_6 emissions are not included for Coahuila due to data availability during the original construction of the baseline; although some small level of emissions is expected within the power supply subsector (it is used as an insulator within electrical equipment). Emissions of PFCs and NF_3 may also occur in small quantities (e.g. the electronics industry).

As shown in the chart and supporting table of Figure 2-1, as well as Figure 2-3 below, emissions are expected to more than double from the year 2005 to the end of the planning period in 2035. The emissions are shown on a "net" basis, meaning that carbon sinks have been subtracted from the overall emissions totals (these carbon sinks occur in the AFOLU and WM sectors).[17] As indicated in the results shown in Figure 2-3, the ES and Industry sectors are expected to contribute to most of the emissions growth in Coahuila during the forecast period. In fact, emissions from both of these sectors are expected to double between the years 2005 and 2035.[18]

Figure 2-3. Coahuila's Net GHG Baseline by Sector



Note: within Energy Supply, Power Supply emissions are shown on a consumption-basis (excluding emissions from net power exports).

Figures 2-4 and 2-5 provide emissions intensities on a per capita basis and per unit of economic output basis, respectively. Due to a relatively low population and the presence of heavy industry in the State, Coahuila's carbon intensity is higher than the forecasted national carbon intensity and is expected to remain higher on a per capita basis (note that these carbon intensity charts exclude emissions associated with power exports). Carbon intensities are expected to increase

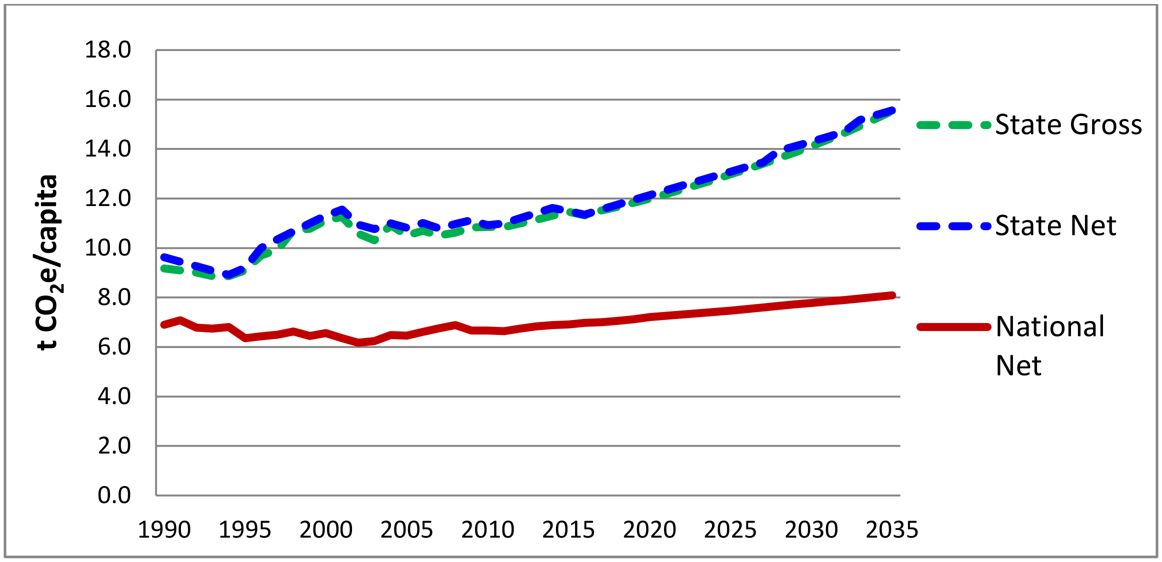
[17] Note that since carbon sinks in CO are relatively small, GHG emissions presented on a net basis are similar to those shown on a gross basis (i.e. sources only).

[18] There have been recent discussions by the national government about the potential closure of one of the State's 2 coal-fired power plants. This would have a significant impact on forecasted emissions; however, no changes to the operation of these plants has been considered in this GHG baseline.

sharply during the forecast period as economic output (and expected average personal income) increase leading to higher levels of energy consumption. Since Coahuila has relatively low rates of carbon sequestration, the State per capita carbon intensity is about the same whether measured on a net or gross basis.

On an economic output basis, Coahuila's carbon intensity is expected to continue to grow while that of the nation is expected to decline slightly during the forecast period. It's important to note that these carbon intensities are currently based on a simple extrapolation of the most recent 10 years of gross state/national product estimates,[19] not any sophisticated modeling of future economic activity.

Figure 2-4. Coahuila's Carbon Intensity Per Capita



[19] State and national annual economic output data for 2003-2013 were available from INEGI: http://www.inegi.org.mx/est/contenidos/proyectos/cn/pibe/.

Figure 2-5. Coahuila's Carbon Intensity Per Unit Economic Output

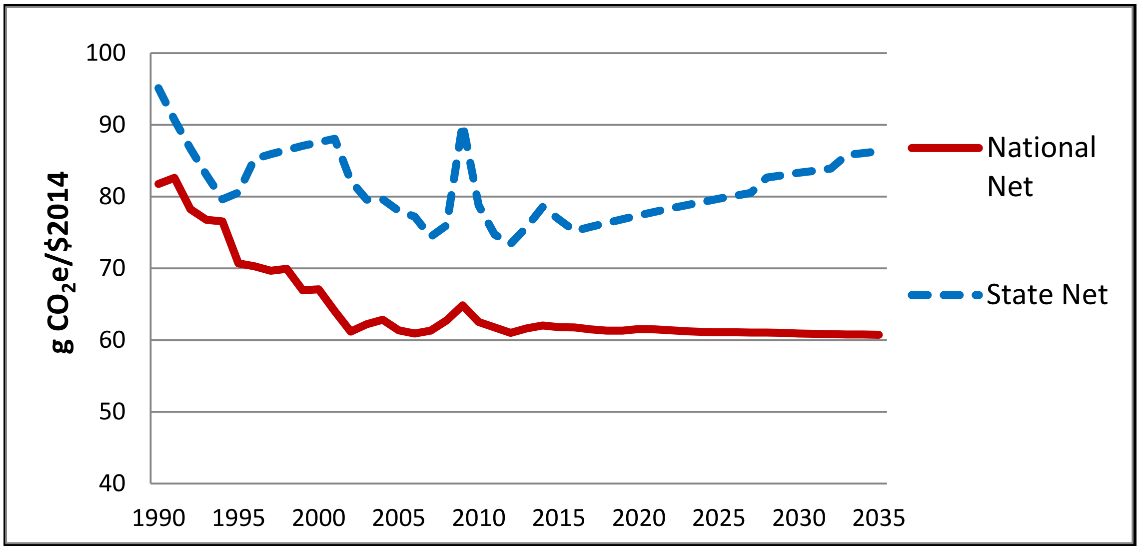
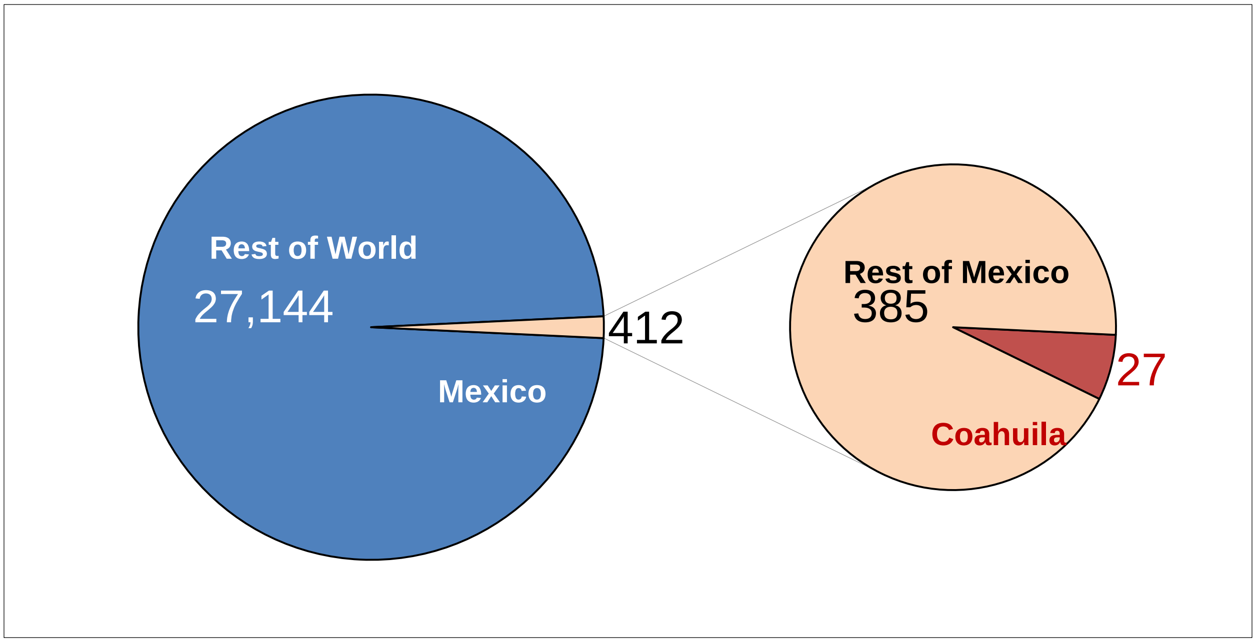


Figure 2-6 provides an indication of the national and global context of emissions for Coahuila. Using 2005 as a reference year for just carbon dioxide emissions, 27,556 TgCO_2 were emitted worldwide. Mexico emitted about 412 TgCO_2, which is about 1.5% of worldwide emissions. In Coahuila, 27 TgCO_2 were emitted (if all Power Supply sector emissions were included, the value would be 38 TgCO_2). This represents about 6.6% of Mexico's emissions.[20] Assuming Mexico's future emissions follow the growth from 2000 – 2010, the national net emissions would be around 1,147 TgCO_2e in 2035. Coahuila would contribute around 4.8% of national emissions in 2035 (55 TgCO_2e).[21]

[20] World Resources Institute – Climate Analysis Indicators Tool, www.wri.org/tools/cait/, accessed January 2013.
[21] Assumes the 2000 – 2010 growth rate nationally continues through 2030. Historical national emissions were taken from: *Inventario Nacional de Emisiones de Gases de Efecto Invernadero 1990-2010*, http://www.inecc.gob.mx/descargas/cclimatico/inf_inegei_public_2010.pdf.

Figure 2-6. National and Global Context of 2005 Coahuila CO_2 Emissions, $TgCO_2$



Additional sector-level baseline information assembled for the CO SCAP is provided at the beginning of Chapters 4 through 8. Details on methods and data sources used during baseline construction can be found in Appendix A.

Chapter 3
Coahuila State Climate Action Plan – Phase 2

3.1 Background and Objectives of the Phase 2 Process

Since 2009, the Border Environment Cooperation Commission (BECC) has been supporting the border region on climate change related issues. During 2009-10, the Center for Climate Strategies (CCS) collaborated with experts and institutions in the six Mexican border-states in the development of greenhouse gas emissions inventories (initial year 1990) and forecasts to 2025 for Coahuila and the other border-states. These activities by CCS were carried out within a framework of collaboration between BECC and the US Environmental Protection Agency (EPA), and in coordination with Mexico's National Institute of Ecology and Climate Change (INECC).

In 2010 - 2011, BECC sponsored CCS in working with the states of Baja California, Sonora and Coahuila in developing Phase 1 CAPs for each state. The Phase 1 State Climate Action Plan (SCAP) process for Coahuila was described in Chapter 1. A key objective of the Phase 1 process was to identify a list of high priority State GHG reduction policy options for further detailed analysis in Phase 2. Selection of these priority policy options in the Phase 1 process in each State was designed to set the stage for the detailed policy design and technical analysis to be conducted in Phase 2.

For the Coahuila Phase 2 effort, the following objectives were agreed upon:

- Enhance State capacity to conduct climate planning and analysis through a "learn by doing" approach directed by CCS that includes policy design and direct impacts analysis (GHG reductions and net societal costs) of mitigation policy options.
- Develop an initial Coahuila SCAP which includes design and micro-economic level analysis (direct GHG reductions and net societal costs/ savings) that can be used to commence the State's GHG mitigation efforts by targeting the 17 climate mitigation policies selected for initial detailed analysis during Phase 1, recognizing that additional measures or stronger versions of the initial measures will likely be needed over time. Now, with the Paris Accord in place, the level of ambition for emissions reduction in both developed and developing countries has become more widely known and accepted. Pursuit of Mexico's contributions to this global effort will require significant efforts by State governments. While State target setting was not part of the Phase 2 effort, Coahuila is now positioned to assess its part in achieving the global and national GHG reductions necessary to support the levels anticipated in the recent Paris Accord.
- Prepare a draft and final report of the Coahuila SCAP.

3.2 Participating Institutions

BECC financed and sponsored the Phase 1 level work in the three States described above. BECC then teamed up with the U.S. Agency for International Development (USAID)/ Mexico Low Emissions Development (MLED) Program to help finance and sponsor the Phase 2 process in two States, Baja California and Coahuila. BECC and the MLED Program then engaged CCS to assist in facilitating, training and providing technical support for the Phase 2 process. For the Phase 2 Coahuila SCAP process, the following entities have joined together as Partners in this collaborative effort:

- The Secretaria de Medio Ambiente (SEMA) is the state environmental agency for the State of Coahuila for whom the SCAP has been prepared;
- The Border Environment Cooperation Commission (BECC) is a sponsoring organization which provided significant funding for the project;
- The USAID MLED Program is a second sponsoring organization which provided significant funding for the effort;
- The Center for Climate Strategies (CCS) is a non-profit entity that was contracted by BECC and the MLED Program to perform technical, facilitative and project management services in developing the Coahuila SCAP.

3.3 Panel of Experts - Members and CCS Training

One of the primary objectives of the Coahuila SCAP process was to help build State capacity in the climate action planning process and in technical analysis associated with micro-economic (direct) impacts analysis of GHG mitigation strategies. To this end, a local Panel of Experts (PE) was formulated at the outset of the SCAP process. The capacity building process was designed from the outset to be a learn-by-doing effort in which CCS trained the PE in policy design, technical analysis, and other foundational topics, as needed (e.g. GHG baseline construction), and then shared the workload of actually conducting the technical analysis of the selected policy recommendations. Following is a list of the Members of the PE and their affiliations. Also presented is a brief summary of the training initiatives provided to the PE by the CCS Team.

<u>Members of the Coahuila Panel of Experts</u>:

- Dr. Alejandro Dávila, Universidad Autónoma de Coahuila, Local Coordinator and Transportation and Land Use Sector
- Dr. Miriam Valdés Ibarra, Universidad Autónoma de Coahuila, Energy Supply and Residential, Commercial, Institutional and Industrial Sectors
- Dr. Antonio Escamilla Díaz, Universidad Autónoma de Coahuila, Agriculture, Forestry and Other Land Use, and Waste Management Sectors

CCS Training of the Panel of Experts:

CCS provided two in-person training sessions for the members of the PE and Partners representatives. Following is a short summary of each of the training sessions:

- Mitigation Policy Design Workshop: Four members of the CCS Team travelled to Saltillo to provide the first training session in May 2015. The focus of this workshop was to provide training to the Panel of Experts and other invited participants in the CCS step-wise SCAP planning process. This included training in the development of the Policy Description, Policy Design, Implementation Mechanisms, Related Policies and Programs in Place elements of the Policy Option Template, as well as training in development of Causal Chains for each policy option. This training session was designed to equip the PE members with the basic understanding needed to develop the first half of the Policy Option Template for each policy prior to embarking on the analytical process for the policies.

- Climate Mitigation Policy Micro-Economic Analysis Workshop: Four members of the CCS Team travelled to Saltillo for this training session that was held in July 2015. The focus of this session was to provide detailed instruction in the micro-economic (direct impacts) analysis of the policy options in each sector. Sessions addressed the Quantification Memo (focusing on quantification of the net costs and GHG effects of micro-economic policy impacts), Common Assumptions, formulation of Excel workbooks, the Data sources, assumptions and methodology needs, exporting of results for macro-economic analysis, and the data exports for inter-sector overlaps/integration analysis. It also included discussions about the roles, assignments, division of labor and schedules for completion of tasks between CCS and the PE.

In addition to the formal training sessions above, the CCS Sector leads spent extensive additional time on phone calls working with their PE colleagues to train them in the details of policy design, the micro analysis process including the development of Excel workbooks, and the development of Policy Option templates for each policy, as well as coaching them and in reviewing and commenting on the actual work of the PE members on individual policies.

3.4 Advisory Group and Technical Work Groups

Advisory Group

At the outset of the Phase 2 SCAP process SEMA formed an Advisory Group (AG) which was responsible for participating as stakeholders in the process, and for reviewing and approving the design of the policy options and the results of the analyses prepared by the PE and CCS. The AG consists of 25 members which are specialists in climate change and in the various sectors. The members come from the government, business, academia and civil society sectors. The AG Members are listed in Chapter 1.

The first official meeting of the AG was held on July 15, 2015 to endorse the selection and design of the highest priority policy options recommended by the Panel of Experts. The second AG meeting was held on December 1, 2015 to endorse the full Policy Option Documents (PODs) and the results of the micro-economic impact analysis of the policy options in each sector.

Technical Work Groups

At the outset of the Phase 2 SCAP process, five sector-based Technical Work Groups (TWGs) were formed to help advise the AG and PE. They consisted of approximately 8 members each. These individuals are knowledgeable persons regarding the social impacts of policies and are specialists in their respective economic sectors. They are public officials of the three levels of government, entrepreneurs, members of academia or of a civil society organization. The TWGs held several meetings between the AG meetings and were consulted about the development of the PODs for each sector and about the preliminary quantification results of the policies.

3.5 Overview of the Phase 2 Micro-Economic Analysis Methodology

Micro-economic (direct impacts) analysis addresses two main impacts for climate action planning: net energy and GHG impacts; and net direct societal costs. CCS provided a "Principles and Guidelines for Quantification of Policy Options" Technical Memorandum (see Appendix B) to the PE that: outlined the overall approach for conducting the analysis of each policy, provided examples of direct policy impacts that should be addressed, included example calculations of net GHG and direct net societal costs, and established the following key planning metrics, concepts and parameters:

- *Planning period*: 2016 – 2035; although the initial year of implementation for any policy might begin further into the future than 2016;
- *Net GHG reduction potential*: expressed as teragrams (Tg; million metric tons) carbon dioxide equivalent (CO_2e) removed, including net effects of carbon sequestration or sinks, measured as an incremental change against a forecasted business as usual (BAU) baseline; where very small denominations of GHGs are involved use of metric tons (tCO_2e);
- *Global warming potentials (GWPs)*: consistent with the GHG Baseline, 100-year GWPs for each GHG from the IPCC Second Assessment Report;
- *Direct economic impacts*: the two key analytical endpoints are cost effectiveness (expressed as $/tCO_2e$ removed); and net societal costs/savings, presented as the net present value (NPV) of the stream of annualized costs/savings incurred to implement the policy over the planning period; these analyses include avoided costs of policy options, such as energy savings and avoided cost of investment in infrastructure or services from energy efficiency or other measures;
- *Financial base year*: 2014;
- *Discounting or time value of assets*: 5 %/yr real and 7 %/yr nominal, applied to net flows of costs or savings over the CO SCAP planning horizon (implementation year – 2035);
- *Full energy-cycle impacts*[22]: for example, assessing embedded GHGs in the fuel supply, in addition to those from fuel combustion (e.g. for gasoline, this includes the emissions associated with petroleum extraction, processing and transport); and
- *Levelized costs*: an averaging method for directly comparing the costs of one technology against another.

[22] Due to data limitations for Mexico, screening-level estimates were developed using upstream emission factors for fuels based on US national data derived from the US Department of Energy Argonne National Labs GREET Model: https://greet.es.anl.gov/.

See Appendix B for details. The appendix also discusses the difference between "stand-alone" and integrated policy analysis results:

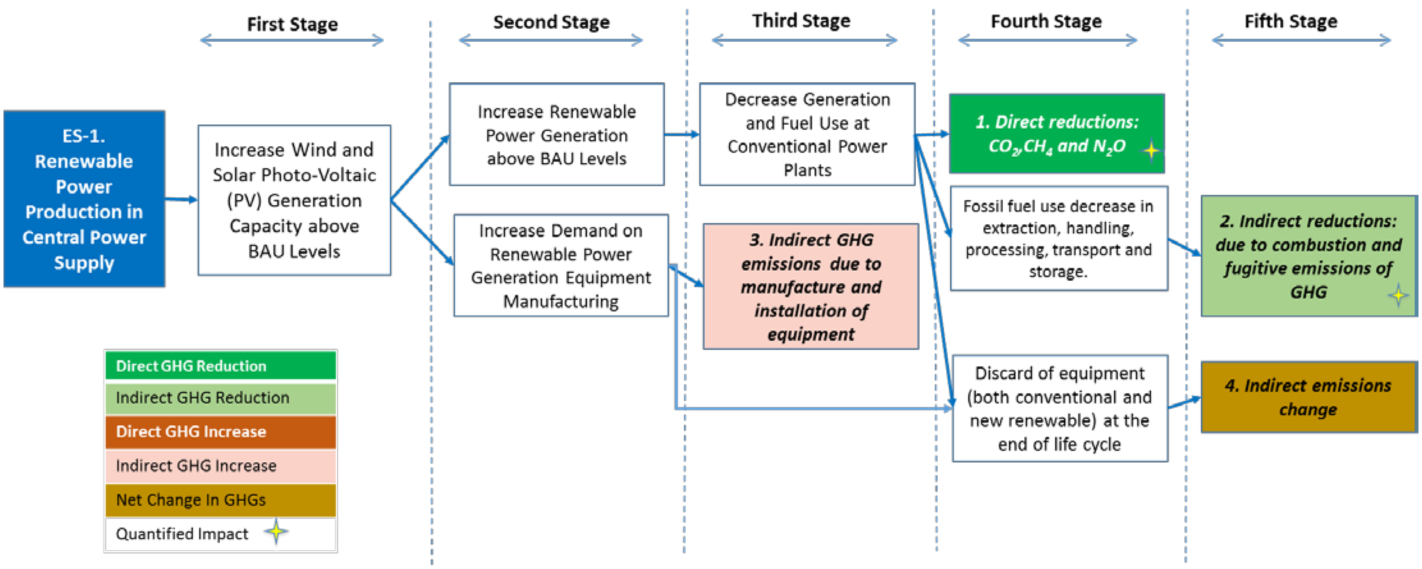
- *"Stand-Alone Results"*- these results are quantified under the assumption that the policy is the only one to be implemented, and the impacts are evaluated against business as usual (BAU) conditions (e.g. as informed by the GHG Baseline);
- *Integrated Results* – these separately address:
    - *Intra-sector integrated results:* these results include adjustments to estimated GHG reductions and costs in situations where policies within a sector overlap with one another (e.g. a policy promoting energy efficient residential air conditioners and another policy promoting improvements to residential building envelopes);
    - *Inter-sector integrated results:* these results are adjusted for any interactions or overlaps between policies in different sectors. The most common example here is for electricity supply and demand policies. In a situation where the BAU electricity supply system is significantly changed as a result of all supply and demand policies (e.g. the carbon intensity of the marginal resource mix of the supply system has been lowered), then the GHG impacts of the demand-side policies will need to be adjusted (in this case, downward to account for the cleaner marginal resource mix). More is presented on this topic specific to the CO SCAP later in this Chapter.

Figure 3-1 provides an example causal chain developed for one of the policies analyzed for the SCAP (all policies are documented in the associated policy templates in Appendices C-G). The causal chain identifies each of the intended and unintended policy impacts and the subsequent energy and GHG impacts (green or red shaded boxes). The GHG impacts include those that were quantified during micro-economic analysis (those with the star symbol).

In this example, implementation of the policy will: increase the installed capacity of renewable generation resources (wind and solar photo-voltaic) at central power stations above BAU conditions (first stage); this will result in an increase in renewable power generation in the second stage as compared to BAU (second stage); as a result, there will be decrease (an offset) of power generation required from fossil-based power plants (third stage). In the fourth stage, emission reductions would occur at the fossil-based plants due to the generation offset (a direct decrease in emissions, as it will occur at the point of combustion). Separately, due to the lower fuel demands for fossil power plants (also in the fourth stage), there are additional indirect reductions for the upstream fuel supply (e.g. coal, petroleum and natural gas extraction, processing, and shipping/transmission).

An unintended consequence of the policy shown in the second series of links in the chain begins in Stage 2. Indirectly, an emissions increase would occur during manufacturing and installation of the renewable generation resources (although this increase may occur outside of Coahuila). Also shown at the bottom of the fourth stage is another unintended impact of the policy. This indicates that emissions would occur during decommissioning of both fossil fuel power plants (potentially earlier than under BAU conditions) and for the new renewable resources targeted by the policy (e.g. photo-voltaic panels or wind turbines and associated electrical equipment). Depending on the size of the emissions impacts between decommissioning conventional plants and new renewables, the resulting net GHG impact could be positive or negative. Impacts without a star symbol are expected to be relatively small and/or temporary, and so were not included in the direct impacts analysis.

Figure 3-1. Causal Chain of GHG Reductions for a Renewable Energy Policy



3.6 Summary of CO SCAP Micro-Economic Analysis Results

Table 3-1 below provides a summary of the micro-economic analysis for all SCAP policies. These results have been adjusted for both *intra*- and *inter*-sector policy overlaps and interactions, and for that reason, these results will not always match those shown for the policy-specific analyses documented in Chapters 4 through 8. Intra-sector overlaps and interactions are those that occur between policies in the same sector. Inter-sector overlaps and interactions occur between policies in different sectors (see the respective sector chapters for details on overlaps and interactions). Results for each policy include:

- annual GHG reductions expected in 2025 and 2035;
- 2016 – 2035 cumulative in-State reductions;
- 2016 – 2035 total cumulative reductions;[23]
- net present value (NPV) of direct societal costs or savings in million 2014 pesos;
- cost effectiveness of the policy: calculated as the NPV divided by the total cumulative GHG reductions.

Figure 3-2 and the associated tabular results below provide a summary of the SCAP policy reductions by sector as compared to the GHG baseline. As shown in this chart, most of the reductions are attributed to the ES and RCII sectors (about 79% of total cumulative GHG

[23] For example, these include the upstream energy-cycle emissions that may not occur within the State's boundaries.

reductions through 2035). TLU sector policies contribute about 11% of the total cumulative GHG reductions through 2035. The AFOLU and WM sector policies are expected to contribute another 10% in total cumulative GHG reductions through 2035. However, the expected GHG reductions estimated for the SCAP policies are generally in line with the expected emission contributions from each sector – combined, the Transportation, AFOLU and WM sectors are expected to only contribute about 15% toward projected 2035 emissions.

The overall results shown in Figure 3-2 indicate that more work will be needed on GHG mitigation in Coahuila before the expected emissions curve is flattened or pushed into a downward trajectory (i.e. emissions are still far from peaking by 2035). Hence, more policies, more stringent SCAP policies, or both will be needed.

Mexico's Intentional Nationally-Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC) includes an unconditional commitment to reduce BAU GHG and black carbon (BC) emissions by 25% by 2030.[24] This commitment implies a 22% GHG reduction and a 51% BC reduction. The INDC is consistent with Mexico's intent to reduce GHG emissions by 50% by 2050 relative to a year 2000 baseline.

At the December 2015 Paris climate conference (COP21), 195 countries agreed that GHG mitigation should reduce the expected increase in globally-averaged temperature to well below 2 degrees Celsius (ºC) and to aim for an increase of not more than 1.5 ºC, since this would significantly reduce the risks and impacts of climate change.[25] Collectively to date, the INDCs submitted by all nations are not expected to keep temperature rise below the 2 ºC threshold.

Significant GHG reductions will be needed from each of Mexico's states in order for the nation to achieve its intended reduction targets. The carbon intensity charts provided in Chapter 2 (Figures 2-4 and 2-5) indicate that Coahuila's emissions intensities (both per capita and per unit of GDP) are higher than the nation as a whole. This implies that emission reductions in Coahuila may need to be higher than for other states so that national commitments are met. Within this context, this initial SCAP for Coahuila sets the stage for future development of additional mitigation policies and potential strengthening of the policies adopted in this plan.

[24] http://www4.unfccc.int/submissions/INDC/Published%20Documents/Mexico/1/MEXICO%20INDC%2003.30.2015.pdf. (Mexico indicates that the commitments are subject to support from developed countries).
[25] European Commission: http://ec.europa.eu/clima/policies/international/negotiations/future/index_en.htm.

Table 3-1. Summary of CO SCAP Micro-Economic Analysis of Policies and Results (Part 1)

Policy ID	Policy Name	2025 In-State Annual Reductions ($TgCO_2e$)	2035 In-State Annual Reductions ($TgCO_2e$)	Cumulative In-State 2016-2035 ($TgCO_2e$)	Cumulative Total 2016-2035 ($TgCO_2e$)	NPV Costs / Savings 2016-2035 ($2014MM)	Cost Effectiveness ($2014 / tCO_2e)
ES-1.	Electricity production through renewable energy technologies (photovoltaic panels, wind generators) in Central Station Power Supply	(0.92)	(1.31)	(18.5)	(25)	($2,179)	($89)
ES-2.	Photovoltaic energy in residential buildings	(0.034)	(0.054)	(0.64)	(0.82)	($304)	($369)
ES-3.	Photovoltaic energy in public buildings	(0.015)	(0.021)	(0.27)	(0.35)	($124)	($352)
ES-4.	Photovoltaic energy in commercial and industrial buildings	(0.078)	(0.15)	(1.6)	(2.1)	($983)	($458)
ES-5.	Cogeneration in the industrial sector	(0.12)	(0.22)	(2.4)	(2.4)	($1,614)	($670)
	Energy Supply Sector Totals	**(1.2)**	**(1.8)**	**(23)**	**(30)**	**($5,203)**	**($172)**
RCII-1.	Building Codes and Standards	(0.025)	(0.049)	(0.51)	(0.65)	($855)	($1,311)
RCII-2.	Increasing energy efficiency in new constructions- Equipment (Appliances, solar water heaters, flow water heaters).	(0.014)	(0.029)	(0.29)	(0.38)	($601)	($1,590)
RCII-3.	Increasing energy efficiency in existing constructions, excluding industrial sector - Equipment (Appliances, lighting, solar water heaters, flow water heaters).	(0.72)	(1.2)	(14)	(18)	($21,262)	($1,206)
RCII-4.	Energy Efficient Equipment and Processes in the Industrial Sector	(0.18)	(0.54)	(4.3)	(5.5)	($7,200)	($1,307)
	Residential, Commercial, Industrial & Institutional Sector Totals	**(0.94)**	**(1.8)**	**(19)**	**(24)**	**($29,918)**	**($1,238)**

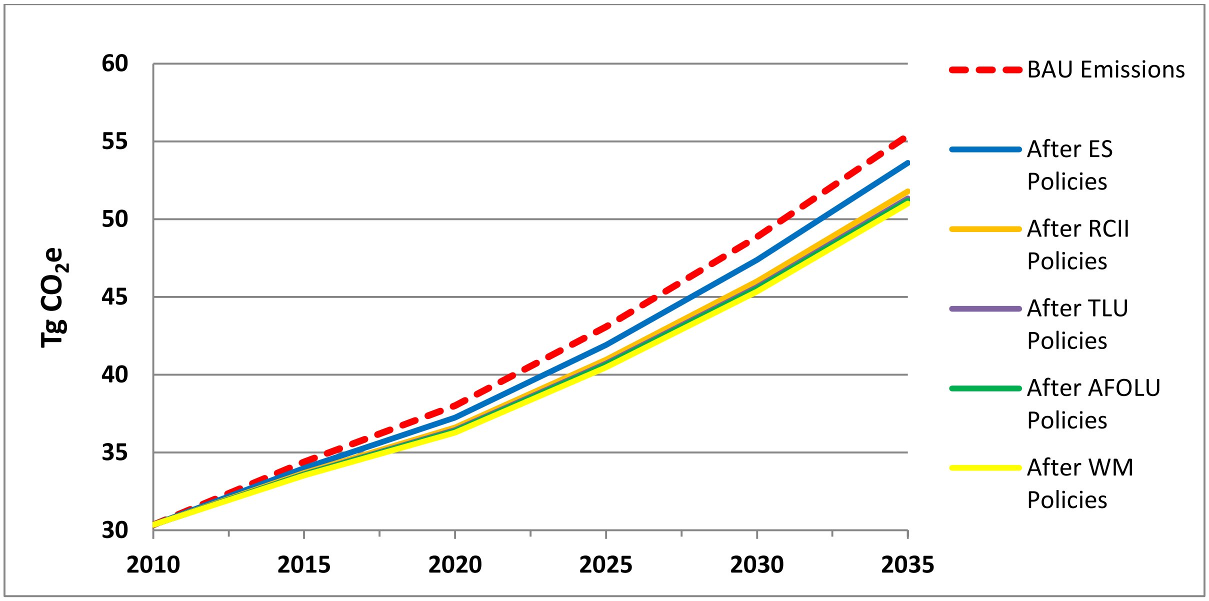
All values adjusted for intra- and inter-sector policy overlaps and interactions

Table 3-1. Summary of CO SCAP Micro-Economic Analysis of Policies and Results (Part 2)

Policy ID	Policy Name	2025 In-State Annual Reductions ($TgCO_2e$)	2035 In-State Annual Reductions ($TgCO_2e$)	Cumulative In-State 2016-2035 ($TgCO_2e$)	Cumulative Total 2016-2035 ($TgCO_2e$)	NPV Costs / Savings 2016-2035 ($2014MM)	Cost Effectiveness ($2014 / tCO_2e)
TLU-1.	Urban Density Index	(0.068)	(0.12)	(1.3)	(1.7)	($3,025)	($1,776)
TLU-2.	Sustainable Urban Mobility	(0.19)	(0.35)	(4.3)	(5.6)	($30,201)	($5,428)
TLU-3.	Energy Efficient Government Fleet	(0.000051)	(0.000088)	(0.00095)	(0.0012)	$3.7	$3,004
	Transportation & Land Use Sector Totals	**(0.26)**	**(0.47)**	**(5.6)**	**(7.3)**	**($33,222)**	**($4,572)**
AFOLU-1.	Dairy Cattle Manure Management	(0.026)	(0.055)	(0.74)	(1.8)	$285	$159
AFOLU-2.	Urban Forestry	(0.0024)	(0.0066)	(0.058)	(0.061)	$7.9	$130
AFOLU-3.	Rural Forestry	(0.042)	(0.084)	(0.88)	(0.88)	$115	$131
	Agriculture, Forestry and Other Land Use Sector Totals	**(0.071)**	**(0.15)**	**(1.7)**	**(2.7)**	**$408**	**$150**
WM-1.	Landfill Methane Gas	(0.13)	(0.13)	(2.1)	(2.2)	($153)	($71)
WM-2.	Water Sanitation and Reuse for Industrial Processes and Irrigation	(0.037)	(0.051)	(0.76)	(0.98)	($2,082)	($2,133)
	Waste Management Sector Totals	**(0.17)**	**(0.19)**	**(2.9)**	**(3.1)**	**($2,235)**	**($712)**
	Total Integrated Plan Results	**(2.6)**	**(4.4)**	**(53)**	**(68)**	**($70,171)**	**($1,039)**

All values adjusted for intra- and inter-sector policy overlaps and interactions

Figure 3-2. Coahuila SCAP GHG Policy Reductions by Sector

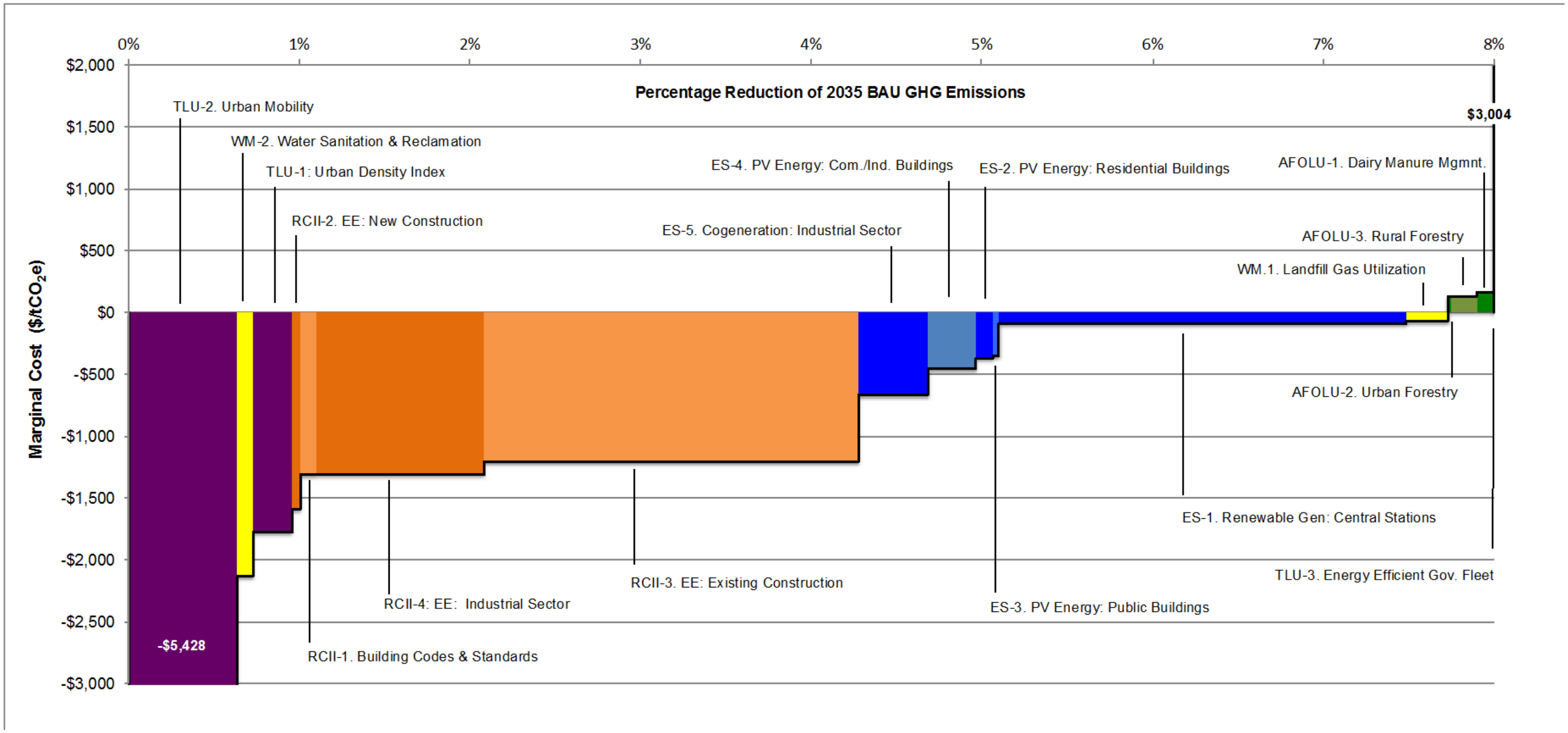


Net Emissions ($TgCO_2e$)										
Emissions/ Emissions Reduction	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Projected GHG Emissions	19	20	26	27	30	34	38	43	49	55
Reductions from Recent Actions	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.07	0.07	0.07
Projected GHG Emissions After Recent Actions	19	20	26	27	30	34	38	43	49	55
Plan Reductions: ES Sector					0.0	*0.4*	*0.8*	*1.2*	*1.5*	*1.8*
Projected Emissions with ES Policies					30	34	37	42	47	54
Plan Reductions: RCII Sector					0.0	*0.3*	*0.6*	*0.9*	*1.4*	*1.8*
Projected Emissions with ES/RCII Policies					30	34	37	41	46	52
Plan Reductions: TLU Sector					0.00	*0.1*	*0.2*	*0.26*	*0.4*	*0.47*
Projected Emissions with ES/RCII/Industry/TLU Policies					30	34	36	41	46	51
Plan Reductions: AFOLU Sector					0.0	*0.0*	*0.0*	*0.07*	*0.1*	*0.15*
Projected Emissions with ES/RCI/Industry/TLU/AF Policies					30	34	36	41	46	51
Plan Reductions: WM Sector					0.00	*0.1*	*0.1*	*0.17*	*0.2*	*0.19*
Projected Emissions with All Policies					30	34	36	40	45	51
Total GHG Reductions from Plan Policies					*0.0*	*0.9*	*1.7*	*2.6*	*3.5*	*4.4*
Emissions After Quantified Plan Policies	**19**	**20**	**26**	**27**	**30**	**33**	**36**	**40**	**45**	**51**

Net Emissions ($TgCO_2e$)										
Emissions/ Emissions Reduction	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
Values in red are interpolated from micro-economic analysis results.										

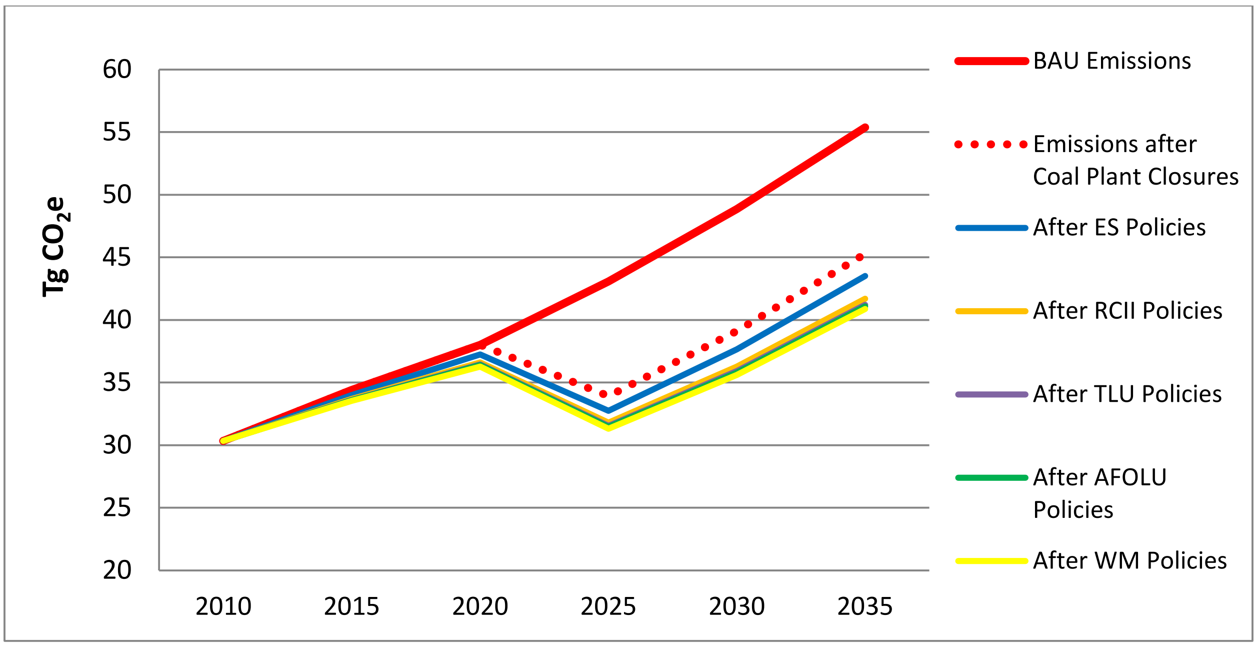
Figure 3-3 provides the marginal abatement cost curve (MACC) for the CO SCAP policies. Policies are ranked by their cost effectiveness along the Y-axis. The length of the line for each policy indicates its contribution to reductions in 2035 BAU emissions (on a percentage basis). As shown at the far right of the chart, the total reductions for the SCAP policies are estimated to be about 8% of BAU emissions in 2035. Nearly all of these reductions are expected to come from policies that achieve a net savings in societal costs (all policies to the left of AFOLU-2 in Figure 3-3).

Figure 3-3. Marginal Abatement Cost Curve for the Coahuila SCAP



Regarding the potential closure of the two coal-fired power plants in the State, the potential impacts in relation to the SCAP final results presented in Figure ExS-9 above are shown in Figure ExS-10 below. This chart shows a substantial downward shift in BAU emissions (about 10 $TgCO_2e$) following closure of both plants in 2025 before emissions growth (in all sectors) pushes emissions higher in the following years. The impacts of SCAP policies are still similar to those shown in Figure ExS-9, since the electricity expected to be offset by RE/EE policies hasn't changed (i.e. still expected to be mostly natural gas combined-cycle generation). So, bending the emissions curve will still require additional or strengthened SCAP policies.

Figure ExS-10. Sector-level GHG Reductions for the CO SCAP with Coal Plant Closures in 2025



A State-level policy to work with the Federal government on a plan for coal plant closures could therefore reduce Coahuila's carbon intensity of electricity supply and its overall emissions substantially. The impacts shown in Figure ExS-10 assume that new generation in the form of natural gas combined-cycle plants would be constructed to make up for lost production only to the level needed by Coahuila's electricity demand. Therefore, other states that rely on imported electricity from Coahuila should also be involved in the development and implementation of a policy of this type.

3.7 Details on the Assessment of Inter-Sector Overlaps and Interactions

The most common area for inter-sector overlaps or interactions to take place is between the policies in the Energy Supply sector and any in the demand sectors (i.e. all other sectors, but most commonly RCII). *Overlaps* occur when two different policies are impacting the same energy consuming activity, and therefore are double-counting the potential emission reductions. A common *interaction* between electricity supply and demand relates to the initial (BAU) assumptions about the carbon intensity and cost of the marginal resource mix and whether those assumptions remain valid after implementation of all supply and demand policies. This re-assessment of the marginal resource mix is addressed in detail in the subsection below.

Inter-sector overlaps identified in the CO SCAP policies are:

- ES-3 [Photovoltaic (PV) Energy in Public Buildings] and ES-4 (PV Energy in Commercial and Industrial Buildings) overlaps with the energy efficiency policies RCII-1 through RCII-3: the policy goals for PV energy production in ES-3 and ES-4 were specified in terms of % of electricity consumption; and implementation of RCII-1 through -3 will reduce future consumption. Therefore, the amount of PV energy required for implementing ES-3 and ES-4 is reduced along with the potential GHG reductions and costs. The level of overlap for ES-3 and the RCII policies was much higher than that for ES-4. For ES-3, the level of overlap was estimated to range from 3% in 2016 to 28% in 2035. For ES-4, the level of overlap was estimated to range from 1% in 2021 to 4% in 2035.

- AFOLU-2 addressing urban forestry includes the energy savings benefits, and the associated GHG benefits and implementation costs. These energy impacts for building shading and wind protection overlap with impacts from policies RCII-2 and -3 that address energy efficiency in residential and commercial buildings (via new codes and standards and increased appliance efficiencies). Therefore, there is a potential for overlap of policy impacts in places where AFOLU-2 and one or both of the RCII policies are also being implemented.

  For RCII-1 (building codes), these will apply to new buildings and major renovations of existing buildings. Also, the policy doesn't get fully ramped up until between 2025 and 2030. As a result, the amount of overlap is likely small, so no adjustments were made to address overlaps.

  For RCII-2 addressing energy efficient appliances, it was assumed that the reductions in building energy intensity to be achieved by the policy would also reduce the expected benefits of building shading/wind protection achieved by AFOLU-2. To develop the estimates of the level of overlap, it was assumed that 50% of building energy intensity reductions would be achieved via more efficient air conditioning equipment installed through implementation of RCII-2. After accounting for the proportion of Coahuila's population that resides in hot versus cool climates and the percentage of electricity use devoted to air conditioning, a level of overlap could be calculated for the AFOLU-2 electricity benefit. That overlap ranged from 1% in 2016 to 16% in 2035 (the electricity reduction benefit of AFOLU-2 was reduced by this amount in the adjusted results). The results of this *inter*-sector adjustment were included in the overall estimates of CO SCAP direct impacts.

Re-assessment of the Marginal Resource Mix of Electricity Supply

Typically, this can occur when the demand sector policies are achieving reductions in power demand through energy efficiency (EE) or are adding renewable energy (RE) resources to the grid (demand sectors are RCII, TLU, AFOLU and WM). The impacts and costs of all of the power related policies (both supply and demand) that reduce expected future loads on the electrical grid are measured against a defined BAU "marginal resource mix". The marginal resource mix refers to the portion of the total electricity supply system that would respond to changes in reduced demand on the grid (as a result of EE or new RE additions). Typically, the marginal resource mix excludes sources that are considered "must run" supply sources, like nuclear plants (these can't be easily turned on/off or up/down; or for other reasons, would not be shut down). Renewable resources (wind, solar, hydro, geothermal) are also often excluded from the marginal resource mix, since the fuel to run them is essentially free. Marginal resources are otherwise expected to be those plants with the highest running costs.

An important concept to understanding "in-State" reductions for electricity supply/demand related impacts is to first recall that the GHG baseline for the Power Supply (PS) subsector is constructed on a consumption basis. This means that emissions and emission reductions are attributed to the point of electricity consumption, rather than the point of generation. The baseline was constructed based on generation statistics for the State's generation sources, although Coahuila's demand draws from a broader regional grid. Since, data were not available as to which generation resources were associated with the State's net exports, it was assumed that the carbon intensity of exported power was equal to the average of power produced in the State.

Figure 3-4 provides a summary of the net generation forecast for Coahuila's generation resources. As a comparison, the CFE forecast for net generation within the northeast region of Mexico (Coahuila, Chihuahua, Durango, Nuevo Leon and Tamaulipas) is shown in Figure 3-5. That forecast indicates a strong and growing reliance on natural gas combined-cycle technologies.

Figure 3-4. Coahuila BAU Net Electricity Generation Forecast

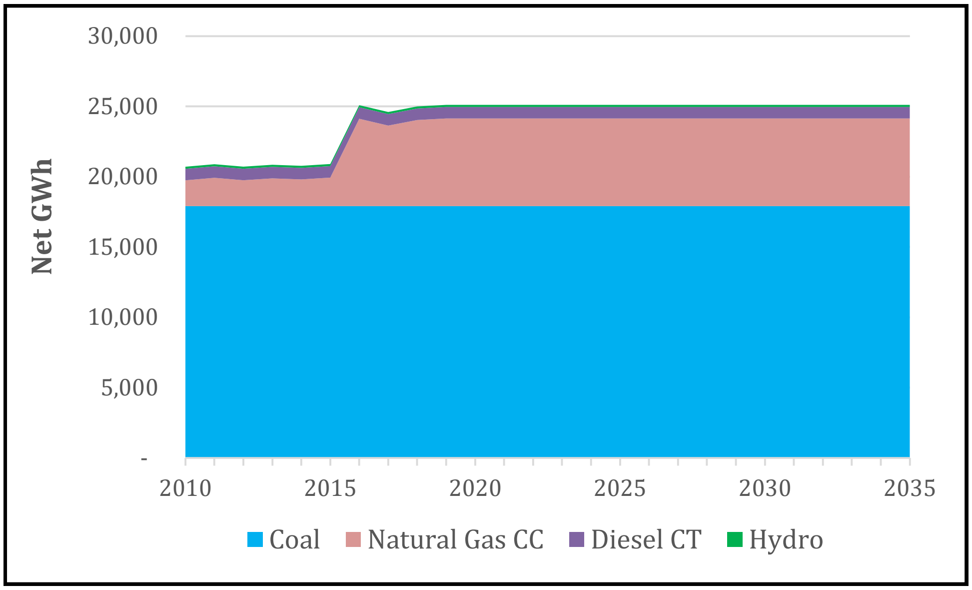
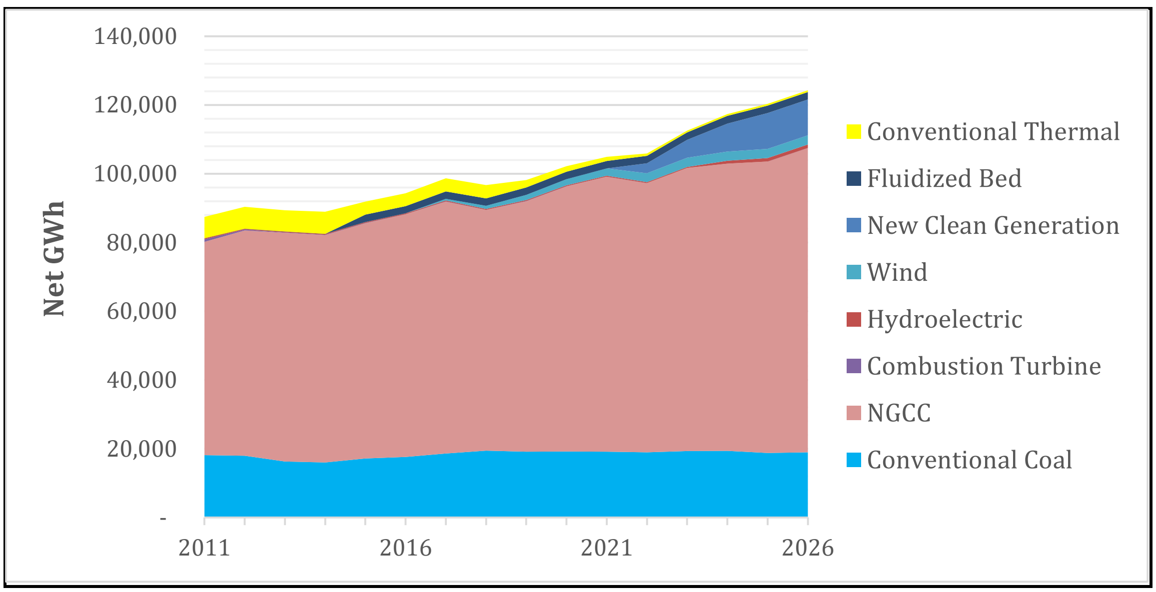


Figure 3-5. CFE Generation Forecast for the Northeast Region



The second issue needed for understanding the estimations of "in-State" reductions from electricity supply/demand relates to how the marginal resource mix for the electricity system is defined. As noted above, the marginal resource mix refers to the portion of the electricity system that will respond to each incremental increase or decrease in load. For the CO SCAP, the marginal resource mix was defined to be made up primarily of natural gas combined-cycle (NGCC) power plants with the remainder being a small amount of diesel-fired combustion turbine plants. Overall, these plants have lower carbon intensities than the State's average (due to the presence of the two large coal plants). Since reductions in load brought about by energy efficiency policies will first reduce generation from the marginal resource mix, the associated emission reductions from such a policy will be lower than would be estimated using the average carbon intensity for the State. Avoided generation costs from an EE policy would also be based on the marginal resource mix, rather than the average generation costs for the State (marginal resources tend to have higher running costs than baseload plants).

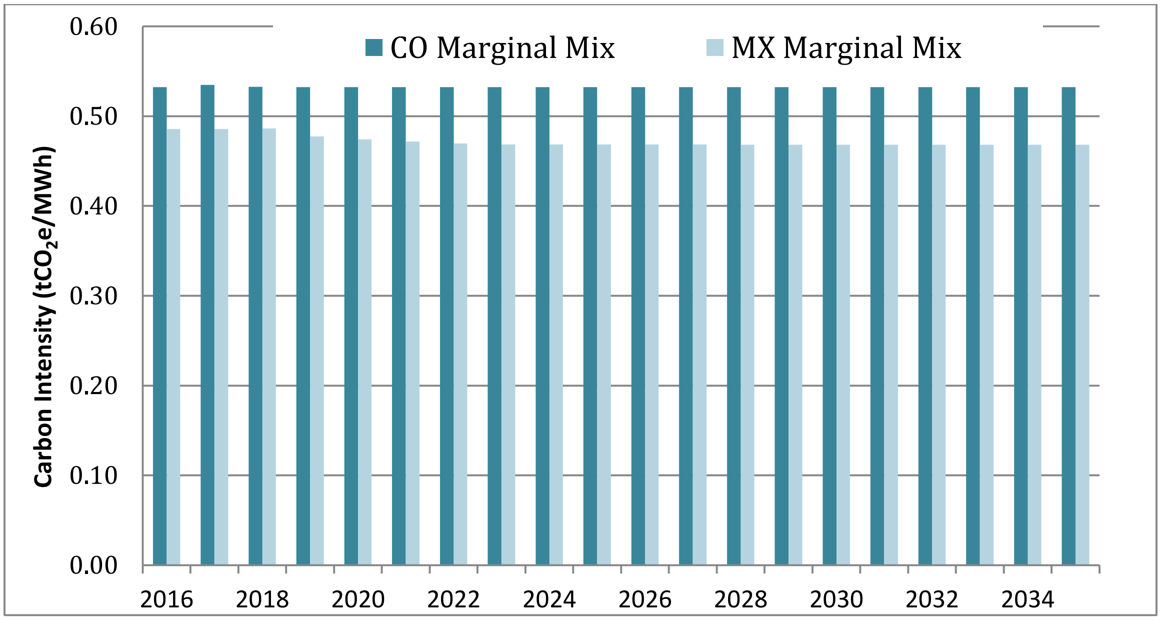
Finally, while we attribute all GHG reductions and costs to the point of electricity consumption, it should be understood that, since the State is served by a much larger national grid, *emission reductions from reduced marginal resource generation requirements could also occur at plants located outside of the State's geographic boundaries.* This could occur, for example, if all of the marginal resources within the State were taken off-line to balance with load reductions, the remaining base-load plants continued to operate at full capacity, and additional load reductions were needed. In this case, the additional load reductions would need to come from out of State plants on the margin. For regional load balancing considerations, these plants would likely be located in nearby States associated with the regional mix shown in Figure 3-5.

For the CO SCAP, Figure 3-4 above shows the BAU net electricity generation forecast by fuel type. In this figure, *all of the natural gas and diesel based generation is considered to be the marginal resource*. This definition of the marginal resource is based on both running costs, as well as the relative ease in ramping these plants up or down to match load (as compared to large conventional coal plants).

For the SCAP policies, all GHG impacts were measured against a BAU carbon intensity for natural gas and diesel generation. The carbon intensity of the Coahuila marginal resource mix was estimated to be 0.532 tCO_2e/MWh in 2016 with very little variability through 2035 (as shown in Figure 3-6 below). Carbon intensities were derived using the net generation forecasts and the GHG emissions per unit of generation from the ES baseline. Next to the CO marginal resource mix, a comparison is provided for the marginal resources presumed for the northeast region of Mexico ("MX marginal mix"). The MX marginal mix is expected to be even more dominated by NGCC, but in addition to a small amount of combustion turbine use, there is also a small amount of conventional thermoelectric plants (presumed to use fuel oil for this analysis).[26] Carbon intensities of the two marginal resource mixes are similar with the MX mix estimated to range from 9 to 13% lower than the CO mix.

[26] Comisión Federal de Electricidad; Sistema de Información Energética, Secretaría de Energía, Evolución de la generación bruta por tecnología y región al 2026, Servicio Público.

Figure 3-6. Carbon Intensities of the Coahuila and Mexico Regional Marginal Resource Mixes



To quantify the direct economic benefits of EE/RE policies, estimates of the avoided generation costs for marginal resources were needed. The Coahuila marginal resource system costs were estimated to be $1,792/MWh in 2016 and increasing to $2,807/MWh by 2035 (mostly due to expected increases in natural gas pricing).[27] These values are shown in Figure 3-7 along with those for the MX marginal mix. The MX marginal mix costs are slightly lower than those for the Coahuila mix. These run about 29% lower early in the forecast period to about 21% in 2035. These lower costs are driven by the higher levels of NGCC in the MX marginal mix. Forecasted natural gas prices are expected to be much lower than diesel and fuel oil through the planning period (see Figure 3-8). Note that the calculations of both carbon intensity and avoided system costs both assume a transmission and distribution (T&D) loss rate of 10.7% throughout the forecast period (consistent with the ES baseline).

If the total system-wide impact of all SCAP policies (electricity savings + new generation – new demand) exceeds the marginal resource mix, then the values used initially during the "stand-alone" policy analysis for carbon intensity and avoided costs could require adjustment. These adjustments would account for a different set of resources (in this case, resources beyond just Coahuila's natural gas and diesel sources) that would be turned down or decommissioned to accommodate the changes in load brought about by implementation of the plan policies.

[27] Generation Costs: source Section 4.4 of *Costos y Parametros de Referencia para la Formulation de Proyectos de Inversion del Sector Electrico*, edition 32, CFE, 2012. Natural gas wholesale costs: natural gas selling price firsthand in Pemex City, data through 2013. Forecasted based on 1.8%/yr annual growth rate in US supplies from US Department of Energy, Energy Information Administration, *Annual Energy Outlook 2014*.

Figure 3-7. Avoided Generation Costs for the Coahuila and Mexico Regional Marginal Resource Mixes

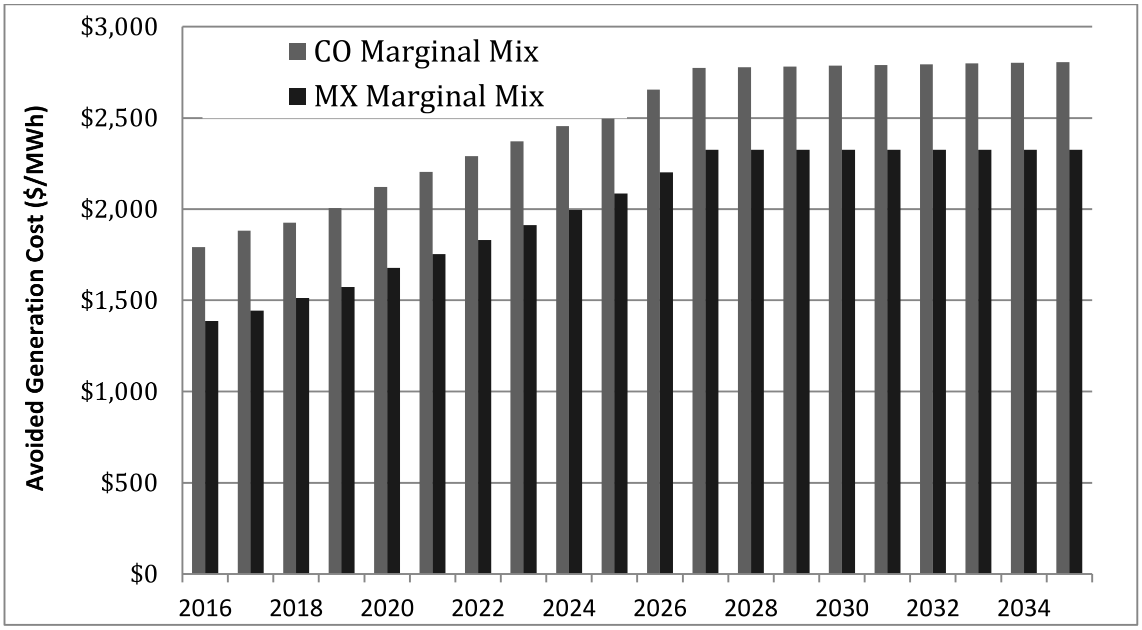


Figure 3-9 provides a comparison of the marginal resource mix and the total CO SCAP policy electricity system impacts. “Total impacts” here refer to the sum of changes to system load brought about by new energy efficiency and renewable energy projects (as well as any new demand, such as greater vehicle electrification). Most of the EE/RE impacts come from policies in the ES and RCII sectors; however, policies in other sectors also contribute (AFOLU-2, WM-1).

As shown in Figure 3-9, the total impacts stay just below the marginal resource mix net generation levels through the end of the planning period. Therefore, no adjustments were needed to address needed changes to the definition of a marginal resource mix and the associated carbon intensity and system costs of power production. As a result, no further adjustments were needed to address inter-sector interactions/overlaps between electricity supply and energy demand policies. Had the total electricity system impacts been higher than the generation levels of the marginal resource mix, then a revision to our initial definition of marginal resources would have been required. For Coahuila, this would mean including some coal-based generation within the marginal resource mix.

Figure 3-8. Wholesale Fuel Price Forecast for the CO SCAP Project

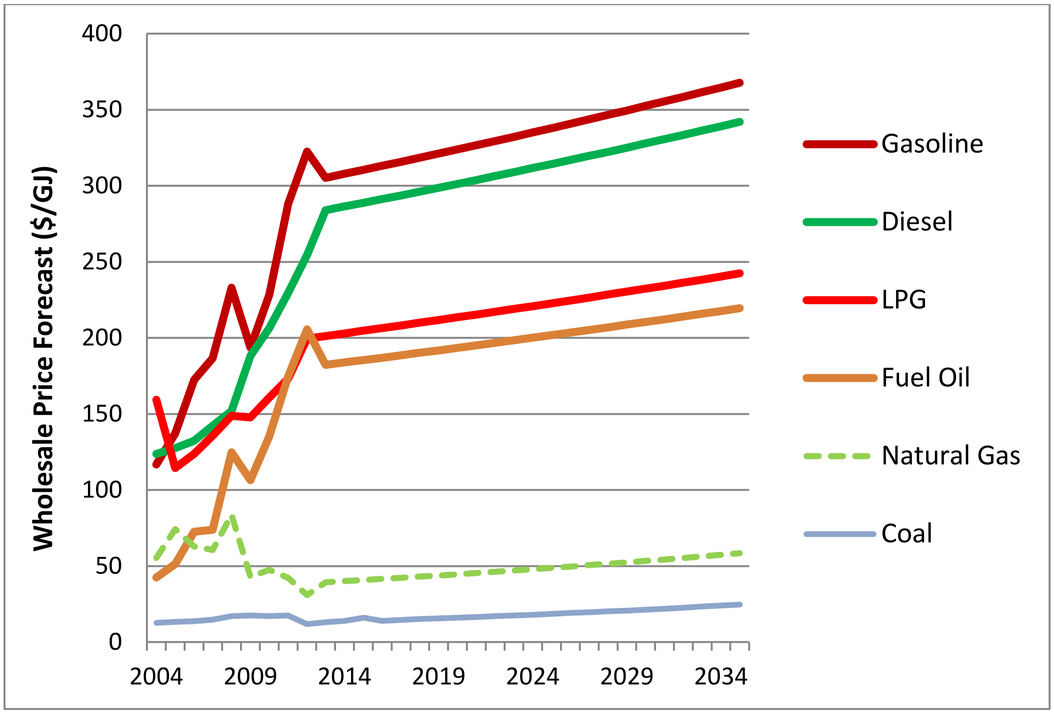
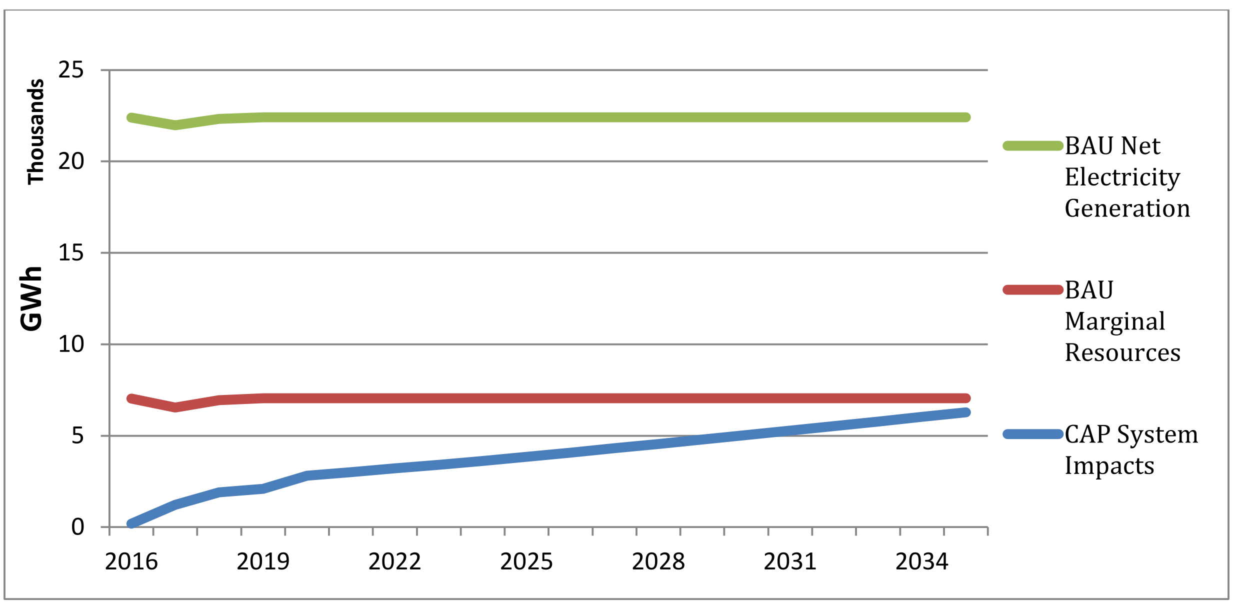


Figure 3-9. Total CO SCAP Electricity System Impacts Compared to the CO Marginal Resource Mix



As a sensitivity analysis for all policies with electricity supply or demand impacts, another set of GHG reductions and net societal costs were derived using a different marginal resource mix that would be more closely associated with the national grid, rather than for Coahuila-specific generation resources. Following from the discussion above, and the regional generation statistics shown in Figure 3-5, an MX regional marginal resource mix was defined to be made up of mostly natural gas combined-cycle plants, but also including a small amount of combustion turbine (presumed to be diesel-fired) and conventional thermal-electric generation (presumed to be residual oil-fired). The carbon intensities and avoided generation costs are shown in Figures 3-6 and 3-7, respectively.

Table 3-2 below provides a summary of the results of this sensitivity assessment. Not surprisingly, the biggest differences are in the ES and RCII sectors where policies with the biggest electricity system impacts occur. Cumulative GHG reductions for these two sectors would be about 10% less if the generation resources displaced through implementation of CAP policies were better characterized by marginal resources in the MX regional mix than for CO-specific marginal resources. Net societal savings would also be lower using the MX regional marginal mix assumptions – about 8%.

While there are also some electricity system impacts associated with the TLU, AFOLU and WM sector policies, the size of these impacts isn't large enough to show a significant difference when using the CO marginal mix versus the MX regional marginal mix. For both GHG reductions and net societal savings, the total differences for all CO SCAP policies are about 9% each.

Table 3-2. Sensitivity Assessment of Differing Marginal Resource Assumptions

Sector	Cumulative Total Reductions ($TgCO_2e$)		NPV Costs or (Savings) ($2014MM)		Cost Effectiveness ($2014/$tCO_2e$)	
	CO Mix	MX Mix	CO Mix	MX Mix	CO Mix	MX Mix
Energy Supply	30	27	(5,203)	($4,302)	($172)	($161)
RCII	24	22	(29,918)	($25,547)	($1,238)	($1,152)
TLU	7.3	7.3	($33,222)	($32,687)	($4,572)	($4,498)
AFOLU	2.7	2.7	$408	$556	$150	$209
WM	3.1	3.1	($2,235)	($2,188)	($712)	($702)
Total – All Sectors	**68**	**62**	**($70,117)**	**($64,168)**	**($1,039)**	**($1,368)**

The initial take-away message from this sensitivity analysis could be that the total emission reductions and savings estimated for the CO SCAP could be over-stated by up to 9% depending on how the electricity supply system is adjusted as a result of implementation of all policies (i.e. how much are Coahuila's marginal resources adjusted as compared to the northeast region's marginal resources).

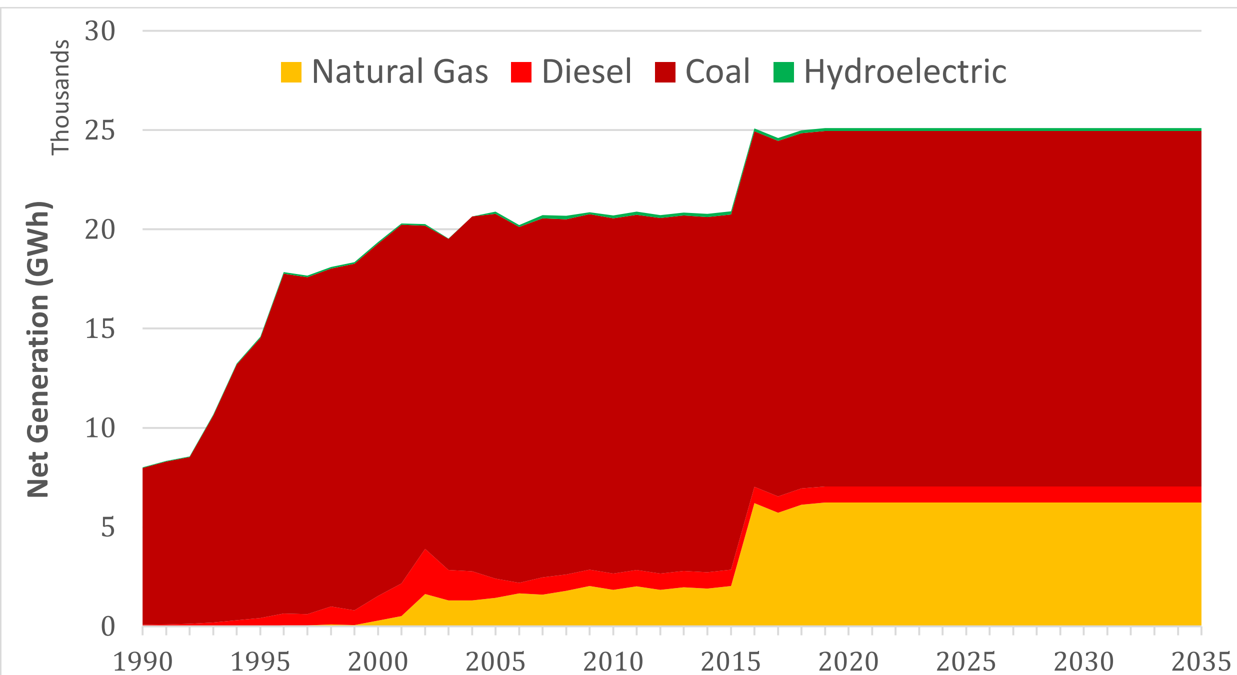
It is important to also consider here that the CO SCAP policies are being quantified without any consideration for policies that could be implemented by other States in the region, which could also serve to reduce generation requirements for the marginal mix of the region (including Coahuila's). To the extent that such policies are developed and implemented, there could be a need to consider adding more resources to the regional marginal mix that would most likely be higher in carbon intensity (e.g. coal-based generation). This would lead to greater GHG reductions for any EE or RE policy (and potentially lower net savings, since these plants have lower levelized generating costs).

Chapter 4
Energy Supply (ES) Sector

Sector Overview

The Energy Supply (ES) sector consists of three subsectors: Power Supply (PS), Heat Supply (HS), and Fuel Supply (FS). According to the 2010 Coahuila Forecast, the Energy Supply sector is projected to comprise 34 percent net greenhouse gas (GHG) emissions across all sectors by 2035. [28] Emissions growth in the sector from 1990-2035 is about 3.0 percent per year. As shown in Figure 4-1, primary energy sources in the ES sector include power generation from fossil fuels, primarily coal and natural gas (hydroelectric generation is almost too small to be seen at the top of the chart).

Figure 4-1. Electricity Generation by Fuel Type in Coahuila



As of 2014, 95% of the total electricity generating capacity came from two coal plants located near the town of Nava: Carbon II with a capacity of 1,400 MW and Rio Escondido (Jose Lopez Portillo) with a generating capacity of 1,200 MW. 5% of the remaining capacity corresponds to a

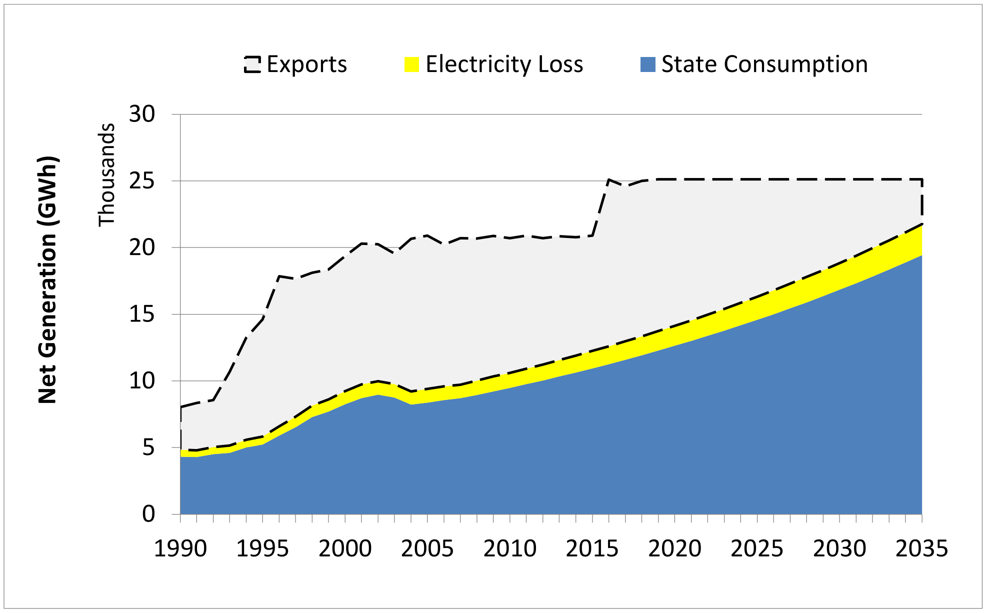
[28] The ES baseline data shown in this chapter are updated from the initial work done for Coahuila and documented in Appendix A (i.e. the 2010 CCS GHG I&F report). The reader should expect to see slight differences in the values shown in that earlier work.

combined cycle plant located in Ramos Arizpe, a hydroelectric plant located in the riverbed of the Rio Grande, and one turbogas plant located in Monclova.

Diesel oil declined as a source of energy overall from 2000 through 2015. Natural gas expanded from near 0 percent of supply in 1999 to almost 25 percent of projected supplies by 2035. This corresponds to an increase in natural gas generation of over 6,250 GWh by 2035.

It should also be noted that exports make up about 50%% of Coahuila's energy production through 2025, which is seen in Figure 4-2.

Figure 4-2. Electricity Balance for Coahuila



Net electricity exports are positive during all years but are contingent on continued generation from Coahuila's coal fleet.

ES sector GHG emissions (Figure 4-3) play a major role in the projected growth rate of overall emissions for Coahuila through 2035. A variety of low emissions policy actions are needed to reduce ES sector emissions.

Figure 4-4 shows that with continued reliance on coal, the trend will be a high per capita-based carbon intensity for in-State power production through 2035. Carbon intensity increases in part because power generation is increasing faster than Coahuila population. Figure 4-4 shows that Coahuila's ratio is significantly higher than the national level.

Measures to reduce GHGs from the sector that were evaluated in this planning process include shifts to renewable energy (solar and wind) and low emitting fossil supplies (natural gas) for both centralized and distributed energy systems. The policy to diversify the centralized power generation (ES-1) provide the majority of future emissions reduction options for the State with over 64 percent of all supply-side policy options (discussed further below).

Figure 4-3. Power Supply Emissions – Consumption Based

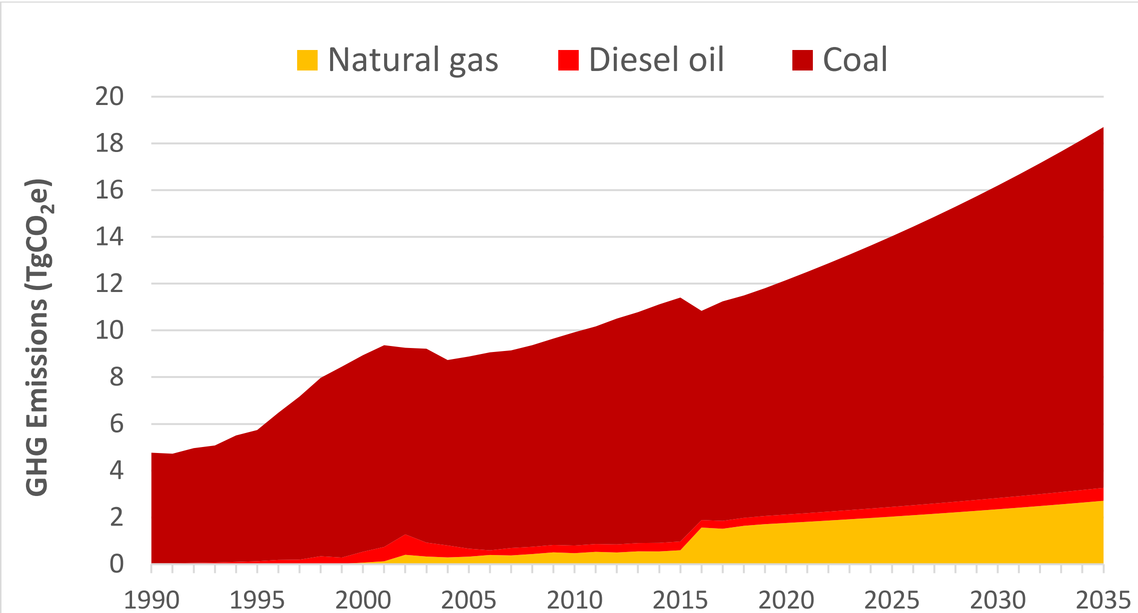
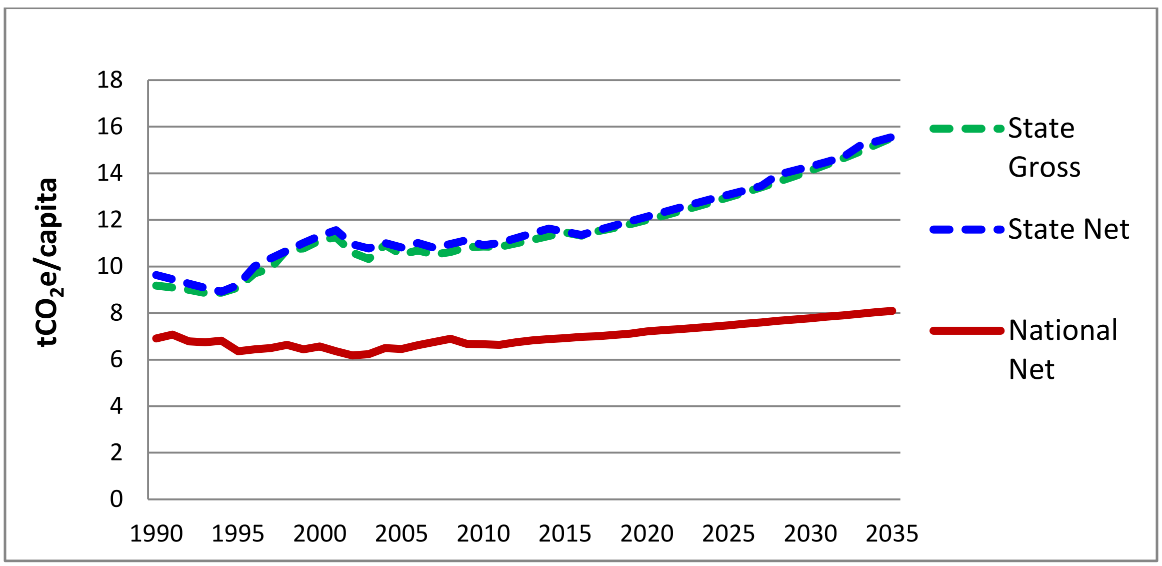


Figure 4-4. Per Capita Carbon Intensity



In comparison, decentralized supply sources from other options (ES-2, -3, -4, & -5) do significantly affect overall generation mix through 2035 (at almost 36%). They also provide important stage-setting actions to support longer-term expansion of distributed renewable generation. Additional supply-side measures could be added to the list of options evaluated in this planning process and potentially include low-emitting practices for extraction and distribution of natural gas (assessed using full energy-cycle effects), as well as continued development and scale up of renewable-energy sources at the state and regional levels.

In this report, supply-side shifts through ES policy actions can be viewed in combination with demand reduction strategies for the Residential, Commercial, Industrial, and Institutional (RCII) sector as an overall power sector strategy. Emissions baselines and demand-side policy options for electricity uses of energy are addressed in a Chapter 5 of this report.

The alternatives for generating electricity in Coahuila from renewable sources are varied and all are feasible to implement, however, the decision to use a particular measure should be based on considering the costs involved in implementation, direct user benefits, and the broader impacts to the State economy. Also, the use of renewable energy sources should do the following: not affect the supply of electricity; should in any case, reduce dependence on imported energy; result in savings for consumers; and simultaneously reduce emissions of greenhouse gases.

Key Challenges and Opportunities

Projected emissions growth rates for the ES sector in Coahuila are high, even though some of the most carbon intense sources (fuel oil and diesel oil) have been all but eliminated as the natural gas share of overall electricity supply expands dramatically. As a result, to stabilize and reduce ES sector emissions, energy growth rates must be managed through demand side (RCII) measures in combination with a significant supply side shift to low or zero carbon renewable energy supplies, including future focus on improved natural gas extraction and distribution practices to reduce the footprint associated with full energy-cycle use of natural gas.

Supply and demand management approaches for the sector will require a series of centralized and decentralized supply measures that cut across a variety of state, local, and private systems. Centralized power systems (power plants and the power grid) represent the largest immediate opportunity for an emissions reduction impact, but decentralized sources of power could grow quickly and broadly with policy and investment support and represent a major scale up opportunity.

Presently, Coahuila lacks a statewide general policy to diversify the energy supply matrix. Such a policy could be defined and developed (through policy option ES-1) to stimulate low carbon shifts in centralized sources (power plants). Expanded planning and analysis could help address policy and investment information needs necessary to support these shifts.

Distributed energy systems, such as residential and commercial solar power applications, also will benefit from improved planning and analysis support for a rapid scale up of best practices at the small local scale to full statewide levels. These actions must be tailored to local conditions that vary considerably in Coahuila, and they will require local government and public-private partnerships that may not currently exist, as well as new spending. In turn, this will require expanded program capacity, outreach, technology cost controls, and investment channels.

Overview of Plan Recommendations and Estimated Impacts

Five policy options were evaluated for the ES sector. These include:

- ES-1. Electricity production through renewable energy technologies (photovoltaic panels, wind generators) in Central Station Power Supply. The purpose of this policy is to take advantage of low carbon energy resources in Coahuila to contribute to the national GHG reduction target (Objective 3)[29] through the strategy of diversification of the energy matrix production in the country (3.2.1).[30] This includes reducing dependence on fossil fuels with high carbon content in electricity generation,[31] by promoting installation of power plants that use renewable energy sources, specifically wind and sun, thereby helping to reduce GHG emissions per mega-watt (MW) generated.

- ES-2. *In-situ* electricity generation in residential buildings with photovoltaic panels. This policy expands the generation and use of renewable energy in the residential sector of Coahuila through the purchase and installation of photovoltaic panels and reduces the emission of greenhouse gases associated with the consumption of electricity from fossil fuels.

- ES-3. *In-situ* electricity generation in public buildings with photovoltaic panels. This policy expands the use and distribution of renewable energy in public buildings in Coahuila for systems and facilities capable of producing their own energy.

- ES-4. *In-situ* electricity generation in commercial and industrial buildings with photovoltaic panels. This policy expands the use and distribution of renewable energy in commercial and industrial buildings in Coahuila for systems and facilities capable of producing their own energy (10% and 25% of electric power consumed in commercial and industrial buildings is self-generated with rooftop solar photovoltaic panels by 2025 and 2035 respectively).

- ES-5. Combined heat and power - Encouragement of efficient cogeneration of electricity in industry. This policy encourages the cement, steel, and mining industries to employ more efficient electricity cogeneration systems rather than conventional systems. CHPs leverage untapped waste heat and reduce unnecessary energy losses, enabling considerable medium and long term savings. Cogeneration mode represents a viable option to contribute to energy sustainability by increasing energy and economic efficiency of the company.

Table 4-1 below provides a summary of the results of the microeconomic analyses conducted for each of the ES policies. These results are shown on a "stand-alone" basis, meaning that they were evaluated against BAU conditions assuming that no other policies would be implemented. These results indicate that the policy to diversify the state energy supply system toward renewable and low emitting sources (ES-1) provides over 80 percent of all emissions reductions

[29] Objective 3: Reduce emissions of greenhouse gases to move to a competitive economy and low emissions development (Special Climate Change Program Promotion Version 2014-2018, 2014-2018 PECC Government of the Republic.)

[30] Strategy 3.2.1 Promote the diversification of the energy matrix with public and private investment in generation through clean energy (Special Climate Change Program Promotion Version 2014-2018, 2014-2018 PECC. Government of the Republic).

from the five options evaluated in this planning process. Overlapping effects within the sector between centralize and decentralized supply sources are minimal due to the domination of centralized sources, but this dynamic will likely shift in the future as decentralized renewable sources become more broadly adopted.

Table 4-1. ES Microeconomic Analysis Summary: "Stand-Alone" Results

		In-State GHG Impacts			*Total GHG Impacts*	*Base Year 2014$*	
		Annual CO_2e Impacts		**2035 Cumulative**	**2035 Cumulative**	**NPV 2016-2035**	**Cost Effectiveness**
Policy ID	**Policy Title**	**2025 Tg**	**2035 Tg**	**$TgCO_2e$**	**$TgCO_2e$**	**$Million**	**$/t$CO_2e$**
ES-1.	Renewable electricity production in Central Station Power Supply	(0.92)	(1.3)	(19)	(25)	($2,179)	($89)
ES-2.	Photovoltaic energy in residential buildings	(0.034)	(0.054)	(0.64)	(0.82)	($304)	($369)
ES-3.	Photovoltaic energy in public buildings	(0.020)	(0.029)	(0.36)	(0.46)	($166)	($359)
ES-4.	Photovoltaic energy in commercial and industrial buildings	(0.079)	(0.16)	(1.7)	(2.2)	($1,008)	($459)
ES-5.	Cogeneration in the industrial sector	(0.12)	(0.22)	(2.4)	(2.4)	($1,614)	($670)
	Totals	**(1.2)**	**(1.8)**	**(24)**	**(30)**	**($5,270)**	**($173)**

*Note: (Negative cost values) imply net savings to society and positive cost values imply net societal costs.

Overlaps Discussion

The interaction of the supply (ES) and demand (RCII) areas of electric power is significant in terms of overlapping and combined effects of both types of policy actions.[32] This includes, for instance, effects on emissions reductions that affect supply-side measures. As demand reduction takes place, supply shifts have a lesser effect on the reduced pool of power generation. In terms of cost effectiveness, by combining ES options with positive net costs with RCII options with negative net costs reduces the net cost of overall electricity sector actions. Taken together, ES and RCII policy actions provide the largest share of overall emissions reduction opportunities evaluated for policy options evaluated for all sectors. *Inter*-sector overlaps were addressed in Chapter 3 above (these include interactions between ES and RCII policies).

Analysis of the impacts of ES measures is reported at a stand-alone (ES sector only with no consideration of overlaps among ES policies) level in Table 4-1 above. Due to the low levels of distributed generation, little overlap exists within the ES sector. Therefore, the results shown in

[32] Traditionally, the Transportation, Agriculture, Forestry & Land Use, and Waste Management sectors have not also been considered as sectors with supply- and demand-side electricity system impacts; however, policies and actions in these sectors can also influence demand (positively or negatively). Examples include the increased power demands of a transportation policy promoting electric vehicles or power production from biomass or waste resources.

Table 4-2 below showing results following intra-sector overlap adjustments are the same as those shown in Table 4-1.

The application of these five policies would allow a reduction of 30.4 teragrams of CO_2 equivalent, producing accumulated savings of $5,270 million pesos and net savings of $173 pesos per CO_2 equivalent ton of emissions avoided.

Table 4-2. ES Microeconomic Analysis Summary: Intra-Sector Overlap Adjusted

		Intra-Sector Overlap Adjusted Results					
		In-State GHG Impacts			*Total GHG Impacts*	*Base Year 2014$*	
		Annual CO_2e Impacts		**2035 Cumulative**	**2035 Cumulative**	**NPV 2015-2035**	**Cost Effectiveness**
Policy ID	**Policy Name**	**2025 Tg**	**2035 Tg**	**$TgCO_2e$**	**$TgCO_2e$**	**$Million**	**$/t$CO_2$e**
ES-1.	Renewable electricity production in Central Station Power Supply	(0.92)	(1.3)	(19)	(25)	($2,179)	($89)
ES-2.	Photovoltaic energy in residential buildings	(0.034)	(0.054)	(0.64)	(0.82)	($304)	($369)
ES-3.	Photovoltaic energy in public buildings	(0.020)	(0.029)	(0.36)	(0.46)	($166)	($359)
ES-4.	Photovoltaic energy in commercial and industrial buildings	(0.079)	(0.16)	(1.7)	(2.2)	($1,008)	($459)
ES-5.	Cogeneration in the industrial sector	(0.12)	(0.22)	(2.4)	(2.4)	($1,614)	($670)
Total After Intra-Sector Interactions /Overlap		**(1.2)**	**(1.8)**	**(24)**	**(30)**	**($5,270)**	**($173)**

*Note: (Negative cost values) imply net savings to society and positive cost values imply net societal costs.

The state energy matrix (option ES-1) covers all sources of centralized power generation. Expansion of distributed renewable generation (options ES-2, -3, and -4) could reduce the level of need for centralized power and the impact of ES-1 by offsetting future grid-based supplies with off-grid renewable energy supplies. As a result, both stand-alone (policy-specific) and integrative (policy aggregate) impacts within the sector are potentially important. However, given the domination of the ES-1 option within the sector, policy options ES-2, -3, and -4 are expected to have a minor overlapping effect and policy option ES-5 will depend on the respective industries.

Similarly, RCII actions that reduce power demand could affect all ES options by reducing the overall pool of power that undergoes shifts to low carbon or zero carbon supplies. The need to address any integrative effects of ES and RCII demand-side measures are addressed in Chapter 3.

The final assessment of any additional electricity system impacts across all supply-demand sectors was addressed in Chapter 3 (Section 3.7, in the assessment of marginal resource mix assumptions). In summary, that assessment showed that the net electricity impacts of all CAP policies (new generation + energy efficiency) were found to be below the total marginal resource for the State. As a result, no adjustments were needed to account for changes needed to the original definitional assumptions for the marginal resource mix. As discussed in Chapter 3, the marginal resource mix was defined as all natural gas and diesel based production in the State. This determination of no need to apply inter-sector integration adjustments assumes that the policies would be successfully implemented at the level and timing specified by each policy design.

Energy Supply Sector Policy Descriptions

Five ES policies were analyzed for the Coahuila SCAP. Following is a short summary of each policy. Appendix C contains the detailed policy descriptions, policy designs, implementation mechanisms, related policies/ programs in place, data sources/ assumptions/ methodologies, causal chains, stand-alone analytic results, key uncertainties, feasibility issues and additional benefits and costs for each policy.

ES-1. Renewable Electricity Production in Central Station Power Supply

The purpose of this policy is to take advantage of low carbon energy resources in Coahuila to contribute to the national GHG reduction target (Objective 3)[33] through the strategy of diversification of the energy matrix production in the country (Strategy 3.2.1).[34] This includes reducing dependence on fossil fuels with high carbon content in electricity generation,[35] by promoting installation of power plants that use renewable energy sources, specifically wind and solar photovoltaic (PV), thereby helping to reduce GHG emissions per megawatt (MW) generated.

This strategy is consistent with the state's resources, as Coahuila receives a high level of solar radiation [2.9 to 6.7 kilowatt-hours per square meter (kWh/m^2)] with high potential for energy conversion. The state can support diversification of electricity supply options by providing siting and construction of new facilities and generation operations with primary renewable energy.

ES-2. *In-situ* Electricity Generation in Residential Buildings with Solar PV Technology

By 2020, the residential sector will be the eighth largest greenhouse gas emitter and the second largest in carbon black[36] (PECC, 2014). These emissions are associated with electricity consumption of households.

The costs of small-scale generation with photovoltaic panels are lower than domestic rates, once the government subsidy is incorporated. Also, the territory of Coahuila receives high levels of solar radiation. Therefore, the implementation of economic and financial incentives will boost

[33] Objective 3: Reduce emissions of greenhouse gases to move to a competitive economy and low emissions development (Special Climate Change Program Promotion Version 2014-2018, 2014-2018 PECC Government of the Republic.)

[34] Strategy 3.2.1 Promote the diversification of the energy matrix with public and private investment in generation through clean energy (Special Climate Change Program Promotion Version 2014-2018, 2014-2018 PECC. Government of the Republic).

[35] 95% of the total electricity generating capacity comes from two coal plants located near the town of Nava: Carbon II with a capacity of 1,400 MW and Rio Escondido (Jose Lopez Portillo) with a generating capacity of 1,200 MW. 5% of the remaining capacity corresponds to a combined cycle plant located in Ramos Arizpe, a hydroelectric plant located in the riverbed of the Rio Grande (within the limits of Coahuila and Texas) and one turbogas plant located in Monclova.

[36] Considering a global warming potential (GWP) of 20 years.

the self-generation of solar photovoltaic electricity in the residential sector.

The implementation of this policy contributes to the reduction of GHG emissions related to the consumption of electricity produced from fossil fuels. Similarly, it supports the national strategy for distributed power generation in the domestic, commercial and industrial sector (Strategy 3.4.3).

ES-3. *In-situ* Electricity Generation in Public Buildings with Solar PV Technology

Electrical energy used in public buildings comes largely from fossil fuels with high global warming potential. Therefore, the objective of this policy is to increase distributed renewable electricity generation in the institutional sector, taking advantage of the high incidence of solar radiation of the entity, promoting the installation of photovoltaic panels in public buildings in Coahuila to meet their electric energy requirements.

With this measure, besides reducing operating costs in the public sector, GHG emissions are mitigated using cleaner and more efficient technologies (including reduced transmission and distribution losses) to replace fossil fuels for power generation.

ES-4. *In-situ* Electricity Generation in Commercial and Industrial Buildings with Solar PV Technology

The commercial and industrial sectors have increasingly contributed to the increase of GHG emissions that alter the energy balance of the climate system. Therefore, it is appropriate to move towards an energy model that considers the consumption of electricity in commercial and industrial buildings by harnessing solar energy.

The auto-consumption of electricity produced by photovoltaic technologies will contribute to savings in operating costs in commercial and industrial buildings, and contribute to mitigation of GHG emissions, both by reducing dependence on non-renewable fuels, and avoiding energy losses during transport and distribution of electrical energy required in the commercial and industrial buildings of Coahuila.

ES-5. Encouragement of Efficient Cogeneration of Electricity in Industry

Electricity cogeneration systems[37] reach a much higher efficiency than conventional systems by leveraging untapped waste heat and reducing unnecessary energy losses, enabling considerable medium and long term savings (CONUEE and CRE, 2013). In Mexico, regulations have been developed considering energy efficient cogeneration projects.

In most companies in the industrial sector, heat and electricity are essential inputs. When these two forms of energy are required together in a production process, it is an opportunity to implement

[37] According to the Law of Electric Energy Public Service, Article 36, Section II, Cogeneration is defined as the production of electrical energy produced in conjunction with steam or other high thermal energy or both; when the thermal energy that is not utilized in the process is used for the direct or indirect production of electric power or when fuels produced during processes are used for direct or indirect power generation.

cogeneration systems, which leads, simultaneously, to achieve greater efficiency in the use of fossil fuels and produce less pollutant emissions per unit of useful energy.

This policy considers the promotion of efficient cogeneration systems[38] according to the productive structure of the State, where the focus for cogeneration is concentrated in the following sectors: Cement industry, steel industry and mining sector. Cogeneration technologies represent a viable option to contribute to energy sustainability by increasing energy and economic efficiency of the company.

[38] Efficient Cogeneration is defined as the generation of electricity under the provisions of Section II of Article 36 of the LSPEE, provided that the process has a higher minimum efficiency established by the CRE:

Capacity of the system	Minimal efficiency (%)
Capacity >0.03-<0.5MW	5
Capacity >=0.05-<30MW	10
Capacity >=30-<100MW	15
Capacity >=100	20

Considering the net electricity generated in a system for a year (E), net useful thermal energy or heat generated in a system and used in a production process for one year (H), the fossil fuel used in a system for one year (F), where the electrical performance RE = E / F and the thermal efficiency RT = H / F. For more information check: 5 CRE (Feb. 22, 2011): http://www.sener.gob.mx/res/Acerca_de/REScalculoEficienciaCogeneracionEficienteCRE_220211.pdf.

Chapter 5
Residential, Commercial, Institutional and Industrial (RCII) Sector

Sector Overview

The residential, commercial, institutional, and industrial sectors (RCII) sectors include building related greenhouse gas (GHG) emissions as well as industrial sector emissions. There are three categories of emissions associated with the RCII sectors: direct emissions, industrial process emissions, and electricity sector emissions. First, the RCII sectors were directly responsible for nearly 4.0 $TgCO_2e$ direct GHG emissions in 2015. Direct emissions from these sectors result principally from the on-site combustion of natural gas, liquefied petroleum gas (LPG), and industrial diesel oil. Direct emissions in the RCII sector produces GHG emissions when fuels are combusted to provide space heating, process heating, and other applications.

Second, industrial sector emissions also include the release of CO_2 and fluorinated gases (hydrofluorocarbons, or HFCs, and perfluorocarbons, or PFCs) during industrial processing, the leakage of HFCs from refrigeration and related equipment, and to a smaller degree, from the use of sulfur hexafluoride (SF_6) in the electricity supply sector (note: SF6 emissions associated with electricity transmission and distribution equipment were not addressed in the current SCAP baseline and are typically represented in the ES baseline).

Finally, in addition to direct emissions from combustion of fuels and industrial processes in the RCII sectors, nearly all of the electricity sold in Coahuila is consumed in buildings as the result of residential, commercial, institutional and industrial activity. Emissions associated with producing the electricity consumed in Coahuila were over 10 $TgCO_2e$ GHG emissions in 2015.[39] Fuel use, industrial process emissions, and electricity account for about 35% of the State's total net GHG emissions. Coahuila's future GHG emissions therefore will depend significantly on future trends in the consumption of both electricity and fuels in the RCII sectors.

Historical and projected BAU GHG emissions for fuel combustion in the RCII sector are provided in Figure 5-1. Emissions from direct fuel combustion (LPG, petroleum, wood and natural gas) are expected to increase by about 1.3% per year over the 2014-2035 period. Figure 5-2 shows the emissions associated with industrial processes (i.e. non-combustion emissions). These emissions are expected to rise annually by about 2.6% between 2014 and 2035.

[39] Net emissions here denote GHG emissions from all activities in Coahuila, adjusted for exports of electricity, and including estimated "sinks" of GHGs in the Agriculture, Forestry & Other Land Use, and Waste Management sectors.

Figure 5-1. RCII Fuel Combustion GHG Emissions Baseline

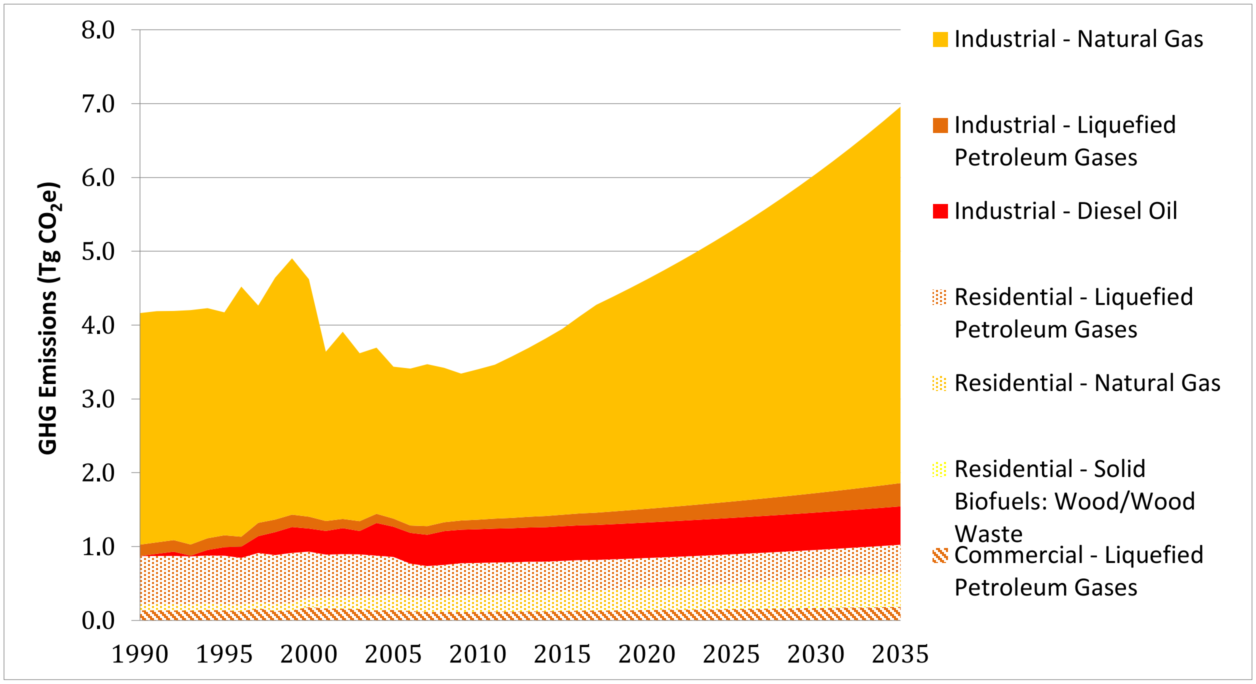


Figure 5-2. Industrial Process and Product Use Emissions

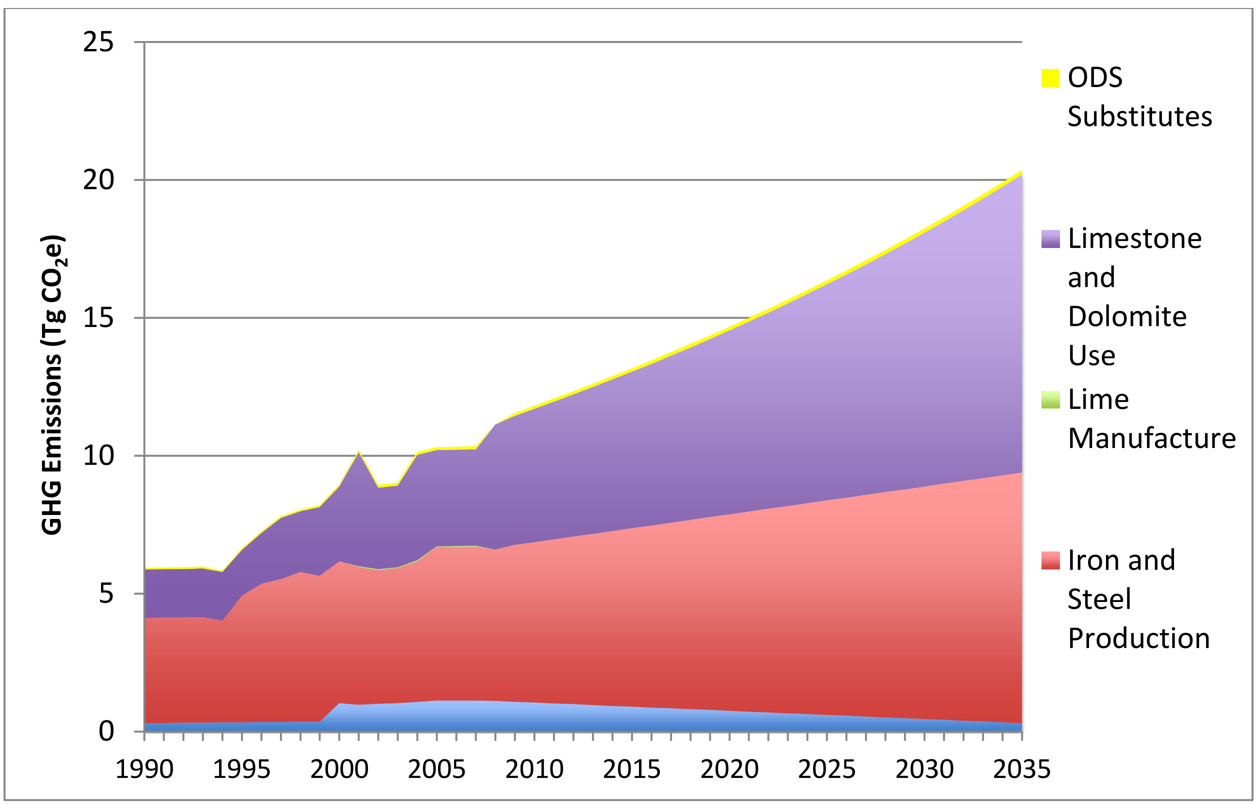
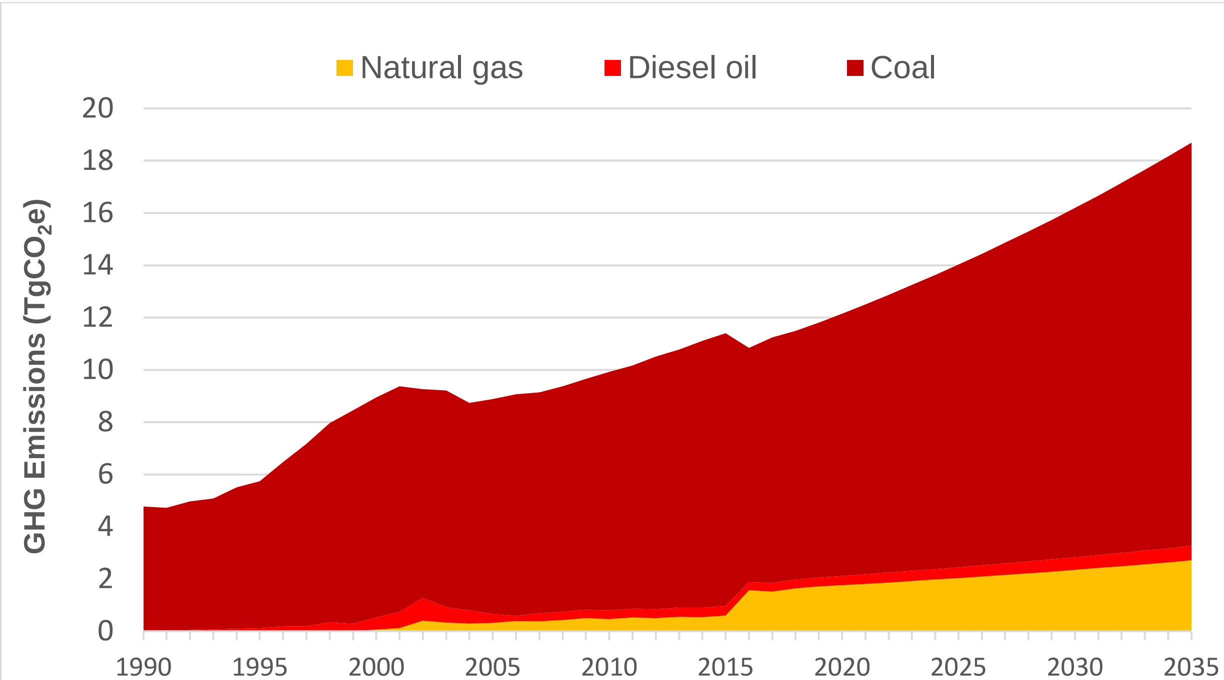


Figure 5-3 provides indirect (consumption-based) emissions estimates for electricity consumption. These emissions account for electricity exports to other States.

Figure 5-3. Electricity GHG Baseline

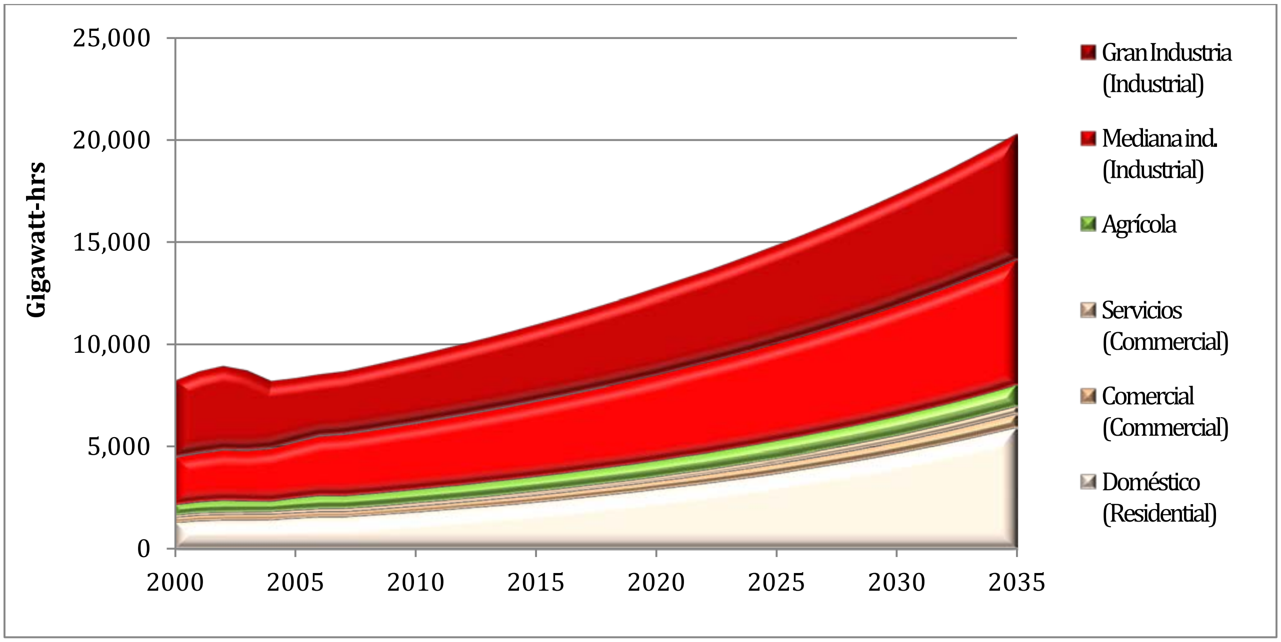


As indicated in Figure 5-4, most electricity consumption occurs in the RCII sectors, so most of the emissions associated with production of electricity can be attributed to the RCII sector.[40] The three sources of RCII emissions are forecasted to increase by approximately 3.0% annually between 2014 and 2035, but this estimate masks large changes within emission sources. These increases are due mainly to increases in forecasted electricity demand and the associated increase in natural gas generation shown in Figure 5-3 (since the fraction of net exports decreases through the forecast, the coal-based generation emissions also increase on a consumption basis).

Figure 5-4 shows most of the electricity consumption occurs within the industrial subsectors. Roughly, three-quarters of consumption occurs in the industrial sector, while the bulk of the other quarter occurs in the residential sectors.

[40] Note that when a complete economy-wide GHG baseline is presented (such as those shown in Chapter 2), all electricity emissions are attributed to the ES sector to avoid double-counting.

Figure 5-4. Electricity Sales by Sector



Key Challenges and Opportunities

The principal means to reduce RCII emissions in Coahuila focuses on improving energy efficiency through measures such as building codes for new construction, more efficient equipment (e.g. appliances, water heaters, etc.) for new construction as well as existing construction, and more efficient equipment and processes for the industrial processing sector (e.g. boilers, process heat systems, HVAC, motors, etc.). The state's limited pursuit of energy efficiency until recent years offers abundant opportunities to reduce emissions through programs and initiatives to improve the efficiency of buildings, appliances, and industrial practices. The advantages of having "low hanging fruit" in the form of low cost energy efficiency opportunities in the RCII sectors are countered by an underdeveloped private sector that will likely be responsible for scoping, implementing and evaluating energy efficiency projects. These green collar jobs require special training and equipment that take time for firms within the State to acquire.

Coahuila's large industrial sector presents opportunities for cost effective demand reductions. Industrial energy efficiency is typically relatively cheap compared to new sources of energy supply, and energy efficiency can increase the competitiveness of firms in the State.

Overview of Plan Recommendations and Estimated Impacts

The Coahuila Climate Action Plan has identified significant opportunities for reducing GHG emissions growth attributable to the RCII sectors. These include expanding or launching energy efficiency programs for existing residential buildings, promoting high performance new residential buildings, requiring state governments to implement green power purchase/generation, improving industrial energy efficiency, and promoting the use of solar and pass heaters for residential water heating needs.

The Plan recommends a set of four policy options for the residential, commercial, and industrial sectors detailed in Table 5-1.[41] The GHG emission reductions and costs per ton of GHG reductions for all of these policies were quantified. The quantified policy recommendations could lead to emissions savings from reference case projections of:

- 1.8 $TgCO_2e$ per year by 2035. A cumulative savings of almost 19 $TgCO_2e$ from 2014-2035;
- Net cost savings of approximately $30 billion pesos through 2035 on a net present value basis. The weighted average cost savings of these policies is about $1,238 (pesos) per metric ton of CO_2e.

Table 5-1. RCII Microeconomic Analysis Summary: "Stand-Alone" Results

		In-State GHG Impacts			*Total GHG Impacts*	*Base Year 2014$*	
		Annual CO_2e Impacts		**2035 Cumulative**	**2035 Cumulative**	**NPV 2016-2035**	**Cost Effectiveness**
Policy ID	**Policy Title**	**2025 Tg**	**2035 Tg**	**$TgCO_2e$**	**$TgCO_2e$**	**$Million**	**$/$tCO_2e$**
RCII-1.	Building Codes and Standards	(0.025)	(0.049)	(0.51)	(0.65)	($855)	($1,311)
RCII-2.	Increasing EE in new constructions- Equipment	(0.014)	(0.029)	(0.29)	(0.38)	($601)	($1,590)
RCII-3.	Increasing EE in existing constructions, excl. Ind. sector - Equipment	(0.72)	(1.2)	(14)	(18)	($21,262)	($1,206)
RCII-4.	EE Equipment and Processes in the Industrial Sector	(0.18)	(0.54)	(4.3)	(5.5)	($7,200)	($1,307)
	Totals	**(0.94)**	**(1.8)**	**(19)**	**(24)**	**($29,918)**	**($1,238)**

*Note: (Negative cost values) imply net savings to society and positive cost values imply net societal costs.

[41] The net cost savings are based on fuel expenditures, operations, maintenance, and administrative costs, and on amortized, incremental equipment costs. All NPV values shown here are calculated using a 5% per year real discount rate.

Overlaps Discussion

To assess the cumulative emission reductions for the policies in the RCII sector, it is necessary to consider any potential overlaps among the policies that affect similar types of energy use. No overlaps were identified within RCII policies (i.e. *intra*-sector overlaps). The RCII policies were designed to cover separate end-uses and measures. For new construction, RCII-1 includes the energy consuming end-uses associated with building energy codes such as building envelope and heating, ventilating and air conditioning (HVAC), while RCII-2 includes only the energy consumption associated with appliances in new buildings. RCII-3 excludes industrial sector building energy-use (HVAC and lighting) as these are included in RCII-4. Therefore, each of the stand-alone policy results are what can reasonably be expected for GHG reductions for the individual policies, given their implementation schedule and assumptions in the analysis. *Inter*-sector overlaps were addressed in Chapter 3 above (these include interactions between ES and RCII policies).

To ensure no RCII sector overlaps, policies were compared in terms of the type of energy use they target and the energy reduction measures each is expected to implement. Overlaps were identified ahead of time, and quantified, so that the measures and sectors would not be redundant to each other and therefore prevent double-counting of GHG emissions reductions. Since there were no *intra*-sector overlaps or adjustments needed, the GHG reductions and costs shown in Table 5-2 are the same as those shown in Table 5-1 above.

Table 5-2. RCII Microeconomic Analysis Summary: Intra-Sector Overlap Adjusted

		Intra-Sector Overlap Adjusted Results					
		In-State GHG Impacts			*Total GHG Impacts*	*Base Year 2014$*	
		Annual CO_2e Impacts		**2035 Cumulative**	**2035 Cumulative**	**NPV 2015-2035**	**Cost Effectiveness**
Policy ID	**Policy Name**	**2025 Tg**	**2035 Tg**	**$TgCO_2e$**	**$TgCO_2e$**	**$Million**	**$/tCO_2e$**
RCII-1.	Building Codes and Standards	(0.025)	(0.049)	(0.51)	(0.65)	($855)	($1,311)
RCII-2.	Increasing EE in new constructions - Equipment	(0.014)	(0.029)	(0.29)	(0.38)	($601)	($1,590)
RCII-3.	Increasing EE in existing constructions, excl. Ind. sector - Equipment	(0.72)	(1.2)	(14)	(18)	($21,262)	($1,206)
RCII-4.	EE Equipment and Processes in the Industrial Sector	(0.18)	(0.54)	(4.3)	(5.5)	($7,200)	($1,307)
	Total After Intra-Sector Interactions/ Overlap	**(0.94)**	**(1.8)**	**(19)**	**(24)**	**($29,918)**	**($1,238)**

*Note: (Negative cost values) imply net savings to society and positive cost values imply net societal costs.

It is also common for *inter*-sector overlaps to occur between the RCII electricity demand-side policies and the supply-side policies in the ES sector. For example, if the supply of electricity is significantly different following implementation of ES policies than it was under BAU (i.e. cleaner), then an adjustment to the carbon intensity of the electricity supply system might be warranted. A description of the assessment for whether there was a need to make this adjustment is included in Section 3.7. Briefly, the results indicated that the total change to the electricity supply system brought on through implementation of all SCAP policies was not large enough to exceed the total system marginal resource. Therefore, there was no need to make any inter-sector overlap adjustments between the RCII and ES policies.

An interaction exists between the EE policies in the RCII sector and both ES-3 (PV in Public Buildings) and ES-4 (PV in Commercial and Industrial Buildings). The ES PV generation policy goals are presented in terms of energy consumption in the respective sector. For example, ES-3 has a goal to generate enough PV electricity to meet 60% of consumption in public buildings by 2035. Since, policies RCII-1 through RCII-3 will result in reductions in electricity consumption, the amount of PV generation required to meet the ES policy goals is reduced (which leads to lower GHG reduction potential). The degree of interaction was calculated, and the PV generation requirements for ES-3 and ES-4 were reduced to account for that interaction. Those final results are shown in the final results summaries of Chapter 3 and the Executive Summary of this report.

An inter-sector policy overlap was identified between AFOLU-2 (urban forestry) and RCII-1 and RCII-2 which address higher efficiency buildings and the use of higher efficiency appliances, including air conditioners. One of the benefits of AFOLU-2 is an energy savings for buildings that will be shaded through an expansion of the urban tree canopy. This shading will reduce the air conditioning (AC) energy requirements for each of these buildings, and as a result, the energy savings (and GHG benefits) of both policies will not be additive. This overlap was adjusted for by reducing the energy savings benefits of AFOLU-2. The electricity impacts of AFOLU-2 were adjusted to account for the higher efficiency building shells and appliances resulting from RCII-1 and RCII-2. The overlap between AFOLU-2 and RCII was assumed to be 50% after full implementation of the policies in 2035. The percent of building energy intensity that is associated with AC was estimated to be 32% in 2035, consistent with the assumptions used for RCII-1. This overlap results in a reduction of AFOLU-2 electricity impacts, GHG benefits and associated electricity costs of 16% in 2035.

The policy recommendations described briefly below, and in more detail in Appendix D, result not only in significant emission reductions and costs savings, but offer a host of additional benefits as well. These benefits include savings to consumers and businesses on energy bills, which can result in the reduction in spending on energy by low-income households; reduced peak demand, electricity system capital and operating costs, risk of power shortages, energy price increases, and price volatility; improved public health as a result of reduced pollutant and particulate emissions by power plants; reduced dependence on imported fuel sources; and green collar employment expansion and economic development.

For the RCII policies recommended by the SCAP to yield the levels of savings described here, the policies must be implemented in a timely, aggressive, and thorough manner. This means, for example, not only putting the policies themselves in place, but also attending to the development of “supporting policies” that are needed to help make the recommended policies effective. While the adoption of the recommended policies can result in considerable benefits to Coahuila’s environment, security of energy supply, and the State’s consumers, careful, comprehensive, and detailed planning and implementation, as well as consistent support, of these policies will be required if these benefits are to be achieved.

Residential, Commercial, Institutional & Industrial (RCII) Policy Descriptions

Four RCII policies were analyzed for the Coahuila CAP. The following is a short summary of each policy. Appendix D contains the detailed policy descriptions, policy designs, implementation mechanisms, related policies/ programs in place, data sources/ assumptions/ methodologies, causal chains, stand-alone analytic results, key uncertainties, feasibility issues and additional benefits and costs for each policy.

RCII-1. Increasing Energy Efficiency in New and Existing Construction - Building Codes and Standards

Construction and design modifications of a building can contribute to increase energy efficiency, reducing energy demand to satisfy thermal conditioning and lighting needs, improving inhabitants' comfort, thus contributing to mitigate deterioration of the environment.

Within the framework of energetic sustainability, this policy covers regulation of design, construction and major remodeling of buildings, with the objective of building low carbon footprint "green buildings". All of this through enhancement, improvement, and adoption of regulations and standards that promote thermal isolation technologies, installation of low-power consuming lighting systems: halogen, compact-fluorescent (LFC) and light-emitting diode (LED) lamps, and carbon sequestration activities (such as green roofs, vertical gardens, and urban gardens) in new residential, commercial, institutional, and industrial buildings.

RCII-2. Increasing Energy Efficiency in New Constructions - Equipment

Part of the emissions of GHG in the residential, commercial, and institutional sectors (RCII) comes from the consumption of electricity to satisfy the needs of lighting, water heating, thermal conditioning and appliance operation.

The goal of this policy is to increase energy efficiency in the RCI sectors by reducing the energetic demand, supporting a decrease in GHG emissions from generation, distribution and consumption of energy. (Note that industrial building appliance efficiency is addressed in RCII-4). This policy promotes the following measures specifically:

- Use of solar energy through installation of solar water heaters in households, thus reducing consumption of liquefied petroleum gas (LPG), natural gas (NG) or electricity for water-heating purposes.
- Encourage the use of flow water heaters, with the purpose of reducing the use of LPG and NG.
- Acquisition of energy efficient appliances.

- Use of more energy efficient thermal conditioning equipment (e.g. mini-split inverter).

This policy is complementary to policies 2, 3 and 4 of the Energy Sector, which consider the installation of photovoltaic panels for in situ generation in residential, commercial, industrial and institutional buildings.

RCII-3. Increasing Energy Efficiency in Existing Construction – Equipment (Excluding Industrial Sector)

In this policy, GHG mitigation strategy is oriented to satisfy energetic needs of existing buildings of RCI (Residential, Commercial, Institutional) sectors by replacing high-energy-demanding technologies (electricity and gas) with more efficient ones. This policy specifically promotes the following measures:

- Use of solar energy through installation of solar water heaters in households, thus reducing consumption of liquefied petroleum gas (LPG), natural gas (NG) or electricity for water heating purposes.

- Use of flow water heaters, with the purpose of reducing the use of LPG and NG.

- Acquisition of energy efficient appliances.

- Replacement of incandescent bulbs for efficient lighting systems: halogen, compact-fluorescent (LFC) and light-emitting diode lamps (LED).

- Replacement of standard air-conditioning equipment for more energy efficient thermal conditioning equipment (e.g. mini-split inverter).

RCII-4. Stimulating Energy Efficiency in the Industrial Sector through Equipment and Industrial Process Improvement

The Special Climate Change Program anticipates that for 2020, the industrial sector will be the third GHG emission generator at a national level. The main polluting sources of this sector come from the consumption of fossil fuels during manufacturing processes, especially in the iron, steel and cement industries.

Due to the sectorial structure of economy in Coahuila, where the machinery and equipment production manufacturing sector stands out, in the iron and steel industries, as well as the metal-mechanic, industry in the state generates 29% of the total emissions of GHG.

The purpose of this policy is to implement regulations and incentives to decrease potential global warming through greater energy efficiency of the industrial sector, through improvements in operation processes, replacement and acquisition of low-energy consuming machinery and equipment, as well as replacement of high-energy demanding technologies for industrial operation (electricity and gas) for more efficient technologies (e.g. replacement of incandescent luminaries for efficient lighting systems: halogen, fluorescent-compact (LFC), and (LED) lamps; solar water heaters, etc.

Chapter 6
Transportation and Land Use (TLU) Sector

Sector Overview

Activities represented in transportation and land use (TLU) sector include fuel combustion emissions produced by light and heavy-duty on-road vehicles, as well as emissions produced by aircraft, marine vessels and rail movements. Mitigation policies in the TLU sector take into consideration direct emissions from vehicle exhaust as well as transportation system emissions associated with the extraction, production and distribution of transportation fuels, most notably oil distillates such as gasoline, diesel and aviation gasoline.

In 2010, total transportation emissions were estimated at 3.4 $TgCO_2e$. The largest contributors were on-road gasoline and on-road diesel combustion, accounting for 64% and 28% of total sector emissions, respectively. The Transportation sector GHG baseline is shown in Figure 6-1 below.

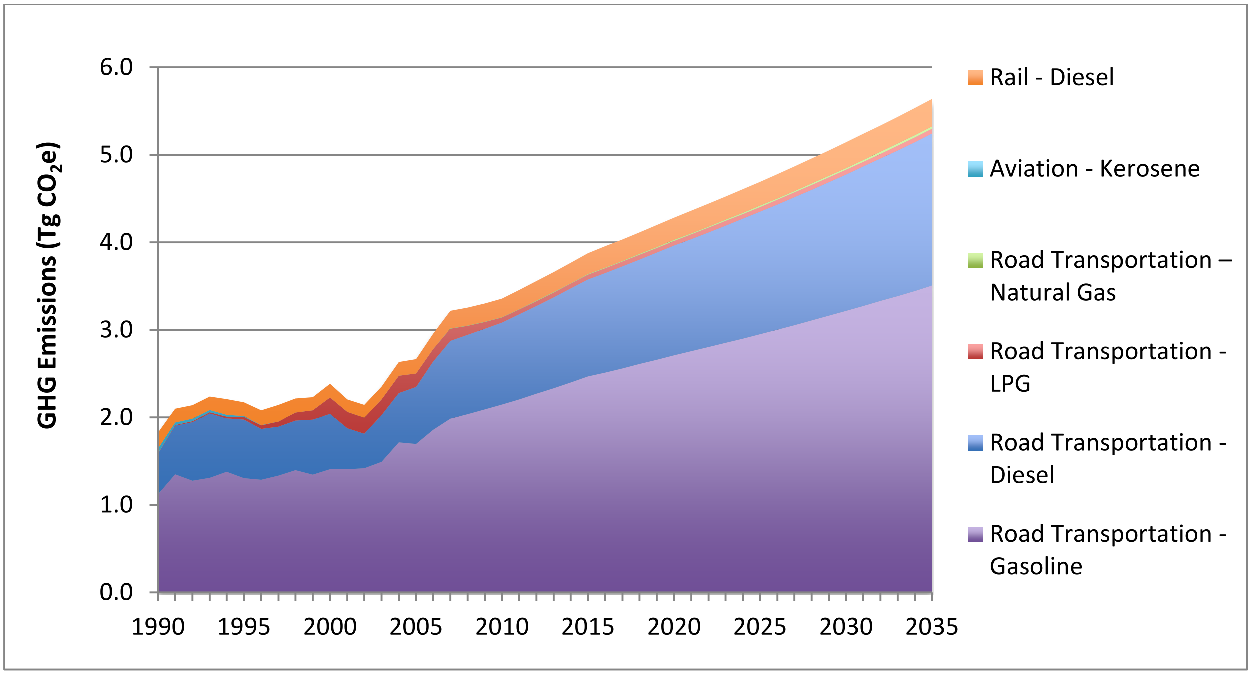
Between 1990 and 2010, total transportation emissions increased by 84%. In this time period, on-road diesel emissions increase by 103% and at a faster rate than on-road gasoline emissions, which increased by 91%.

Total transportation emissions are expected to reach 5.6 $TgCO_2e$ by 2035 representing a 68% increase from 2010. In 2035, on-road gasoline emissions are expected to account for 62% of total sector emissions followed by on-road diesel (31%) and rail diesel (6%).

The crossing of heavy trucks is one of the highlights of the dynamics at the border, and in addition to the economic benefits, this has also environmental and health impacts. Heavy diesel vehicles, construction and agriculture machinery are the three largest GHG emitters in the Mexican side of the border region.[42] Note the GHG emissions associated with fuel sales on the Mexican side of the border are included in Coahuila baseline; however, emissions from fuels purchased on the US side of the border are not included.

[42] Industrial Economics, Incorporated. 2007. *Análisis de emisiones de diésel en la región fronteriza de México y Estados Unidos*. http://www.unep.org/transport/pcfv/PDF/dieselanalysis-Sp.pdf

Figure 6-1. Transportation GHG Emissions by Mode and Fuel Source



Key Challenges and Opportunities

Coahuila has substantial opportunities to reduce GHG emissions from transportation sources. The principal approaches to reducing GHG emissions include:

- increasing urban density;
- shifting urban travel to more energy-efficient modes of transit; and
- improving vehicle efficiency.

During the last fifty years, the national population not only tripled, but there has been a migration from rural to urban settlements. By 2010, cities of more than 15,000 inhabitants accounted for 72% of the total national population (National Urban Development Program, 2014-2018, p. 3). The accelerated rate of population growth in cities was followed by an expansion of urban areas and a decrease in urban density. At the same time, there has been a drastic growth in the number of vehicles in the State's vehicle fleet. These trends reveal the disorderly growth of Mexican cities, where urban mobility systems are increasingly dependent on the private car. Despite large investments in road infrastructure, traffic congestion problems have continued to become more acute, while the average distances traveled have increased exponentially. More cars are on roads increasing total vehicle-kilometers traveled (VKT), at decreasing average speeds, producing significant externalities in time, travel costs and GHG emissions.

Sustainable urban mobility systems seek to stop and reverse these trends, through qualitative and quantitative diversification of mobility options. It seeks to ration car use by encouraging the use of mass transit and non-motorized modes of transportation. For this, it is required to modernize mass transit systems, develop infrastructure for pedestrians and cyclists, and implement beautification projects and expansion of green areas in roads, parks, gardens and other urban spaces.

To encourage the purchase of electric, plug-in hybrid and hybrid cars, this policy seeks to: incorporate this type of vehicles in the state and local governments' fleets; provide individuals who acquire them, tax incentives upon purchase (value added tax exemption and ISAN) and possession (exemption for this concept) as well as special privileges for parking; support, together with manufacturers of electric and hybrid cars with plants in the State, the development of a network of charging stations.

Overview of Plan Recommendations and Estimated Impacts

Three policies were developed and analyzed for the TLU sector that are consistent with the opportunities identified above.

- *TLU-1: Urban Density Index* – Increase the urban density index (inhabitants/ hectare) of the major metropolitan zones in the state (i.e., Saltillo-Arteaga-Ramos Arizpe, La Laguna, Monclova-Frontera, Piedras Negras-Nava).
- *TLU-2: Sustainable Urban Mobility* –Restructure the demand for the various modes of transportation, that is, reduce the percentage of private passenger car use and increase the relative participation in the use of mass public transportation, bicycling and walking.
- *TLU-3: Energy Efficient Government Fleet* - Increase participation of hybrid, pluggable hybrid and electric vehicles in the state's fleet.

Table 6-1 provides a summary of the microeconomic analysis of CAP policies for the TLU sector. These results are shown on a "stand-alone" basis, meaning any overlaps among policies have not yet been taken into account.

Table 6-1. TLU Microeconomic Analysis Summary: "Stand-Alone" Results

		In-State GHG Impacts			*Total GHG Impacts*	*Base Year 2014$*	
		Annual CO_2e Impacts		**2035 Cumulative**	**2035 Cumulative**	**NPV 2015-2035**	**Cost Effectiveness**
Policy ID	**Policy Title**	**2025 Tg**	**2035 Tg**	**$TgCO_2e$**	**$TgCO_2e$**	**$Million**	**$/$tCO_2e$**
TLU-1	Urban Density Index	(0.068)	(0.12)	(1.3)	(1.7)	($3,025)	($1,776)
TLU-2	Sustainable Urban Mobility	(0.19)	(0.35)	(4.4)	(5.6)	($30,338)	($5,390)
TLU-3	Energy Efficient Government Fleet	(0.000051)	(0.000088)	(0.00095)	(0.0012)	$3.7	$3,004
Totals		**(0.26)**	**(0.48)**	**(5.7)**	**(7.3)**	**($33,359)**	**($4,549)**

*Note: (Negative cost values) imply net savings to society and positive cost values imply net societal costs.

Overlaps Discussion

It is not expected that TLU-3 will interact with other policies in the sector given that the policy has an effect on a very narrow segment of the vehicle fleet in the state of Coahuila, namely, the government vehicle fleet, which is not directly addressed by TLU-2 or TLU-1. Some overlap is expected between TLU-1 and TLU-2 because greater urban densification in TLU-1 is likely to induce less passenger vehicle travel, which will affect the mode shift from passenger vehicle travel to public bus transit. For that reason, the cost and emission savings from gasoline from TLU-2 are adjusted downward to account for less overall vehicle travel. This overlap increases over the policy period; by 2030, TLU-2 gasoline reductions are adjusted downward by a factor of 1.9%, which is equivalent to the reduction in vehicle-kilometers traveled achieved by TLU-1.

The incorporation of plug-in electric vehicles to the State government fleet contemplated in TLU-3 will increase electricity demand. Policy scenario emissions from this marginal consumption of electricity is accounted for in the microeconomic analysis in order to evaluate the cost-effectiveness of this action. The relatively small additional increase in electricity demand for TLU-3 was taken into account in the integrative assessment described in Section 3.7 for electricity supply and demand. The TLU-3 impact did not result in any need to re-define the marginal electricity generation mix used during GHG impacts analysis.

Table 6-2. TLU Microeconomic Analysis Summary: Intra-Sector Overlap Adjusted

		Intra-Sector Overlap Adjusted Results					
		In-State GHG Impacts			*Total GHG Impacts*	*Base Year 2014$*	
		Annual CO_2e Impacts		**2035 Cumulative**	**2035 Cumulative**	**NPV 2015-2035**	**Cost Effectiveness**
Policy ID	**Policy Name**	**2025 Tg**	**2035 Tg**	**$TgCO_2e$**	**$TgCO_2e$**	**$Million**	**$/$tCO_2e$**
TLU-1	Urban Density Index	(0.068)	(0.12)	(1.3)	(1.7)	($3,025)	($1,776)
TLU-2	Sustainable Urban Mobility	(0.19)	(0.35)	(4.3)	(5.6)	($30,201)	($5,428)
TLU-3	Energy Efficient Government Fleet	(0.000051)	(0.000088)	(0.00095)	(0.0012)	$4	$3,004
Total After Intra-Sector Interactions /Overlap		**(0.26)**	**(0.47)**	**(5.6)**	**(7.3)**	**($33,222)**	**($4,571)**

*Note: (Negative cost values) imply net savings to society and positive cost values imply net societal costs.

Transportation and Land Use (TLU) Policy Descriptions

Three TLU policies were analyzed for the Coahuila CAP. Following is a short summary of each policy. Appendix D contains the detailed policy descriptions, policy designs, implementation mechanisms, related policies/ programs in place, data sources/ assumptions/ methodologies, causal chains, stand-alone analytic results, key uncertainties, feasibility issues and additional benefits and costs for each policy. The policy recommendations described briefly here not only result in emission reductions and in some instances cost savings, but also offer a host of additional benefits, such as reduced local air pollution; more livable, healthier communities; and increased transportation choices. Policies seeking to improve travel choices and reduce VMT would have the additional effect of reducing congestion and improving travel times and travel-time reliability, while allowing vehicles to idle less and operate at speeds where they are more efficient. Policies improving the efficiency of vehicles and supplying cleaner fuels would make those miles driven less emissions-intensive. Overall, most policies produce significant fuel savings, which results in savings directly to the driving public and to businesses. For TLU-1 and TLU-2, these savings exceed any costs to comply with regulation or to implement new programs.

TLU-1. Increase Urban Density Index to Reduce Average Distance in Urban Transportation

The critical variable of efficient urban mobility is not the speed of transfers, but the average distance traveled. During the last fifty years, as in the major metropolitan areas of the country, in the state's major cities, urban density has been drastically declining (in terms of inhabitants per hectare). This policy would seek to contain first and then reverse the trend, allowing the creation of more compact cities in which the average distance of daily transfers is reduced.

It is important to note that greater urban density does not require a substantial increase in the height of buildings, as there are important land reserves in urbanized areas of the cities (e.g., in the state capital, vacant lots account for nearly a quarter of the surface area of Saltillo). Raising property tax in undeveloped areas would raise the cost of land speculation and thus encourage the practice of urban infill to meet the needs of a growing population. Additionally, local zoning should allow mix use developments, thus helping to reduce distance traveled in urban trips.

TLU-2. Promote Sustainable Urban Mobility Systems

The purpose of these measures is to modify the structure of daily transfers for clean or with lower GHG emissions, while simultaneously reducing costs and travel times, improving the aesthetics of public spaces, quality of life and economic competitiveness of cities. The expansion of green areas would also enhance their ability to capture carbon.

As part of these actions, Coahuila will join the national strategies that seek to design and implement a policy of sustainable mobility for cities of 500,000 or more inhabitants (Strategy 3.5.1 PECC), which aims to promote key transportation projects that exhibit transit travel time reduction, socio-economic profitability and improved environmental impact. (Strategy 3.5.7, PECC).

TLU-3. Increase Purchase and Use of Hybrid Electric Vehicles in Government Fleets

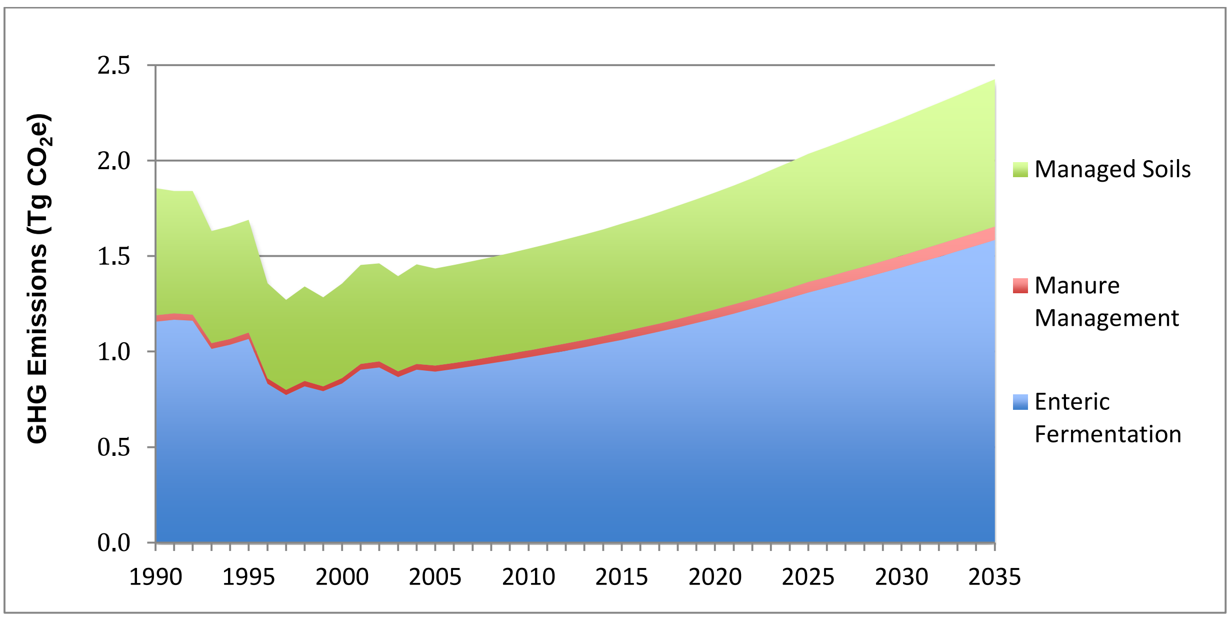
To encourage the purchase of electric, plug-in hybrid and hybrid cars, this policy seeks to: incorporate this type of vehicles in the state and local governments' fleets; provide individuals who acquire them, tax incentives upon purchase (VAT exemption and ISAN) and possession (exemption for this concept) as well as special privileges for parking; support, together with manufacturers of electric and hybrid cars with plants in the state, the development of a network of charging stations.

Chapter 7
Agriculture, Forestry and Other Land Uses (AFOLU) Sector

Sector Overview

The AFOLU sector consists of two main subsectors: Agriculture; and Forestry & Other Land Use. The agriculture subsector can be further disaggregated into crop production and livestock management. GHG emissions from crop production come mainly from a group of sources referred to as “managed soils”. Figure 7-1 provides the GHG emissions baseline for the agriculture sector. The managed soils emissions include N_2O emissions from nitrogen inputs to crop soils and CO_2 emissions from urea application and soil liming. In Coahuila, information on urea application and soil liming were not identified during the 2010 baseline effort, and thus are not included. In addition, emissions of N_2O and CH_4 from crop residue burning are expected to add small amounts to the agriculture sector totals, however, data on this activity were also lacking.

Figure 7-1. Coahuila Agriculture GHG Baseline



As indicated in Figure 7-1, emissions for the agriculture sector are expected to grow throughout the forecast period due to continued growth in the livestock sector. Emissions from the livestock management subsector include CH_4 from manure management and from enteric fermentation (mainly cattle). Figure 7-1 indicates that manure management emissions are very small contributors to sector level emissions. This is due to both the climate of Coahuila, as well as the methods of manure management. Enteric fermentation emissions along with managed soils are the predominant sources of GHGs for Coahuila.

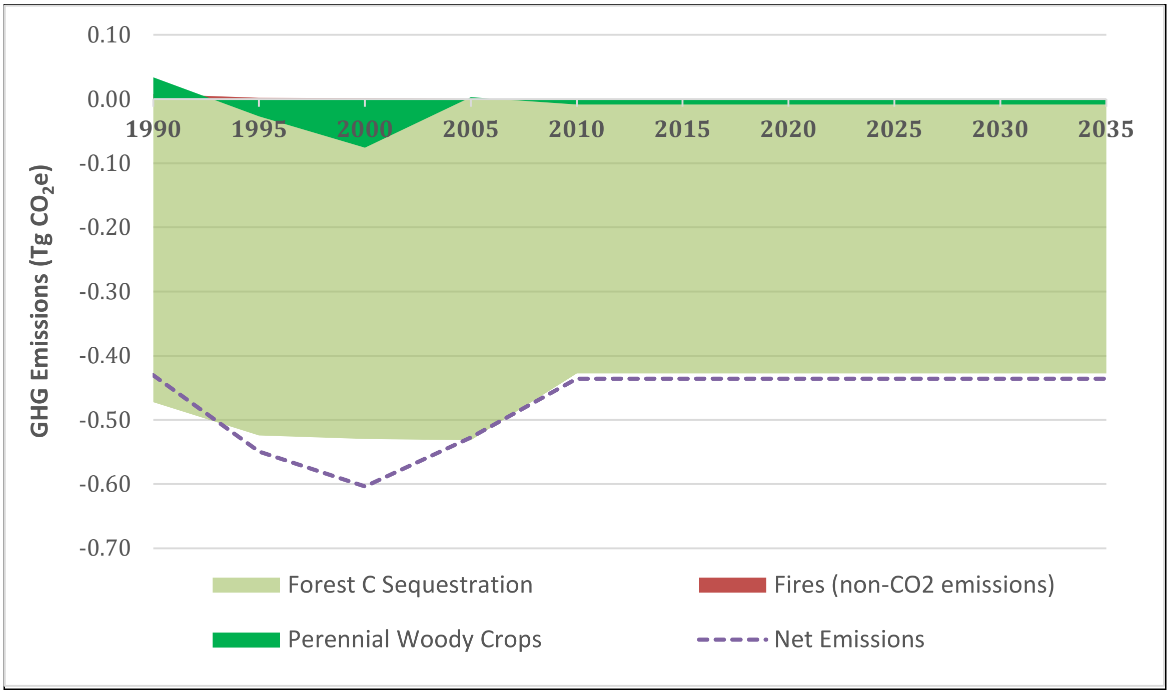
Overall, the Agriculture sector contributes only a small amount of CO's GHG emissions. In 2005, the sector contributed about 5% of state-wide emissions. This is expected to remain about the same by 2035 under BAU conditions. It is important to note that these emission estimates only include non-combustion sources. GHG emissions would also occur from the combustion of fuels in agricultural equipment and processes. However, as is common in many inventory efforts, a break-out of fuel combustion for the agricultural use was not available from the previous inventory work conducted by CCS. The only exception was for liquefied petroleum gas (LPG) combustion in agriculture (in 2005, about 0.02 $TgCO_2e$ were emitted). Diesel fuel is the most common fuel for use in agriculture, especially crop production. The agricultural fuel usage is assumed to be included in the fuel use data used to estimate the commercial or industrial fuel use. Since a full accounting of fuel use could not be made for all fuels, the emissions were excluded from Figure 7-1; however these are included in the total State-wide emissions summaries elsewhere in this report.

The Forestry & Other Land Use (FOLU) GHG baseline is provided in Figure 7-2 below. In contrast to the other sectors, FOLU is estimated to be net emissions sink in Coahuila. The net emissions line shown in the chart indicates that as a result of carbon sequestration in the forestry subsector, the overall net emissions for FOLU are about a half of a teragram. The forest carbon (C) sequestration values address the accumulation of biomass in the State's forests, net of losses to disturbances (including fires) and wood harvests.

Additional sources of emissions in the FOLU sector are non-CO_2 emissions (CH_4 and N_2O) from wildfires and net carbon flux in perennial agriculture (i.e. orchards). These non-CO_2 emissions are too small to be seen in the chart. For wildfires, the CO_2 emissions are biogenic and therefore treated as neutral in terms of climate forcing, although they are netted out of the total forest C sequestration estimates. The perennial agriculture emissions are also shown as negative, indicating a net sequestration of CO_2 from the atmosphere.

Urban forest carbon flux is a FOLU subsector that was not addressed in the previous CO baseline work due to a lack of data. This subsector includes net sequestration of CO_2 in urban trees. It is not expected that urban forests would be a significant net source or sink in CO based on climate and current urban cover; however, expansion of urban forest cover is a common policy objective in many climate action plans and was analyzed as a policy for this CO Climate Action Plan (as described later in this chapter).

Figure 7-2. Coahuila FOLU GHG Baseline



Key Challenges and Opportunities

While the AFOLU sector contributes little to the overall Coahuila emissions baseline, there are opportunities for emissions reduction in other sectors that result from implementation of agricultural and forestry policies. For example, renewable electricity production from anaerobic digestion of livestock manure offsets power requirements from the electrical grid, which indirectly reduces emissions from the electricity supply sector. Similarly, a policy that seeks to expand urban forest canopies within the State not only produces GHG benefits through increased carbon sequestration, but also reduces energy requirements for buildings that are shaded by the new urban trees. This again reduces electricity requirements from the grid and offsets electricity supply emissions.

It is these types of actions that offer the best opportunities for net GHG reductions and the associated economic benefits in Coahuila. Additional areas for future consideration of policy analysis in the AFOLU sector are soil carbon management and nutrient management. Aligned with nutrient management is the implementation of new and more efficient crop production technologies. These also offer potential for reducing emissions in other sectors, since due to current data limitations, the fuel use for agriculture is included within the Transportation sector.

Overview of Plan Recommendations and Estimated Impacts

Three policies were developed and analyzed for the AFOLU sector that are consistent with the opportunities identified above:

- *AFOLU-1: Dairy Cattle Manure Management* – This policy proposes using manure generated in the dairy farms of the state of Coahuila for the production of biofertilizer and electricity, thus supporting the reduction in the use of fossil fuels in energy generation.
- *AFOLU-2: Urban Forestry* – Urban reforestation includes complete restoration and maintenance of green areas with emphasis in rescuing and preserving native species which permits conservation and protection of the wide genetic biodiversity in the state. Also, urban trees strategically planted to provide shade or wind protection for buildings can generate benefits in energy savings (in CO, mostly lowering summer air conditioning costs). Additionally, urban trees capture rain water, which reduces the amount of storm-water that ends up at water treatment plants in areas with combined sewerage systems.
- *AFOLU-3: Rural Forestry* - Reforestation and conservation of these forested lands promotes an increase in carbon dioxide sequestration above the levels expected in BAU landcover (e.g. grassland or brushland). Additional benefits of reforestation include greater potential for the rescue of native species, protection of biodiversity, and enhancement of water resources.

Table 7-1 below provides a summary of the results of the microeconomic analyses conducted for each of the AFOLU policies. These results are shown on a “stand-alone” basis, meaning that they were evaluated against BAU conditions assuming that no other policies would be implemented. These results indicate that the total annual 2035 GHG reductions would be 0.15 $TgCO_2e$ and the cumulative reductions would be 1.7 $TgCO_2e$ from 2016-2030. Net societal implementation costs would be 404 million pesos ($2014). Implementation costs for the suite of policies (CE = $147) is fairly low for policies in the AFOLU sector, although the GHG reduction potential was found to be modest.

Table 7-1. AFOLU Microeconomic Analysis Summary: "Stand-Alone" Results

		In-State GHG Impacts			*Total GHG Impacts*	*Base Year 2014$*	
		Annual CO_2e Impacts		**2035 Cumulative**	**2035 Cumulative**	**NPV 2016-2035**	**Cost Effectiveness**
Policy ID	**Policy Title**	**2025 Tg**	**2035 Tg**	**$TgCO_2e$**	**$TgCO_2e$**	**$Million**	**$/tCO₂e**
AFOLU-1.	Dairy Cattle Manure Management[a]	(0.026)	(0.055)	(0.74)	(1.8)	$285	$159
AFOLU-2.	Urban Forestry[b]	(0.0037)	(0.0093)	(0.085)	(0.089)	$4.2	$47
AFOLU-3.	Rural Forestry[c]	(0.042)	(0.084)	(0.88)	(0.88)	$115	$131
	Totals	**(0.072)**	**(0.15)**	**(1.7)**	**(2.8)**	**$404**	**$147**

*Note: (Negative cost values) imply net savings to society and positive cost values imply net societal costs.
[a] Cost estimates exclude potential incremental value of bio-fertilizer.

[b] Full benefits for tree planting policies are not realized until the full life of the newly planted trees are considered. For example, in 2075, the CE = -MX$130, indicating a net savings to society.

[c] Full benefits for tree planting policies are not realized until the full life of the newly planted trees are considered. For example, in 2075, the CE = MX$27, indicating a much smaller cost to society.

Overlaps Discussion

No *intra*-sector overlaps were identified among the AFOLU policies. However, potential *inter*-sector overlaps or interactions do exist among CO SCAP policies. For example, AFOLU-2 addressing urban forestry includes the energy savings benefits, and the associated GHG benefits and implementation costs, for building shading and wind protection overlaps with policies RCII-2 and -3 address energy efficiency in residential and commercial buildings (via new codes and standards and increased appliance efficiencies). These overlaps are further discussed in Chapter 3 (Section 3.7).

The other area where there can be *inter*-sector interactions is in situations where an AFOLU policy has an estimated electricity system impact (e.g. new renewable energy or energy efficiency). Section 3.7 provides a discussion of how these types of electricity system interactions were addressed for all sectors with policies that have electricity system impacts. The AFOLU policies involved here are AFOLU-1 and -2. AFOLU-1 (dairy manure management) implementation will result in additional renewable electricity being supplied to the grid, while AFOLU-2 (urban forestry) will reduce building energy demand.

Another *inter*-sector overlap identified for the AFOLU sector policies is between AFOLU-2 and RCII-1 (and potentially to a lesser extent RCII-2). The building energy savings impacts achieved through implementation of AFOLU-2 (greater shading of buildings resulting in lower air conditioning demands) overlaps with the energy reductions associated with greater air conditioning appliance efficiencies in the RCII sector. To address this overlap, a 50% reduction was made to the electricity savings estimated for AFOLU-2. These adjustments were described in the Chapter 5 section addressing RCII policy overlaps, and they are captured within the final CO SCAP results.

Since no AFOLU *intra*-sector overlaps were identified, the results shown in Table 7-2 below show no change from the stand-alone results shown in Table 7-1 above.

Table 7-2. AFOLU Microeconomic Analysis Summary: Intra-Sector Overlap Adjusted Results

		Intra-Sector Overlap Adjusted Results[a]					
		In-State GHG Impacts			*Total GHG Impacts*	*Base Year 2014$*	
		Annual CO_2e Impacts		**2035 Cumulative**	**2035 Cumulative**	**NPV 2015-2035**	**Cost Effectiveness**
Policy ID	**Policy Name**	**2025 Tg**	**2035 Tg**	**$TgCO_2e$**	**$TgCO_2e$**	**$Million**	**$/tCO_2e$**
AFOLU-1.	Dairy Cattle Manure Management	(0.026)	(0.055)	(0.74)	(1.8)	$285	$159
AFOLU-2.	Urban Forestry	(0.0037)	(0.0093)	(0.085)	(0.089)	$4.2	$47
AFOLU-3.	Rural Forestry	(0.042)	(0.084)	(0.88)	(0.88)	$115	$131
Total After Intra-Sector Interactions /Overlap		**(0.072)**	**(0.15)**	**(1.7)**	**(2.8)**	**$404**	**$147**

*Note: (Negative cost values) imply net savings to society and positive cost values imply net societal costs.
[a] No intra-sector overlaps were identified among the AFOLU policies.

Agriculture, Forestry and Other Land Uses (AFOLU) Policy Descriptions

Three AFOLU policies were analyzed for the Coahuila SCAP. Following is a short summary of each policy. Appendix F contains the detailed policy descriptions, policy designs, implementation mechanisms, related policies/ programs in place, data sources/ assumptions/ methodologies, causal chains, stand-alone analytic results, key uncertainties, feasibility issues and additional benefits and costs for each policy.

AFOLU-1. Dairy Cattle Manure Management

This policy proposes using manure generated in the dairy farms of the state of Coahuila for the production of bio-fertilizer and electricity, thus supporting the reduction in the use of fossil fuels in energy generation. The focus will be in the Laguna Region, where under BAU conditions, it is expected that only about 7% of dairy manure will be managed using anaerobic digestion (AD) technologies that reduce methane emissions and produce renewable electricity. Through implementation of this policy, 40% of dairy manure will be managed via anaerobic digestion by 2025. The policy will target implementation of AD technology at both large dairies (>1,500 head of cattle; 60% of targeted population) and medium-sized dairies (500 – 1,500 head of cattle; 40% of targeted population).

AFOLU-2. Increase and Maintenance of Urban Vegetation

Urban reforestation includes complete restoration and maintenance of green areas with emphasis in rescuing and preserving native species. This supports conservation and protection of the wide genetic biodiversity in the State. Also, strategically-planted urban trees provide shade and/or wind protection for buildings and thus can generate benefits in energy savings (in CO, mostly lowering summer air conditioning costs). Additionally, urban trees capture rain water, which reduces the amount of storm-water that ends up at water treatment plants in areas with combined sewerage systems.

The policy addresses incremental urban tree plantings of 5,000 trees per year beginning in 2016 all the way through the planning period of 2035. This results in a total expansion of the urban forest of the State of 100,000 trees (the equivalent of about 240 hectares of rural forest for the State). Further, most of these new plantings (65%) will be strategically-sited to achieve energy savings benefits.

AFOLU-3. Increase and Conservation of Vegetation in Rural Areas

Reforestation and conservation of these forested lands promotes an increase in carbon dioxide sequestration above the levels expected for the BAU landcover (e.g. grassland or brushland). Additional benefits of reforestation include greater potential for the rescue of native species, protection of biodiversity, and enhancement of water resources.

Through property acquisition or the establishment of conservation easements with property owners, the goals of the policy are to reforest approximately 3,200 hectares per year during the 20 year CO SCAP planning period (nearly 64,000 hectares total). Lands targeted for conservation and reforestation will be at the rural-urban interface which will indirectly influence more efficient land use and "smart growth". Thus, this policy is complementary to TLU-1 which seeks to achieve higher urban densities.

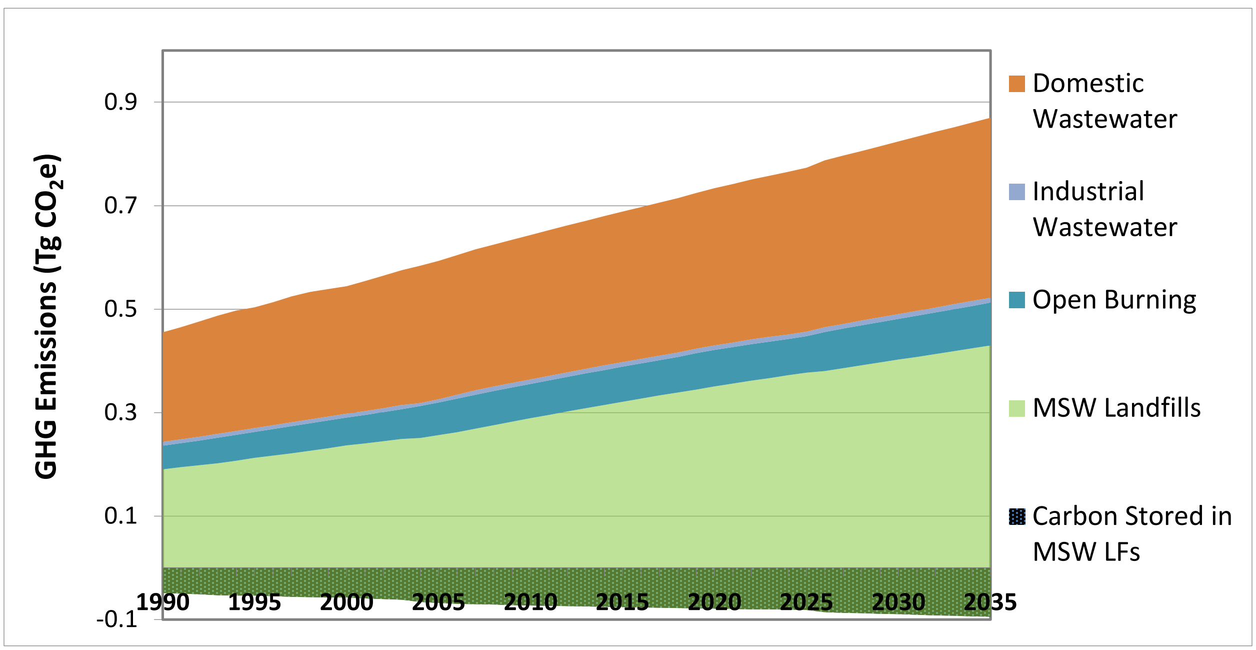
Chapter 8
Waste Management (WM) Sector

Sector Overview

The WM sector consists of two subsectors: solid waste management; and wastewater treatment. Each of these can be further disaggregated into industrial and municipal subsectors; however, in Coahuila, very little industrial waste management or wastewater treatment activity was identified. Therefore, the GHG emissions are nearly all associated with municipal treatment. Energy consumption (both fuels and electricity) are included within the RCII and Transportation sectors.

Figure 8-1 below provides the non-energy GHG emissions baseline for the WM sector. Direct energy related emissions would include sources like municipal solid waste (MSW) landfill (LF) equipment fuel usage. This type of information for fuel consumption could not be disaggregated from the State level fuel consumption data, so the fuel consumption is likely lumped into the Transportation and/or RCII fuel consumption totals. Also, not included in these totals are the indirect emissions associated with electricity consumption, notably in the wastewater treatment subsector (those would also be aggregated within the commercial or industrial subsectors).

Figure 8-1. CO Waste Management GHG Baseline, Non-Energy Net Emissions



The emissions shown in Figure 8-1 represent net emissions, since biogenic carbon storage in landfills is also included. Biogenic carbon here refers to food and garden waste. When biogenic waste materials (food, lawn/garden waste, wood, paper) are placed in landfills, these materials will likely take many decades to decompose. As a result, some level of carbon storage takes place, and it is accounted for in the net emissions results shown in Figure 8-1. Standard accounting procedures are to credit carbon storage for food and lawn/garden waste, but not for other biogenic materials, such as wood and paper, since the sustainability of their sourcing is uncertain. This carbon storage is estimated to be 0.07 $TgCO_2e$ in 2010 and is expected to grow to 0.09 $TgCO_2e$ in 2035.

Methane emissions from MSW landfills contribute about 50% of the gross emissions in 2010 (0.36 $TgCO_2e$). The contributions from this source are expected to grow to about 54% (0.53 $TgCO_2e$) by 2035. The other large contributor is domestic wastewater treatment (CH_4 and N_2O emissions from the treatment process). Gross emissions contributions were about 39% in 2010 (0.28 $TgCO_2e$) and are expected to contribute around 36% (0.35 $TgCO_2e$) in 2035.

Overall, the WM sector contributes a small amount of the total State-wide emissions. The sector contributed a little under 3% to the 2010 emissions totals, and in 2035, the contribution is expected to be 2% of State-wide emissions. It is important to note that these emissions only address non-energy emissions. Emissions associated with fuel combustion (e.g. for the transportation of waste, landfill operations, etc.) or for electricity consumption (e.g. for wastewater treatment processes) are included in the totals of the RCII and Transportation sectors. Future work on the baseline should attempt to allocate the energy related emissions from these sectors to the applicable WM subsectors.

Key Challenges and Opportunities

Within the solid waste management subsector, opportunities for reducing emissions are typically thought about in terms of the following hierarchy:

- I. *Solid waste source reduction*: when generation is reduced, the emissions associated with all downstream management are reduced (e.g. waste combustion or landfilling); as are the emissions associated with the initial production and transportation of the waste material (upstream emissions);
- II. *Recycling*: recycling a waste material will often reduce the overall emissions associated with the upstream production of materials and their subsequent downstream management in the waste stream;
- III. *Organics Management:* examples include anaerobic digestion, composting, or other methods that reduce downstream management emissions as compared to conventional management methods (e.g. landfilling or combustion);
- IV. *Other Enhanced Downstream Management Approaches:* these could include any number of methods to reduce emissions from conventional methods, including waste to energy projects, landfill gas utilization, and other technologies.

The solid waste policy selected for analysis in the CO SCAP addresses group IV in the solid waste management hierarchy above: extension of landfill gas management within the State.

For wastewater treatment, there are three general approaches in the hierarchy to managing emissions and energy use, and all of these have many alternatives:

- I. *Reducing Wastewater Generation*: as with solid waste, for any reduced wastewater generation – a) less water has to be extracted, treated and distributed from the source, saving energy and emissions; and b) less wastewater has to be treated, also saving energy and emissions; so, this approach addresses any actions taken by residential, commercial, institutional, or industrial end users to reduce their initial consumption of water;
- II. *Re-Use or Reclamation of Wastewater*: wastewater can often be re-used or reclaimed for another purpose; thereby, the overall energy and emissions associated with sourcing water and treating wastewater are reduced, as is the consumption of the primary water resource itself (e.g. surface or groundwater);
- III. *Reducing Process and/or Energy Emissions during Wastewater Treatment, including on-site renewable energy generation:* many alternatives exist here with the most common being energy efficiency retrofits at wastewater treatment plants; however, other alternatives could include process improvements to reduce methane or nitrous oxide emissions, as well as the use of anaerobic digestion of organic wastes to generate methane for use as process heat or to generate electricity.

Policy WM-2 selected for the CO SCAP, Water Sanitation and Reclamation for Industrial Processes and Irrigation, comes from group II in the hierarchy above. More details on the WM policies and an assessment of their direct impacts is provided in the next section.

Overview of Plan Recommendations and Estimated Impacts

Two policies were developed and analyzed within the WM sector:

- *WM-1. Landfill Gas Management:* This policy seeks to capture methane from the landfills of Saltillo and Torreon to reduce GHG emissions and to generate electricity with connection into the public grid;
- *WM-2. Water Sanitation and Reclamation for Industrial Processes and Irrigation:* This policy supports projects to increase the percentage of wastewater sanitation and the subsequent re-use of wastewater. Increased re-use of wastewater for use in industry or for irrigation purposes decreases energy use as compared to the use of potable water which may be sourced and pumped from distant sources.

Table 8-1 below provides a summary of the results of the microeconomic analyses conducted for each of the WM policies. These results are shown on a "stand-alone" basis, meaning that they were evaluated against BAU conditions assuming that no other policies would be implemented. These results indicate that the total annual 2035 in-State GHG reductions would be 0.17 $TgCO_2e$ and the cumulative in-State reductions would be 2.9 $TgCO_2e$ from 2016-2035. Total reductions, including in-State and potentially out of State reductions, produced by these policies would total 3.1 $TgCO_2e$ from 2016 – 2035. Implementation of both policies is estimated to result in net societal savings upon full implementation of $2,234 million pesos ($2014). These savings are presented on a net present value (NPV) basis using a financial base year of 2014. The net savings produce a negative cost effectiveness (CE) value of -\$712/tCO_2e.

Table 8-1. WM Microeconomic Analysis Summary: "Stand-Alone" Results

		In-State GHG Impacts			*Total GHG Impacts*	*Base Year 2014$*	
		Annual CO_2e Impacts		**2035 Cumulative**	**2035 Cumulative**	**NPV 2016-2035**	**Cost Effective -ness**
Policy ID	**Policy Title**	**2025 Tg**	**2035 Tg**	**TgCO_2e**	**TgCO_2e**	**$Million**	**$/t$CO_2$e**
WM-1.	Landfill Methane Gas	(0.13)	(0.13)	(2.1)	(2.2)	($153)	($71)
WM-2.	Water Sanitation and Reclamation for Industrial Processes and Irrigation	(0.037)	(0.051)	(0.76)	(0.98)	$2,081	($2,132)
	Totals	**(0.17)**	**(0.19)**	**(2.3)**	**(3.1)**	**($2,234)**	**($712)**

*Note: (Negative cost values) imply net savings to society and positive cost values imply net societal costs.

Overlaps Discussion

No *intra*-sector overlaps were identified among the WM policies. *Inter*-sector overlaps or interactions among CAP policies, however, do exist. Both policies will produce renewable electricity that will either supplant on-site use or be supplied to the local grid. As a result, this produces a possible interactive effect with the electricity supply-side policies. The overall CO SCAP electricity supply and demand *inter*-sector integration assessment is provided in Section 3.5.

Since there were no intra-sector interactions or overlaps identified, the results shown in Table 8-2 below show no change from the stand-alone results shown in Table 8-1 above.

Table 8-2. WM Microeconomic Analysis Summary: Intra-Sector Overlap Adjusted Results

		In-State GHG Impacts			*Total GHG Impacts*	*Base Year 2014$*	
		Annual CO_2e Impacts		**2035 Cumulative**	**2035 Cumulative**	**NPV 2016-2035**	**Cost Effective-ness**
Policy ID	**Policy Name**	**2025 Tg**	**2035 Tg**	**$TgCO_2e$**	**$TgCO_2e$**	**$Million**	**$/$tCO_2e$**
WM-1.	Landfill Methane Gas	(0.13)	(0.13)	(2.1)	(2.2)	($153)	($71)
WM-2.	Water Sanitation and Reclamation for Industrial Processes and Irrigation	(0.037)	(0.051)	(0.76)	(0.98)	$2,081	($2,132)
Total After Intra-Sector Interactions/ Overlap		**(0.17)**	**(0.19)**	**(2.9)**	**(3.1)**	**($2,234)**	**($712)**

*Note: (Negative cost values) imply net savings to society and positive cost values imply net societal costs.

Waste Management (WM) Policy Descriptions

Two WM sector policies were analyzed for the Coahuila SCAP. Following is a short summary of each policy. Appendix G contains the detailed policy descriptions, policy designs, implementation mechanisms, related policies/ programs in place, data sources/ assumptions/ methodologies, causal chains, stand-alone analytic results, key uncertainties, feasibility issues and additional benefits and costs for each policy.

WM-1. Landfill Methane Utilization

This policy promotes the expansion of landfill methane energy capture and utilization in the State. The policy expands the use of this technology beyond BAU conditions which include the existing 1 mega-watt (MW) methane collection and utilization project in Saltillo. Under the policy, the methane collection and electricity generation capacity at Saltillo will be doubled to 2 MW by 2020. Also, by 2025, a 1 MW system will be constructed at the Torreon landfill. The renewable electricity generated by methane from Coahuila's landfills will be supplied to the Federal Electricity Commission's (CFE) public grid.

Landfill gas capture and utilization reduces direct CH_4 emissions, and indirectly reduces fossil fuel use to produce electricity for the public grid. It also generates local income and employment for landfill operators.

WM-2. Water Sanitation and Reclamation for Industrial Processes and Irrigation

This policy promotes both an increase in the amount of wastewater collected for centralized treatment, as well as increasing percentages of reclamation of wastewater for industrial processes and irrigation of urban green areas and agricultural crops. The policy will then: reduce the amount of GHG emissions and water pollutions resulting from not sanitizing wastewater under BAU conditions; reduce the amount of water consumed from primary sources (e.g. surface or groundwater); and reduce the overall amount of energy required for water use in industrial processes and irrigation purposes.

Since the extension of wastewater treatment collection and centralized treatment services will require an increase in energy consumption as compared to BAU conditions, the policy will also promote the application of renewable energy (photo-voltaic electricity generation) at levels that will offset the increase in energy requirements (because of the expansion of centralized treatment services and the associated energy use, without this aspect of the policy, there would not likely be a net GHG benefit). Usage of reclaimed water for urban green areas allows savings in consumption of water from aquifers, at the same time that green areas in cities are preserved (see AFOLU-2). Drinking water supplies for the population are also conserved.