
# Final Report
## of the
# Baja California Phase 2 Climate Action Plan

Submitted to:
the Secretaria de Proteccion al Ambiente (SPA), 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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# Table of Contents

# Acknowledgments

The Baja Phase 2 Climate Action Plan (CAP) process was guided by a collaboration of the Baja Partners. The Baja Partners included representatives of the Secretaria de Proteccion al Ambiente (SPA), the Border Environment Cooperation Commission (BECC), the Mexico Low Emissions Development (MLED) Program (funded by the U.S. Agency for International Development (USAID) and represented by the World Wildlife Fund (WWF), el Colegio de la Frontera Norte (el Colef) and the Center for Climate Strategies (CCS). The Baja Partners gratefully acknowledge the following individuals and organizations that contributed significantly to the successful completion of the Baja Phase 2 Climate Action Plan development process and the publication of this report:

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The Partners also wish to thank Nayeli Trevino Gil of SPA for serving as the liaison between SPA and the Baja CAP process.

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- Ricardo Troncoso, Antonio Mediavilla and Jessica Roman Ramirez of the Mexico Low Emission Development (MLED) Program, and Mark Oven of Tetra Tech, the MLED Program Manager.

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# 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) or baseline of Greenhouse Gas (GHG) emissions in the state of Baja California (BC) and the other northern border states of Mexico. The key findings of this report are summarized below and in more detail in Chapter 2.

In late 2010 and 2011, BECC and CCS worked closely with the state of BC Secretary of Environmental Protection (Secretaria de Proteccion al Ambiente (SPA)) to conduct a Phase 1 Climate Action Plan (CAP) process in Baja. Results of this Phase 1 process were a set of catalogs of potential state climate action policies and a priority list of policies for further detailed analysis in a Phase 2 CAP process. The Phase 1 process is summarized in Chapter 1.

All of the priority policies developed during the course of Phase 1 in 2010 and 2011 were reviewed and considered as the Phase 2 Baja CAP process commenced in 2013. For the Phase 2 CAP process, the following entities have joined together as Partners in this collaborative effort:

- SPA is the state environmental agency for the state of Baja California for whom the CAP has been prepared;
- BECC is a sponsoring organization which provided more than half of the funding for the project;
- The MLED Program (funded by USAID and represented by WWF) is a second sponsoring organization which provided almost half of the funding for the effort;
- El Colegio de la Frontera Norte (el Colef) is a local university in BC which was contracted to provide the Local Project Manager (LPM) to coordinate the process locally and also provide the members of the Baja California Panel of Experts (PE). El Colef was supported by the Latin America Regional Climate Initiative (LARCI);
- CCS is a non-profit entity that was contracted by BECC and the MLED Program to perform technical, facilitative, capacity-building, and project management services in developing the CAP for Baja; and
- Regional Economic Models Inc. (REMI) is a company that provides macro-economic models to assess economic and employment impacts associated with a wide range of economic activities and sectors. REMI is a sub-contractor to CCS for this service.

The objectives for the BC CAP Phase 2 CAP 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 state CAP for Baja California and to enhance state capacity in climate planning and analysis through a “learning-by-doing” development process directed by CCS.

The capacity development objective evolved early in the Phase 2 process. SPA, BECC and the MLED program determined that el Colef, rather than SPA, would be the entity to host the Panel of Experts (PE) and to receive the training for micro-economic and macro-economic analysis. The capacity building process was designed from the outset to be a learning-by-doing effort in which CCS trained the PE in the step-wise process for policy design and associated micro- and macro-economic analysis, and then shared the work load of actually conducting the policy design and technical analysis of the selected policy recommendations. Chapter 3 includes a list of the Members of the PE and their affiliations. Also presented in Chapter 3 is a brief summary of the training initiatives provided to the PE by the CCS Team.

It is anticipated that following the completion and delivery of this Report to SPA and the State government in Baja California that additional deliberation and analysis will be undertaken to determine which of the policies presented herein have the most potential for immediate implementation and which may take additional development work. The analysis contained herein should be helpful to the decision-makers in the State in making these choices. Assignments will then need to be made to various implementing entities to carry out the initiatives outlined herein. The recommendations contained in this report are meant to be a starting point for implementation of a comprehensive climate action plan. In some cases, more detailed policy design work will be needed prior to implementation. Future work is also expected to involve the addition of new policies in order to bend the curve representing the State's forecasted emissions.

## Baja California GHG Emissions Inventory & Forecast

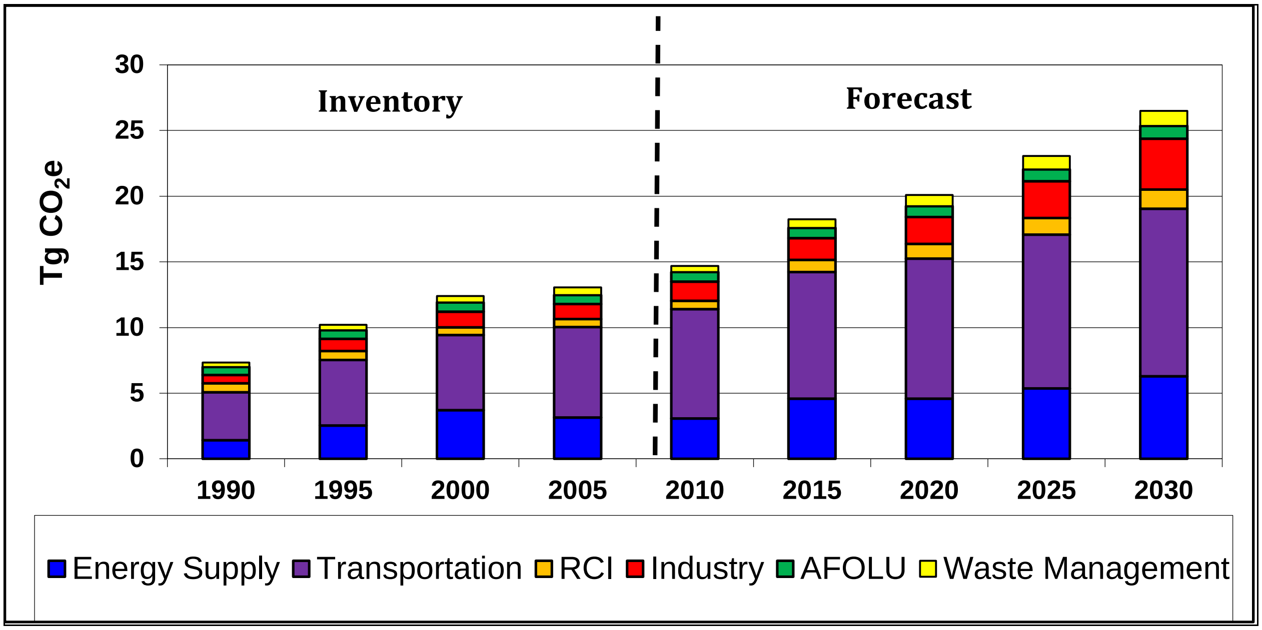
The inventory and business as usual (BAU) forecast (or "baseline") of GHG emissions was constructed primarily from the 2010 GHG I&F prepared by CCS.[1] As summarized in Figure ExS-1 below, the baseline is economy-wide and includes annual emissions data for all sectors. "Net" emissions indicate that these estimates include both sources and sinks of GHGs (e.g. carbon sequestration in the Forestry sector).

All sectors of BC'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 BC, this mainly addresses the Power Supply (PS) subsector;
- Residential, Commercial & Institutional (RCI): this covers emissions from fuel combustion in buildings;

[1] *Greenhouse Gas Emissions in Baja California 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 2030 and revised in some sectors based on information from a COLEF GHG inventory*: Inventario De Gases Efecto Invernadero Del Estado De Baja California, Periodo 1990-2005*, Octubre del 2012. Not documented in Appendix A was an additional revision made to the residential liquefied petroleum gas (LPG) consumption forecast provided by the BC technical team. NOTE: since the baseline results reported in the body of this CAP incorporate revisions made during its development, minor differences should be expected between them and the values reported in the original 2010 CCS baseline report provided in Appendix A.

**Figure ExS-1. Baja California's Net GHG Emissions by Sector**




- 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 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-1, as well as Figure ExS-2 below, emissions are expected to double from the year 2005 to the end of the planning period in 2030. 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-2, the Energy Supply and Transportation sectors are expected to contribute to most of the emissions growth in Baja California during the forecast period.

**Figure ExS-2. BC Net GHG Emissions Baseline by Sector**

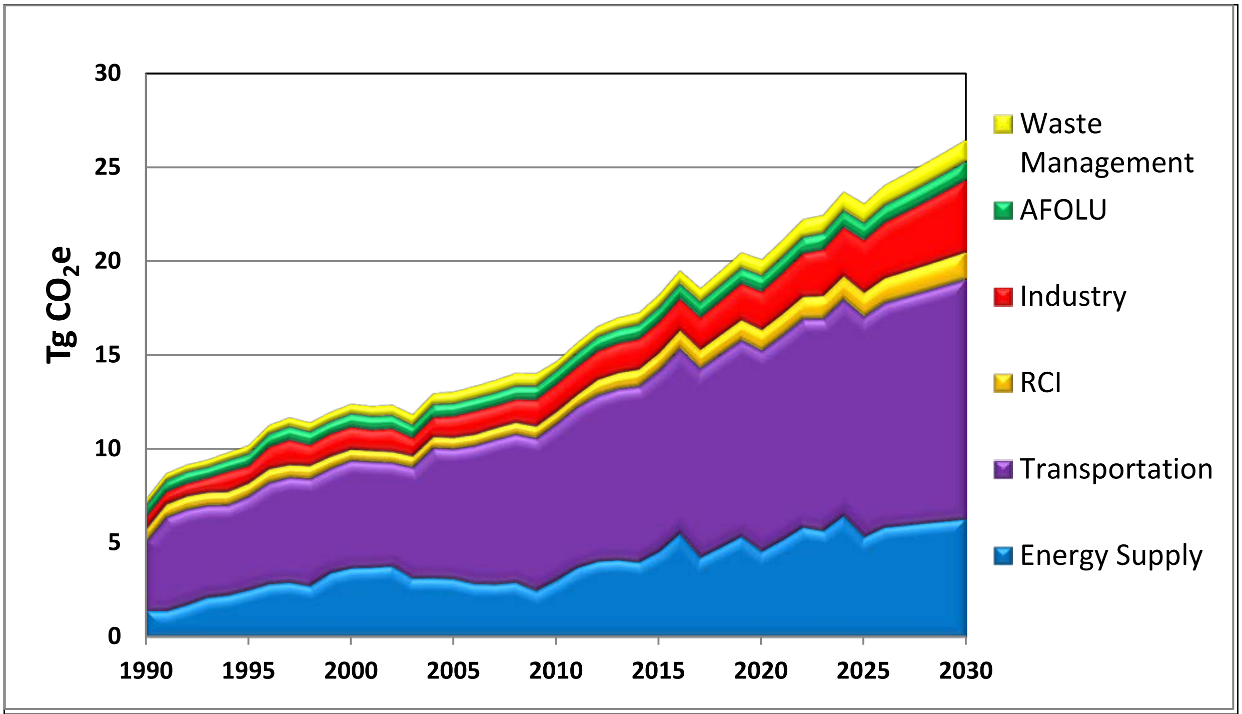



Figure ExS-3 and ExS-4 provide GHG emissions normalized to population and economic output ("carbon intensities"). On a per capita basis, BC's emissions are well below national levels; however, the intensity is expected to increase substantially during the planning period. On the basis of economic output, a mild climate and the historic lack of a lot of heavy industry in BC produces a lower carbon intensity for the State as compared to national levels; however, the future growth in emissions from all of the energy sectors (electricity supply, industry, commercial/residential, and transportation) is expected to increase carbon intensity levels close to the national levels by 2030. A more detailed break-down of Baja California's 2005 GHG emissions can be found in Chapter 2 and Appendix A.

**Figure ExS-3. BC and National Carbon Intensities, per capita**

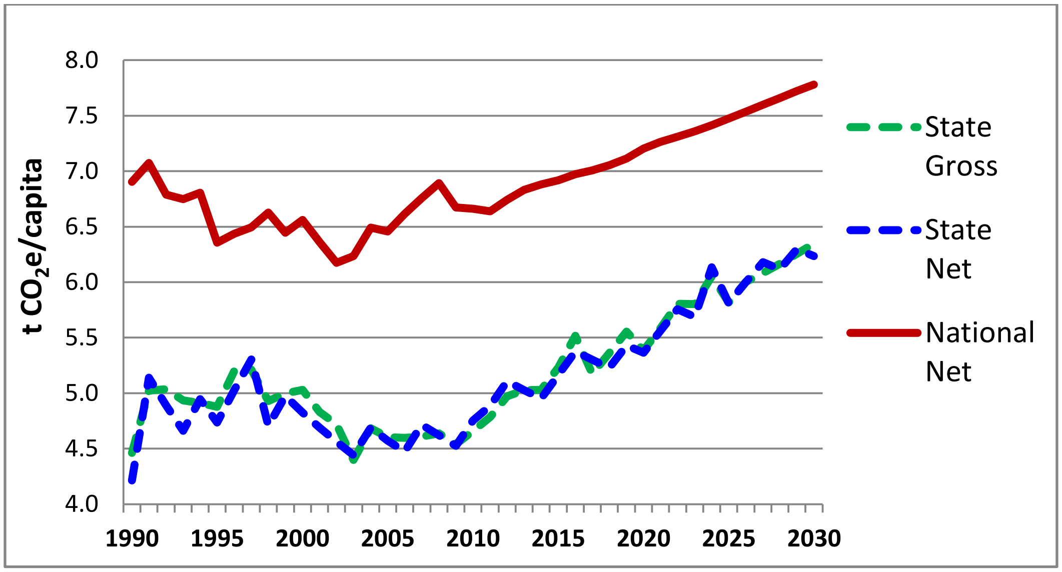
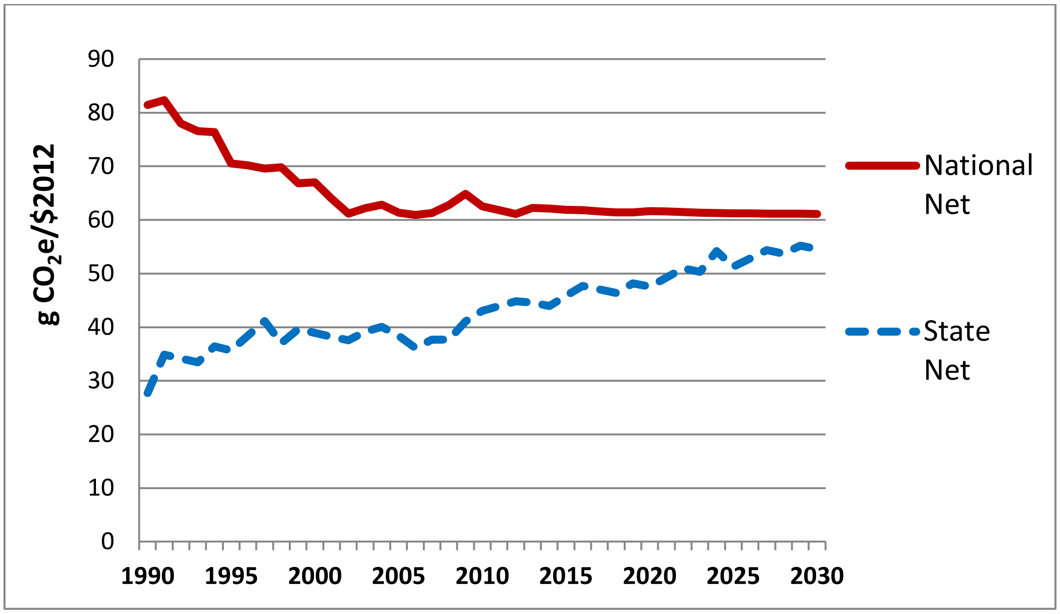



**Figure ExS-4. BC and National Carbon Intensities, per unit economic output**




## Summary of Micro-Economic Analysis Methodology and Results

To initiate work under Phase 2 of the CAP, policy designs were developed for each of the priority policies selected during Phase 1. 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.

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 BC CAP, the planning period extends from the first year of implementation (generally 2016) to 2030. 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 analysis.

Key results from the micro-economic analysis phase are summarized in Table ExS-1 and include:

- Net GHG reductions in 2020, 2030, and cumulative through the planning period. Figure ExS-5 provides the cumulative GHG reductions estimated for each of the CAP policies;
- 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-6 provides a summary of the cost effectiveness estimates for the CAP policies;
- Net changes in activity: changes in electricity consumption, fossil fuel use, renewable power generation, etc.

Figure ExS-7 presents a step-wise marginal abatement cost curve for the BC CAP. The horizontal (x) axis represents the percentage of 2030 BAU GHG emission reductions. The vertical (y) axis represents the marginal cost of mitigation (expressed as the cost-effectiveness for each policy recommendation). In the figure, each horizontal segment represents an individual policy. The width of the segment indicates the GHG reduction potential of the recommendation in percentage terms. The height of the segment relative to the vertical axis shows the average cost (or savings) associated with reducing 1 $tCO_2e$ of GHG emissions for each policy recommendation. Note that recommendation steps appearing below the “$0” line on the vertical axis are cost-saving policies, while the recommendations above this line have positive net direct costs. It is important to note that the policy recommendations with an estimated cost savings still often require significant up-front investments.

**Table ExS-1. Summary of BC CAP Micro-Economic Analysis of Policies and Results**

| Policy ID | Policy Name | 2020 Annual Reductions ($TgCO_2e$) | 2030 Annual Reductions ($TgCO_2e$) | Cumulative 2015-2030 ($TgCO_2e$) | NPV Costs/ Savings 2015-2030 ($2012MM) | Cost Effectiveness ($2012/$tCO_2e$) |
|---|---|---|---|---|---|---|
| ES-1 | Micro-Hydro Renewable Energy Generation | 0.047 | 0.065 | 0.78 | $231 | $294 |
| ES-2 | Energy Supply Diversification | 0.94 | 1.3 | 16.0 | $6,814 | $425 |
| ES-3 | Distributed Energy Supply for Building | 0.013 | 0.019 | 0.22 | $6.9 | $31 |
| ES-4 | Photovoltaic Panel Electricity Generation | 0.018 | 0.025 | 0.30 | $150 | $505 |
| **Energy Supply Sector Totals** | | **1.0** | **1.5** | **17** | **$7,201** | **$415** |
| RCII-1 | Energy Efficiency: Residential Shell Improvement | 0.019 | 0.019 | 0.26 | ($309) | ($1,172) |
| RCII-2 | Energy Efficiency: New Housing Appliances | 0.016 | 0.016 | 0.43 | ($290) | ($675) |
| RCII-3 | Energy Efficiency: Existing Buildings | 0.58 | 0.58 | 8.2 | ($10,952) | ($1,342) |
| RCII-4 | Finance Incentives for Machinery Energy Efficiency | 0.27 | 0.73 | 6.1 | ($11,771) | ($1,915) |
| RCII-5 | Solar Water Heaters on Housing | 0.44 | 0.44 | 6.1 | ($8,800) | ($1,435) |
| RCII-6 | Flow Water Heaters for Residential Sector | 0.14 | 0.14 | 2.0 | ($3,095) | ($1,559) |
| **Residential, Commercial, Institutional & Industrial Sector Totals** | | **1.5** | **1.9** | **23** | **($35,217)** | **($1,523)** |
| TLU-1 | Black Carbon Control Measures | 0.046 | 0.000 | 0.30 | $60 | $196 |
| TLU-2 | Alternative Fuels | 0.03 | 0.08 | 0.77 | ($188) | ($242) |
| TLU-3 | On-road Fleet Efficiency | 0.00 | 0.01 | 0.07 | ($81) | ($1,150) |
| TLU-4 | Increase efficiency in urban mobility | Dropped from final CAP results. | | | | |
| TLU-5 | Smart Growth Planning | 0.011 | 0.036 | 0.28 | ($480) | ($1,716) |
| TLU-6 | Energy Efficient Government Fleet | 0.000084 | 0.00011 | 0.0015 | $2.3 | $1,609 |
| **Transportation & Land Use Sector Totals** | | **0.10** | **0.12** | **1.4** | **($686)** | **($480)** |
| AFOLU-1 | Manure Management: Non-Dairy Livestock | 0.00037 | 0.00037 | 0.0048 | $3.4 | $714 |
| AFOLU-2 | Manure Management: Dairies | 0.020 | 0.021 | 0.27 | $31 | $117 |

| Policy ID | Policy Name | 2020 Annual Reductions ($TgCO_2e$) | 2030 Annual Reductions ($TgCO_2e$) | Cumulative 2015-2030 ($TgCO_2e$) | NPV Costs/ Savings 2015-2030 ($2012MM) | Cost Effectiveness ($2012/$tCO_2e$) |
|---|---|---|---|---|---|---|
| AFOLU-3 | Utilization of Wheat Straw | N/A; GHG reductions and costs are reported with the ES-2 policy totals. | | | | |
| AFOLU-4 | Bioethanol Production from Sweet Sorghum | N/A; GHG reductions and costs are reported with the TLU-2 policy totals. | | | | |
| AFOLU-5 | Livestock Grazing Management | 0.07 | 0.12 | 1.31 | $1,117 | $855 |
| AFOLU-6 | Urban Forestry | 0.00005 | 0.0006 | 0.0034 | $17 | $5,514 |
| **Agriculture, Forestry and Other Land Use Sector Totals** | | **0.090** | **0.14** | **1.58** | **$1,169** | **$739** |
| WM-1 | Landfill Gas Management | 0.27 | 0.32 | 3.9 | $258 | $67 |
| WM-2 | Indirect Potable Water Re-Use | 0.025 | 0.035 | 0.43 | ($226) | ($532) |
| WM-3 | Water Reclamation | 0.041 | 0.071 | 0.76 | ($415) | ($545) |
| WM-4 | Biodiesel Production | N/A; GHG reductions and costs are reported with the TLU-2 policy totals. | | | | |
| Waste Management Sector Totals | | **0.34** | **0.43** | **5.1** | **($383)** | **($76)** |
| **Total Integrated Plan Results** | | **3.0** | **4.1** | **49** | **($27,916)** | **($575)** |

**Figure ExS-5. Cumulative GHG Reduction Potential by CAP Policy**

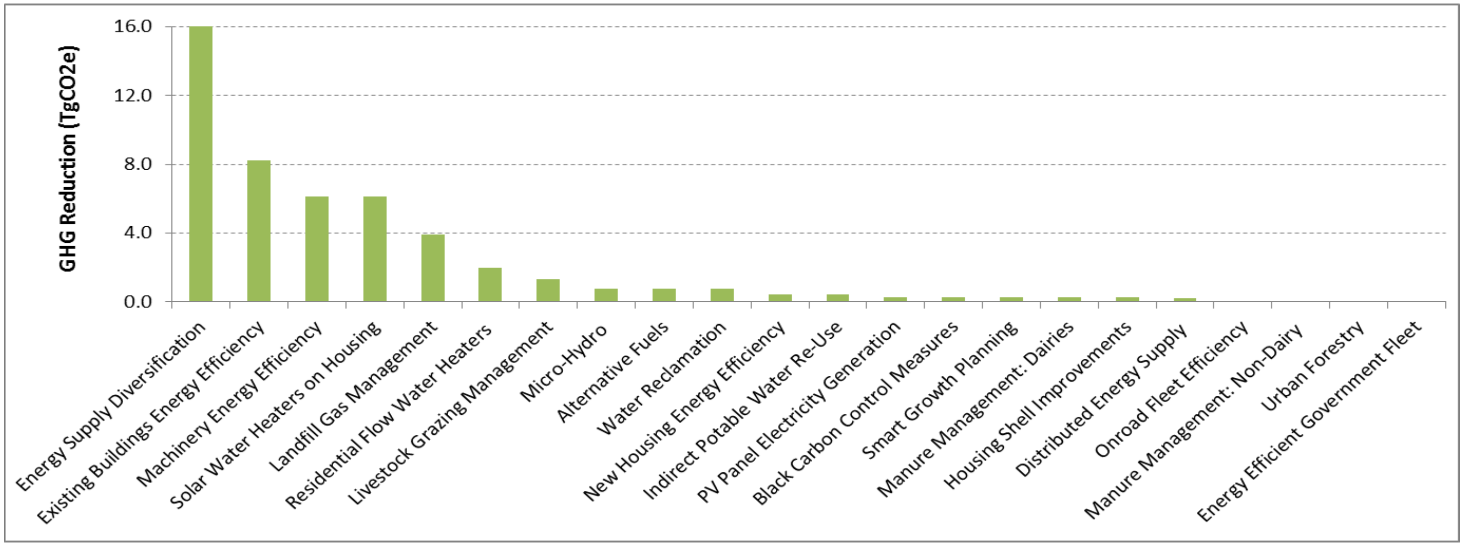



**Figure ExS-6. Cost Effectiveness of each CAP Policy**

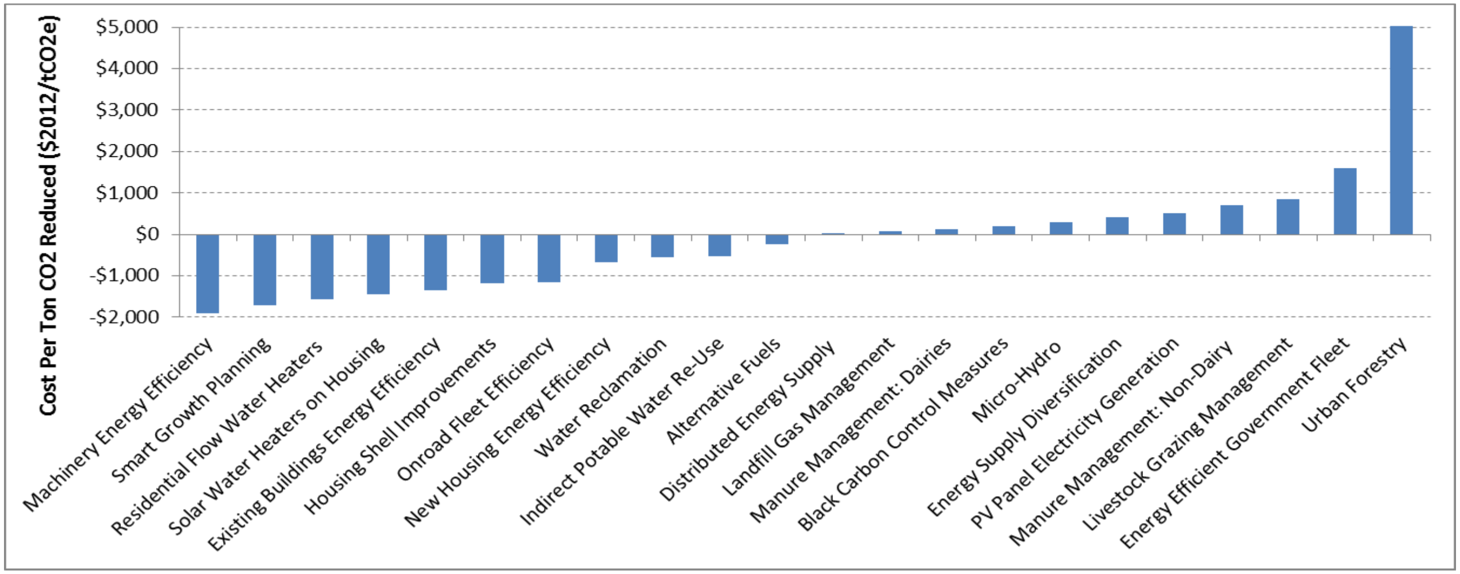
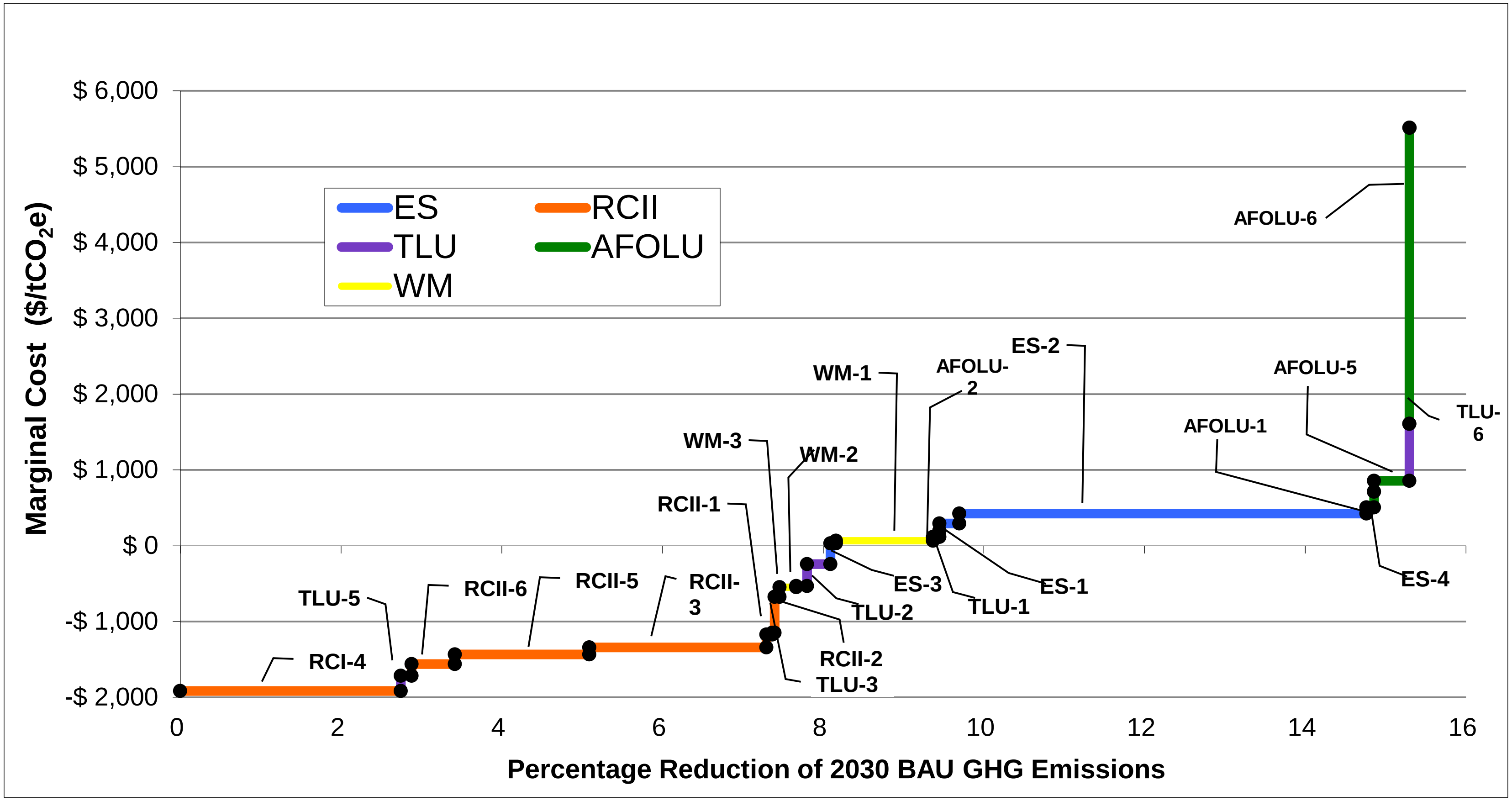


**Figure ExS-7. Marginal Abatement Cost Curve for the BC CAP**




| | | | | |
|---|---|---|---|---|
| ES-1. Micro-Hydro Renewable Energy Generation | RCII-2. EE: New Housing Appliances | TLU-1. Black Carbon Measures | AFOLU-1. Manure Management: Non-Dairy | WM-2. Indirect Potable Water Re-Use |
| ES-2. Energy Supply Diversification (includes AFOLU- | RCII-3. EE: Existing Buildings | TLU-2. Alternative Fuels (includes AFOLU-4 & WM-4). | AFOLU-2. Manure Management: Dairies | WM-3. Water Reclamation |
| ES-3. Distributed Energy Supply for Buildings | RCII-4. EE: Finance Incentives for Machinery | TLU-3. On-Road Fleet Efficiency | AFOLU-5. Livestock Grazing Management | |
| ES-4. Photovoltaic Panel Electricity Generation | RCII-5. Solar Water Heaters on Housing | TLU-4. Increase Efficiency in Urban Mobility | AFOLU-6. Urban Forestry | |
| RCII-1. EE: Residential Shell Improvement | RCII-6. Flow Water Heaters for Residential Sector | TLU-6. Energy Efficient Government Fleet | WM-1. Landfill Gas Management | |

## Summary of Macro-Economic Analysis Methodology and Results

In this project the Regional Economic Models, Inc. (REMI) Policy Insight Plus (PI+) Model was adapted to analyze the macro-economic impacts of the Baja California Climate Action Plan. REMI PI+ Model is the most widely used macro-econometric forecasting and policy impact analysis model in the U.S. and is also used in many additional countries. At its core, the Baja California REMI Model uses a 32-industry input-output (I-O) model developed based on the data found in the World Input-Output Database (WIOD). The I-O feature enables analysis of the interactions between sectors (ordinary multiplier effects) stemming from the direct changes brought on by the mitigation policies. However, the REMI Model is superior to an I-O model by incorporating the responses of the producers and consumers to price signals in the simulation. The REMI Model also brings into play features of labor and capital markets, as well as trade of Baja California with other states in Mexico or with other countries, including changes in competitiveness.

The major input data for the macro-economic impact modeling are the direct costs and savings of the GHG mitigation policy options analyzed in the microeconomic analysis of BC CAP. In addition, in cases where these costs/savings and some conditions relating to the implementation of the policy options were not specified in the micro-economic analysis or were not known with certainty, the micro-economic quantification results were supplemented with additional data and assumptions required for the REMI modeling. A detailed list of the supplemental assumptions is presented in Chapter 9 along with additional details on the macro-economic modeling approach applied for the CAP.

The macro-economic analysis results indicate that, as a group, the recommended GHG mitigation policy options/policy bundles yield a positive impact on the Baja California economy. On net, the combination of the 22 policy options/bundles are expected to result in an increase in employment of about 1,680 new jobs per year during the planning period from 2014 to 2030 and yield an increase in GDP of about $9.85 billion pesos in NPV.

Table ExS-2 presents a summary of the projected impacts on Gross State Product (GSP) from implementation of the policies for each sector. The numbers represent the difference in GSP compared with the baseline level from the implementation of the recommended policies. The GSP impacts are presented for both key years (in terms of impact in those years) and the net present value (NPV) over the entire planning period. Chapter 9 includes the projected economic impacts for each individual policy option/bundle. The last row of Table ExS-2 presents the results for the simultaneous run (i.e. all policies/policy bundles implemented together).

**Table ExS-2. Summary of Gross State Product Impacts by Sector (Difference from Baseline Levels) (Millions of 2012 Pesos)**

| Scenario/Sector | 2015 | 2020 | 2025 | 2030 | NPV |
|---|---|---|---|---|---|
| Sub-total – ES Sector | $0 | $975 | -$3,004 | -$2,760 | -$3,772 |
| Sub-total – RCI Sector | $475 | $1,282 | $1,710 | $2,534 | $14,163 |
| Sub-total – AFOLU Sector | $0 | -$61 | -$26 | $48 | -$303 |
| Sub-total – WM Sector | $0 | -$22 | -$39 | $44 | $79 |
| Sub-total – TLU Sector | $10 | -$35 | -$92 | -$127 | -$202 |
| **Summation Total** | **$486** | **$2,140** | **-$1,451** | **-$261** | **$9,967** |
| **Simultaneous** | **$486** | **$2,141** | **-$1,475** | **-$311** | **$9,853** |

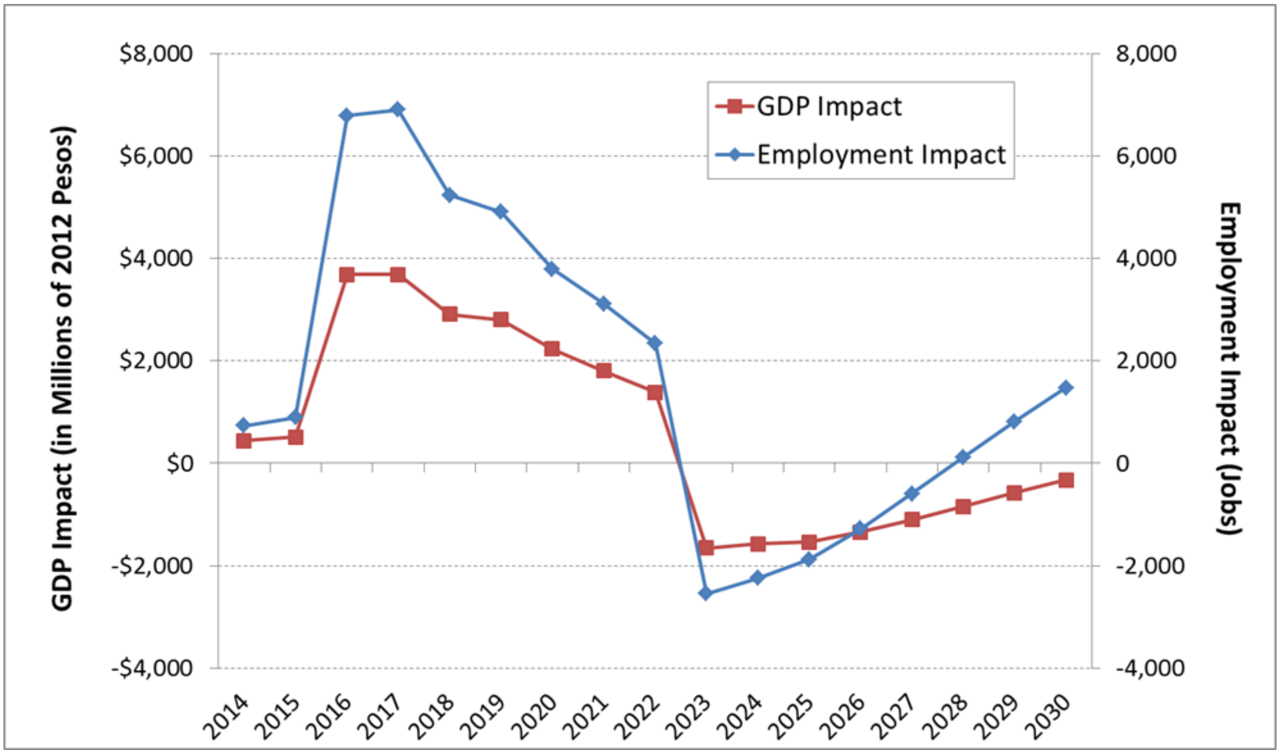
Table ExS-3 presents a summary of the projected employment impacts for each sector. The last row of the table presents the results for the simultaneous run.

**Table ExS-3. Summary of Employment Impacts by Sector (Difference from Baseline Levels) (Number of Jobs)**

| Scenario/Sector | 2015 | 2020 | 2025 | 2030 | Jobs/Year |
|---|---|---|---|---|---|
| Sub-total - ES Sector | 0 | 1,787 | -4,936 | -3,598 | -905 |
| Sub-total - RCII Sector | 863 | 2,600 | 3,776 | 5,543 | 2,994 |
| Sub-total - AFOLU Sector | 0 | -432 | -294 | -43 | -242 |
| Sub-total - WM Sector | 0 | -75 | -118 | 12 | -31 |
| Sub-total - TLU Sector | 31 | -83 | -240 | -303 | -90 |
| **Summation Total** | **894** | **3,797** | **-1,812** | **1,611** | **1,726** |
| **Simultaneous Total** | **894** | **3,794** | **-1,881** | **1,470** | **1,680** |

Figure ExS-8 presents the yearly GSP and employment impacts of the simultaneous run (detailed results of the simultaneous run are presented in Chapter 9).

**Figure ExS-8. Integrated Yearly GSP and Employment Impacts of the 22 Policy Options/Policy Bundles**




The results highlight the following impacts of the GHG mitigation options on the Baja California economy:

- The investment in GHG mitigation policies are estimated to generate significant positive impacts to the Baja California state economy during the upfront investment period of the various projects (primarily between 2015 and 2022, though different options have different starting years and initial investment periods);
- Both the GSP and employment impacts become negative starting from 2023 when the initial investment of the various options is completed and the production of capital equipment has peaked, and the increased annual capital cost (due to the payback of the initial investment) starts to dominate the overall impact;
- The savings resulting from the implementation of energy efficiency related options increase overtime, and, by 2028, the net employment impact is projected to become positive again, while the net GSP impact approaches zero by the target year 2030 (in general employment impacts are more positive than GSP impacts in percentage terms because of the relative labor intensity of the mitigation options);
- The employment gain is projected to be 1,680 jobs per year over the entire planning period;

- The net GSP gain is projected to be about $9.9 billion (2012 pesos) in NPV by 2030. Although the yearly GSP impacts are projected to be negative between 2023 and 2030, the substantial GSP gains in the earlier years more than offset the negative impacts in later years, and thus lead to the overall positive GSP impacts in NPV over the entire planning period; and
- The net disposable personal income gain is projected to be about $11.4 billion (2012 pesos) in NPV over the planning period.

## Key Findings and Recommendations

The PE and LPM, in consultation w/ the project Partners, developed the proposed priority policy recommendations for detailed analysis in Phase 2. 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 25 multi-sector policy recommendations that were analyzed and which are included in this proposed CAP (Note: when fuel supply- and demand-side policies are bundled together for economic analysis, the total = 22);
- As shown below in Table ExS-4, 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 Baja California of 4.1 $TgCO_2e$ in 2030 (15% of BAU forecasted emissions);
- These policies are projected to have a net direct societal savings of almost 28 billion pesos ($2012) cumulatively during the period of 2015 - 2030. The weighted-average cost-effectiveness of these policies is expected to be -$575 ($2012/$tCO_2e$);
- During the course of the Phase 2 CAP process, the CCS 2010 GHG Inventory and Forecast was updated in several sectors using more recent local data and information. The forecast was also extended from 2025 to 2030 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 could nearly double between 2010 and 2030 under business as usual conditions. Key sectors contributing to this growth are Transportation (particularly on-road vehicles), ES (almost all of this from the power supply subsector), and RCII (primarily, the result of increased electricity demand);
- At the macro-economic scale, the analysis results indicate that full implementation of all 22 policies/policy bundles would results in an average of nearly 1,700 jobs created during each year of the planning period (2015 – 2030) and would result in a net GSP gain of nearly 10 billion 2012 pesos during this time-frame; and

- While an annual economy-wide GHG reduction of over 4 $TgCO_2e$ seems sizable as compared to current emissions levels of around 18 $TgCO_2e$; these reductions still 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; 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.

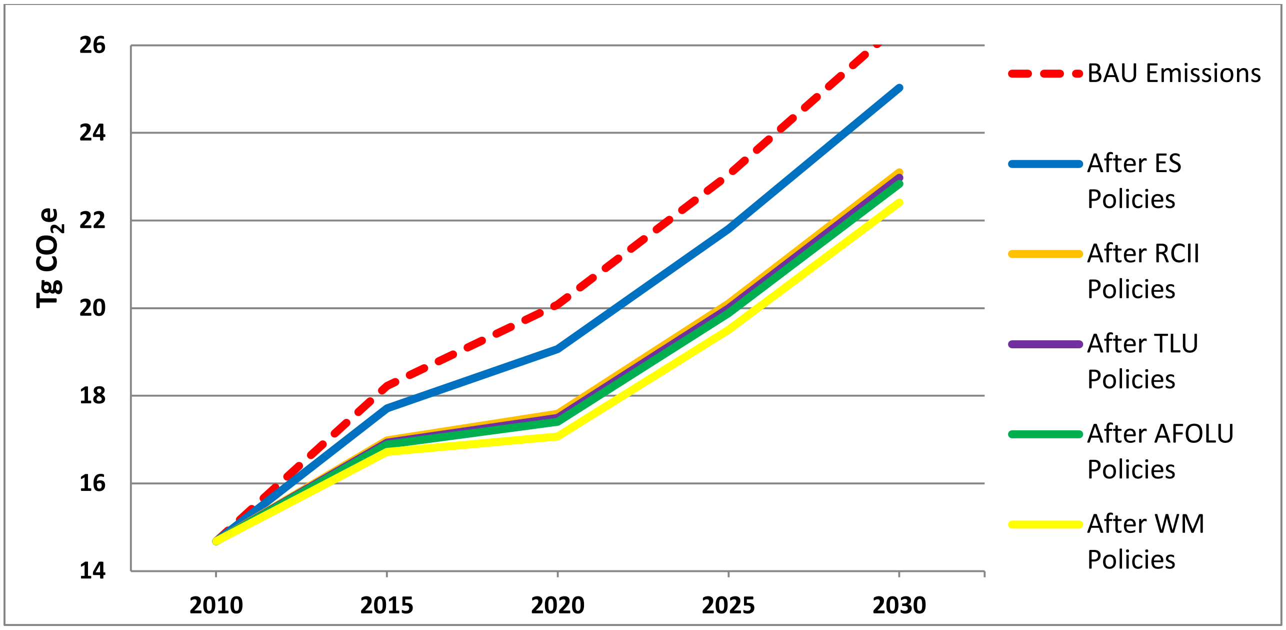
  For example, the Transportation sector contributes about half of the 2030 BAU emissions, however, emissions reductions for TLU policies only provide a little over 2% of the CAP totals in 2030. Additional opportunities for reductions in the ES and RCII sectors could also be important to begin to bend the GHG emissions curve for BC. The current set of CAP policies that address renewable electricity production and energy efficiency (mostly occurring in the ES and RCII sectors) reduce electricity supply emissions by roughly half by 2030.

More details can be found in Chapters 2 through 9 of the report.

**Table ExS-4. Sector-level GHG Reductions for the BC CAP**

| | $TgCO_2e$ | | | | |
|---|---|---|---|---|---|
| **Emissions Metric** | **2010** | **2015** | **2020** | **2025** | **2030** |
| Projected BAU GHG Emissions | 14.7 | 18.2 | 20.1 | 23.0 | 26.5 |
| Plan Reductions: ES Sector | 0.00 | *0.51* | 1.0 | *1.2* | *1.5* |
| Projected Emissions with ES Policies | 14.7 | 17.7 | 19.1 | 21.8 | 25.0 |
| Plan Reductions: RCII Sector | 0.00 | *0.74* | 1.5 | *1.7* | *1.9* |
| Projected Emissions with ES/RCII Policies | 14.7 | 17.0 | 17.6 | 20.1 | 23.1 |
| Plan Reductions: TLU Sector | 0.00 | *0.05* | 0.10 | *0.11* | *0.12* |
| Projected Emissions with ES/RCII/Industry/TLU Policies | 14.7 | 16.9 | 17.5 | 20.0 | 23.0 |
| Plan Reductions: AFOLU Sector | 0.00 | *0.04* | 0.09 | *0.11* | *0.14* |
| Projected Emissions with ES/RCI/Industry/TLU/AF Policies | 14.7 | 16.9 | 17.4 | 19.9 | 22.8 |
| Plan Reductions: WM Sector | 0.00 | *0.17* | 0.34 | *0.38* | *0.43* |
| Projected Emissions with All Policies | 14.7 | 16.7 | 17.1 | 19.5 | 22.4 |
| ***Total GHG Reductions from Plan Policies*** | *0.00* | *1.5* | *3.0* | *3.5* | *4.1* |
| **Emissions After Quantified Plan Policies** | **14.7** | **15.2** | **17.1** | **19.5** | **22.4** |

**Figure ExS-9. Sector-level GHG Reductions for the BC CAP**



# Chapter 1
# Background and Overview

## Summary of Baja California 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 Baja California 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 Baja Secretary of Environmental Protection (Secretaria de Proteccion al Ambiente (SPA)) convened Phase 1 of the Climate Action Plan (CAP) process for Baja California. The Secretary of SPA formed the Baja 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.

Two meetings of the CAG were held in November and December of 2010. Through these two meetings CCS and the CAG developed the Baja Catalogs of Potential State Climate Action Policies.[2] They contained over 300 potential policies for consideration in Baja. The CAG then set about the process of prioritizing the 300+ policies for potential further detailed analysis in a Phase 2 climate planning process, to come later. In early 2011 the SPA Secretary also reached out to other stakeholders to gather input on the potential climate mitigation policies for consideration in Baja.

Following the CAG meetings CCS concluded its Phase 1 work in Baja by presenting its Final Report on the Baja Phase 1 process.[3] SPA continued to consult with stakeholders and work on prioritization of policies for Baja and in November 2011 produced its final report on the Phase 1 process.[4]

All of these priorities developed during the course of Phase 1 in 2010 and 2011 were reviewed and considered as the Phase 2 Baja CAP process commenced in 2013. This Phase 2 CAP process was conducted within the overall context of recent actions on climate that are taking place within the state of Baja California and nationally in Mexico, which the Panel of Experts have summarized on the following two pages.

[2] Baja California Catalog of GHG Reduction Policy Options
[3] Plan Estatal de Acción ante el Cambio Climático de Baja California, Agosto 2011
Fase 1 – Identificación de opciones prioritarias para la mitigación de emisiones de gases efecto invernadero, Agosto 2011
[4] Programa Estatal de Acción ante el Cambio Climático de Baja California, Novembre, 2011

## Recent Actions in Baja California

Climate change is a challenge for the three levels of government in Mexico. At the federal level in recent years various concrete actions to address climate change have been undertaken. As a part of the National Climate Change Strategy of the Mexican government are the General Law on Climate Change and the Special Climate Change Program.

Baja California has also undertaken various efforts to reduce greenhouse gases. Some of the leading strategies from the first phase of the 2008-2012 State Climate Change Action Plan have been undertaken (PEACC-BC). In 2012 the Law on Prevention, Mitigation and Adaptation of Climate Change for the State (LPMACC) was enacted and in 2014 a council to address climate change was established.

The first stage of PEACC-BC was a collective effort that combined the technical, scientific and social experience developed in Baja California. The Ministry of Environmental Protection (SPA) of Baja California prompted this first phase with the support of three academic institutions in the state: Center for Scientific Research and Higher Education of Ensenada (CICESE), the Independent University of Baja California and the School of the North Border; federal authorities: Ministry of Environment and Natural Resources (SEMARNAT), the National Institute of Ecology and Climate Change (INECC) and the Border Environment Cooperation Commission (BECC). The purpose of this program was to develop regional climate change scenarios for the XXI century, assess impacts and vulnerability of various socio-economic sectors of the State, and define mitigation and adaptation action.

The LPMACC was the first law on climate change at the state level enacted in Mexico, thus placing Baja California to the forefront to address this global challenge. The main objective of this law is the design and implementation of public policies to mitigate climate change and adapt to its adverse effects. LPMACC and PEACC-BC are two important and strategic State's tools to tackle climate change.

Some months after the issue of LPMACC, the government of Baja California established the Council on Climate Change (CCC). Likewise, in 2014 the Council for Sustainable Development (CSD) was established. The purpose of both councils is to promote reforms and policies to address climate change. The CCC includes State Secretaries; and the CDS is composed of representatives of the three levels of government and civil society.

The second stage of PEACC-BC began in early 2013 and is the subject of this report.

The most notable actions on climate change in Baja California were proposed by the previous state government; however, the current administration is also aware of the need to reduce GHG emissions, and thus it has included climate change in the 2014-2019 State Development Plan, in relation to the issue of environment and sustainable development, as a core concept of sustainable economic development.

## Recent Actions in Mexico

Climate change policy in Mexico is based on the precepts of the UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. As a non-Annex I country, Mexico has developed policy instruments and legal tools to fulfill its commitments under the Convention and the Protocol (SEMARNAT, 2012).[5]

In November 1997, three years after the UNFCCC entered into force, Mexico submitted the first national communication that aimed at providing an overview of national circumstances regarding climate change, studies and measures - direct and indirect - taken on climate change. The Second National Communication was published in 2001 in an important context since the Kyoto Protocol was ratified unanimously. In 2006 the Third National Communication was published, three years later the Fourth National Communication, and in 2012 Mexico submitted the Fifth National Communication, becoming the first developing country to submit it.

The increasingly specialized and specific content of the National Communications is also due to institutional advancement. In 2005 in Mexico it was established the Inter-ministerial Commission on Climate Change (ICCC) in order to coordinate, within its respective powers, actions of the agencies and entities of the Federal Public Government on the formulation and implementation of policies for the prevention and mitigation of GHG (GHG) emissions, adaptation to the effects of climate change and, in general, to promote the development of programs and strategies for climate change action to comply with the commitments under the UNFCCC.

In 2007 the National Climate Change Strategy (NCCS) was publicly announced, where opportunities for mitigation and adaptation were identified (SEMARNAT, 2012: 30); based on this strategy, the 2009-20012 Special Climate Change Program was developed, an instrument of transversal policy of the Federal Government, to explicitly seek mitigation and adaptation to climate change, without affecting economic growth.

On June 6, 2012 the General Law on Climate Change (GLCC) was published in the Official Journal of the Federation (DOF) and entered into force on October 10 of that year. This law defines the institutional framework for adaptation and mitigation actions in Mexico. It provides, inter alia, the division of responsibilities among the various levels of government (federal, state and municipal); the establishment of the Inter-ministerial Commission on Climate Change (ICCC), the Council on Climate Change and the National Institute of Ecology and Climate Change (INECC). Planning instruments are the National Climate Change Strategy, the Special Climate Change Program (SCCP), and programs of the federal states and municipalities. (SEMARNAT, 2012: 394). Thus, the States have an institutional framework to align objectives of the different sectors to contribute to climate change objectives at the Federal level.

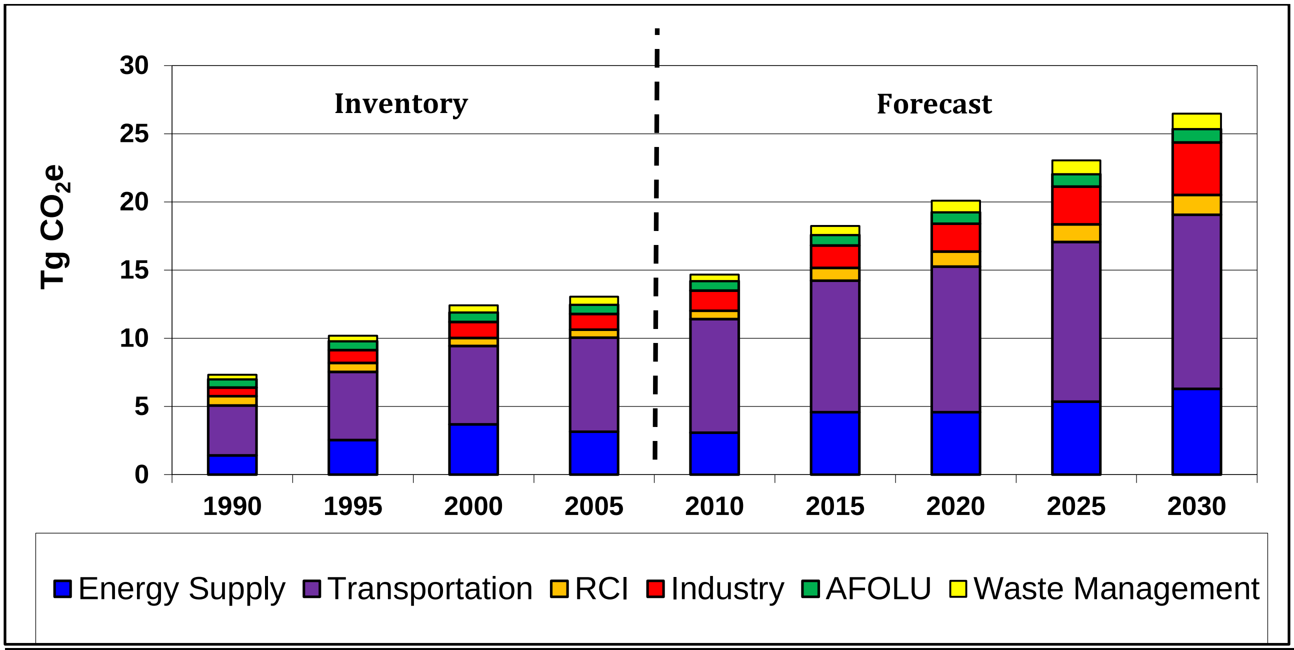
[5] SEMARNAT. 2012. Quinta Comunicación Nacional ante la Convención Marco de las Naciones Unidas sobre el Cambio Climático. Comisión Intersecretarial de Cambio Climático. http://unfccc.int/resource/docs/natc/mexnc5s.pdf

# 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.[6] As summarized in Figure 2-1 below, the baseline is economy-wide and includes annual emissions data for all sectors.

**Figure 2-1. Baja California's GHG Baseline**




| Sector | Tg $CO_2$e | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 | 2030 |
| Energy Supply | 1.4 | 2.5 | 3.7 | 3.1 | 3.1 | 4.6 | 4.6 | 5.4 | 6.3 |
| Transportation | 3.6 | 5.0 | 5.7 | 6.9 | 8.3 | 9.6 | 11 | 12 | 13 |
| RCI | 0.7 | 0.7 | 0.6 | 0.6 | 0.6 | 0.9 | 1.1 | 1.3 | 1.5 |
| Industry | 0.6 | 0.9 | 1.2 | 1.1 | 1.5 | 1.6 | 2.1 | 2.8 | 3.9 |
| AFOLU | 0.6 | 0.7 | 0.7 | 0.7 | 0.7 | 0.8 | 0.8 | 0.9 | 1.0 |
| Waste Management | 0.3 | 0.4 | 0.5 | 0.6 | 0.5 | 0.6 | 0.8 | 1.0 | 1.1 |
| **TOTAL NET Emissions** | **7.0** | **10** | **12** | **13** | **15** | **18** | **20** | **23** | **26** |

[6] *Greenhouse Gas Emissions in Baja California 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 2030 and revised in some sectors based on information from a COLEF GHG inventory: *Inventario De Gases Efecto Invernadero Del Estado De Baja California, Periodo 1990-2005*, Octubre del 2012. Not documented in Appendix A was an additional revision made to the residential liquefied petroleum gas (LPG) consumption forecast provided by the BC technical team. 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 Appendix A.

All sectors of BC'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 BC, 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;
- Agriculture, Forestry & Other Land Use (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;
- 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:

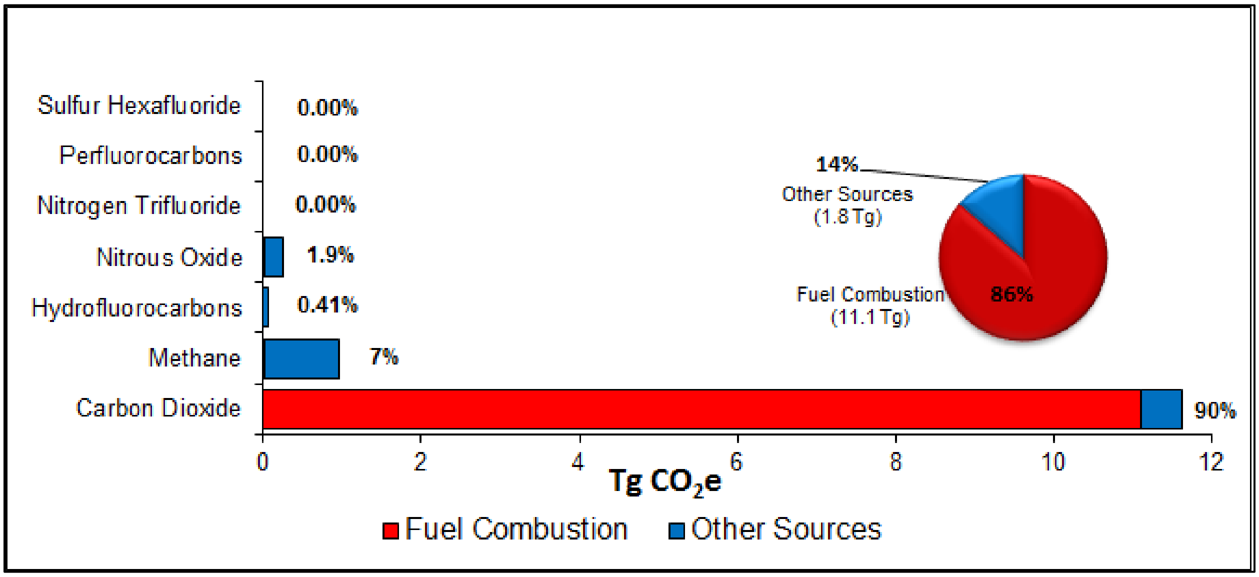
- Carbon dioxide ($CO_2$);
- Methane ($CH_4$);
- Nitrous oxide ($N_2O$);
- Hydrofluorocarbons (HFC);
- Sulfur hexafluoride ($SF_6$);[7]
- Perfluorocarbons (PFC);[8]
- Nitrogen trifluoride ($NF_3$).[9]

[7] 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.
[8] No emissions sources were identified: e.g. electronics manufacturing that would use this compound as a cleaning agent.
[9] Same as for PFC above.

## 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 BC. As shown, $CO_2$ is the dominant GHG contributing 90% of the total emissions on a $CO_2$e-weighted basis. The chart also shows contributions of each gas from fuel combustion or non-combustion sources.

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




As shown in the chart and supporting table of Figure 2-1, as well as Figure 2-3 below, emissions are expected to double from the year 2005 to the end of the planning period in 2030. 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). [10] As indicated in the results shown in Figure 2-3, the ES and Transportation sectors are expected to contribute to most of the emissions growth in Baja California during the forecast period. In fact, emissions from the Transportation sector are expected to nearly double between the years 2005 and 2030.

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 mild climate and lack of heavy industry in the State, BC's carbon intensity is lower than the forecasted national carbon intensity and is expected to remain lower on a per capita basis. However, both are expected to increase sharply during the forecast period as economic output (and expected average personal income) increase leading to higher levels of energy consumption. Since, BC 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.

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

On an economic output basis, BC's carbon intensity is expected to grow to nearly the levels of the nation 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,[11] not any sophisticated modeling of future economic activity.

**Figure 2-3. BC Net GHG Baseline by Sector**

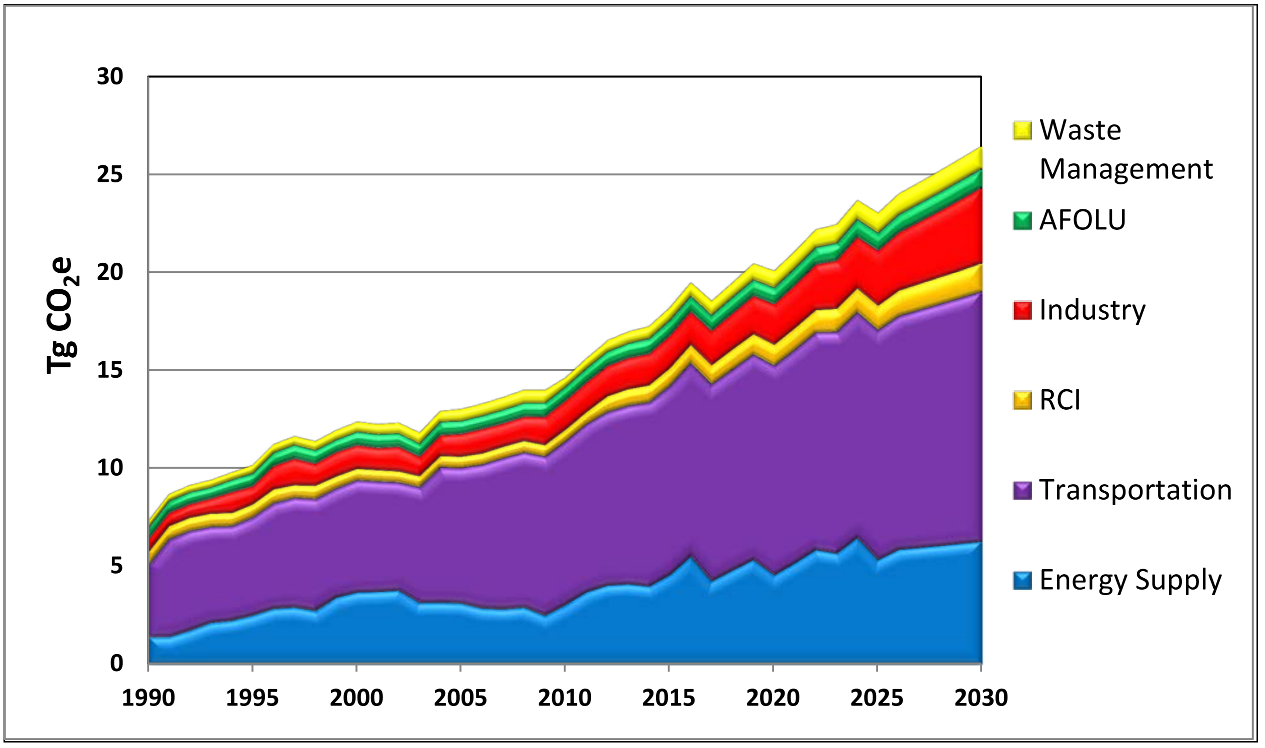



Figure 2-6 provides an indication of the national and global context of emissions for Baja California. Using 2005 as a reference year for just carbon dioxide emissions, 27,155 Tg $CO_2$ were emitted worldwide. Mexico emitted about 412 Tg$CO_2$, which is about 1.5% of worldwide emissions. In Baja California, 12 Tg$CO_2$ were emitted, which represents about 2.8% of Mexico's emissions.[12] Assuming Mexico's future emissions follow the growth from 2000 – 2010, the national net emissions would be around 1,070 Tg$CO_2$e. BC would contribute around 2.4% of national emissions in 2030 (26 Tg$CO_2$e).[13]

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

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[11] State and national annual economic output data for 2003-2013 were available from INEGI: http://www.inegi.org.mx/est/contenidos/proyectos/cn/pibe/.
[12] World Resources Institute – Climate Analysis Indicators Tool, www.wri.org/tools/cait/, accessed January 2013.
[13] Assumes the 2000 – 2010 growth rate nationally continues through 2030. Historical national were emissions 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 2-4. BC GHG Carbon Intensity Per Capita**

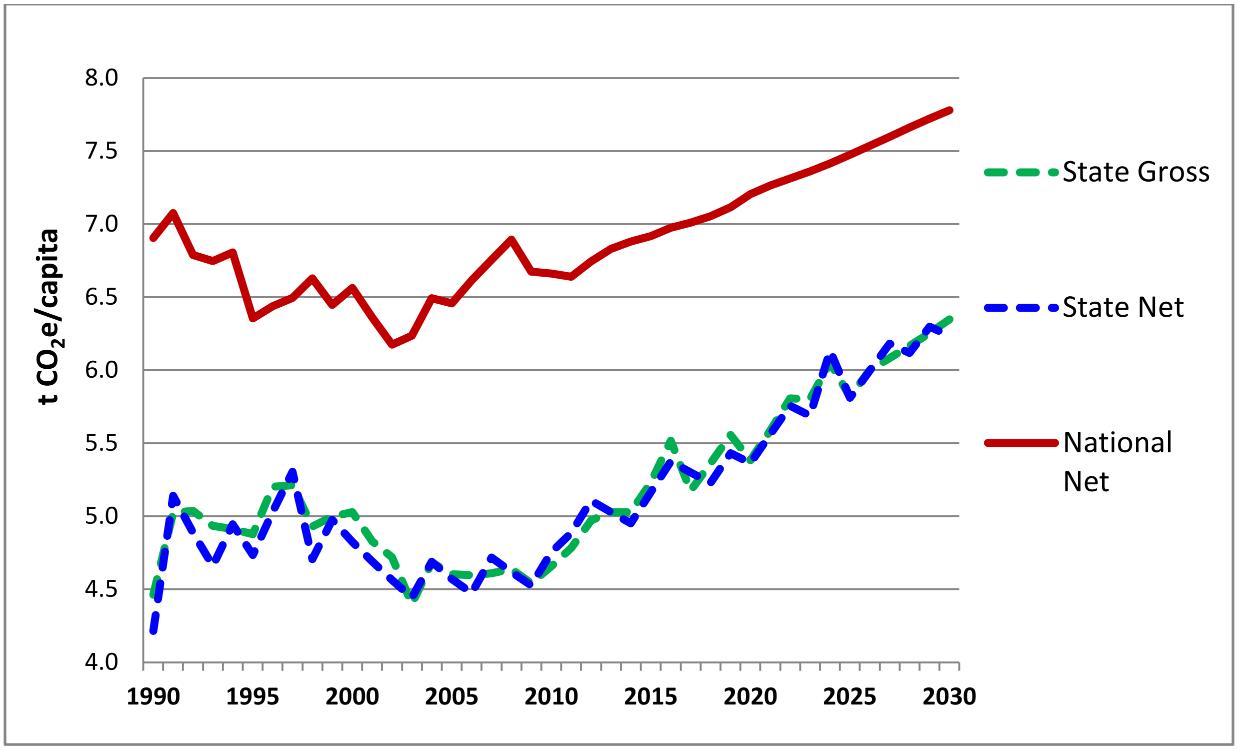



**Figure 2-5. BC GHG Carbon Intensity Per Unit Economic Output**

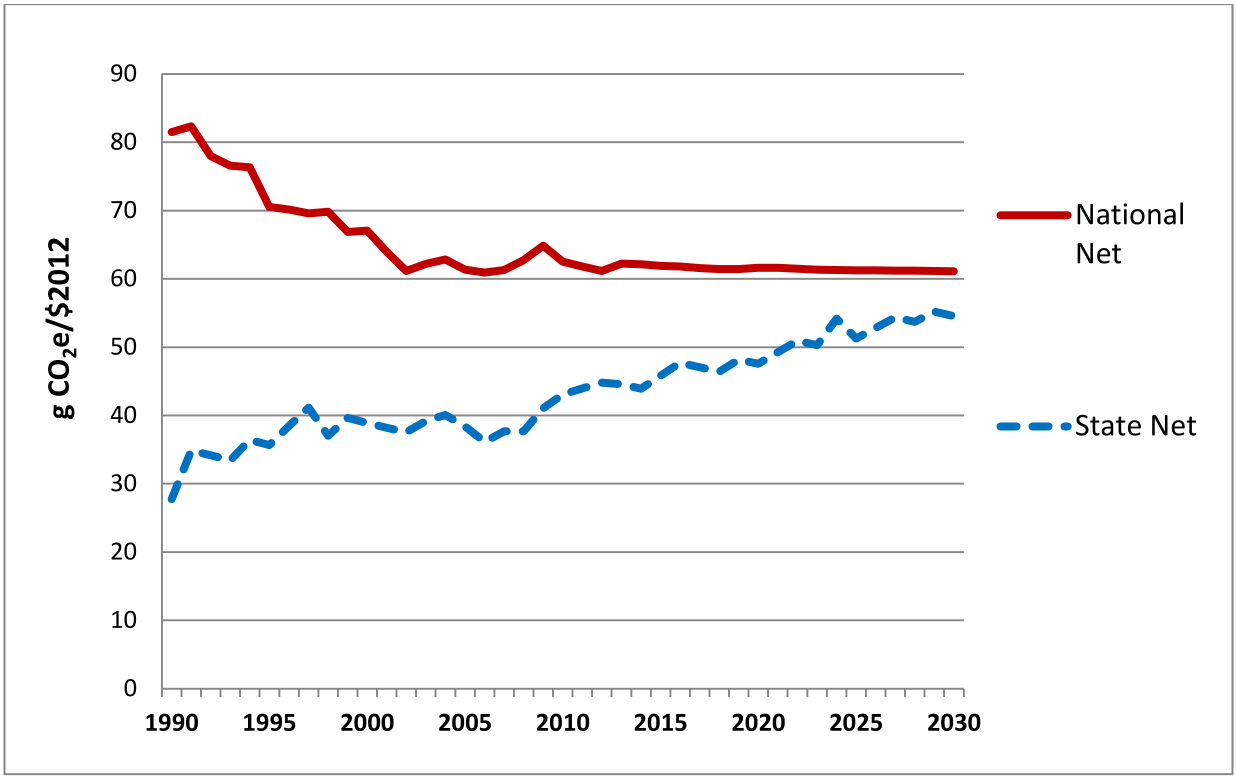
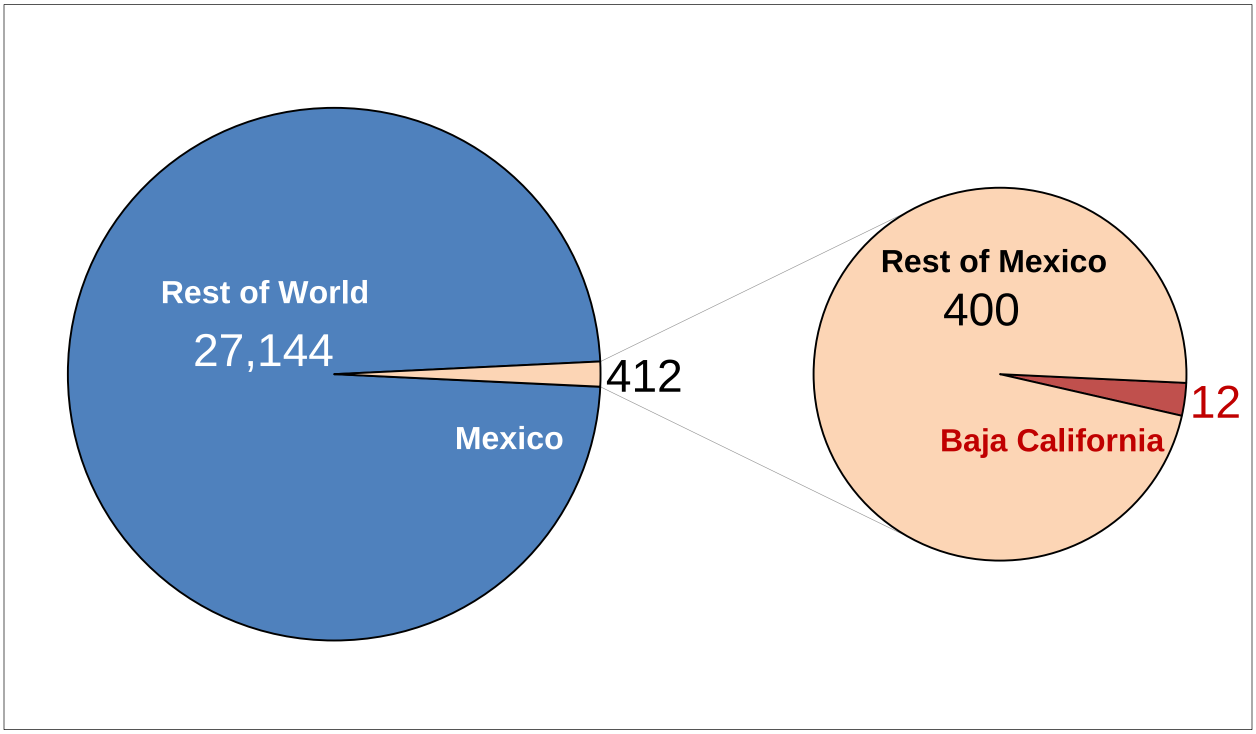


**Figure 2-6. National and Global Context of 2005 BC $CO_2$ Emissions, Tg $CO_2$**



# Chapter 3
# Baja California Climate Action Plan – Phase 2

## 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 (baseline year 1990) and forecasts to 2025 for Baja California (BC) 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 Climate Action Plan (CAP) process for Baja 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 actions 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.

It was determined that the state of Baja California would be the first of the three states to move in to the Phase 2 process. For the BC Phase 2 effort, the following objectives were agreed upon:

- Develop a BC CAP which includes design and micro-economic level analysis (GHG reductions and costs/ savings) of the selected policy options;
- Perform a macro-economic level analysis (including economic growth and employment projections) of the mitigation policy options included in the CAP;
- Prepare a draft and final report of the CAP and macro-economic analysis;
- Enhance state capacity to conduct climate action planning, quantification and economic analysis of climate policy options.

## Participating Institutions

BECC financed and sponsored the Phase 1 level work in the three states described above. BECC then teamed up with the World Wildlife Fund / US Agency for International Development (USAID) 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 BC CAP process, the following entities have joined together as Partners in this collaborative effort:

- The Secretaria de Proteccion al Ambiente (SPA) is the state environmental agency for the state of Baja California for whom the CAP has been prepared;
- The Border Environment Cooperation Commission (BECC) is a sponsoring organization which provided more than half of the funding for the project;
- MLED Program is a second sponsoring organization which provided almost half of the funding for the effort;
- El Colegio de la Frontera Norte (El COLEF) is a local university in Baja California which was contracted to provide the Local Project Manager for the process and also the members of the BC Panel of Experts (PE);
- 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 BC CAP; and
- Regional Economic Models Inc. (REMI) is a company that provides macro-economic models to assess economic and employment impacts associated with a wide range of economic activities and sectors. REMI is a sub-contractor to CCS for this service.

In addition to the Partners above, the Climate Works Foundation provided essential financial assistance to the project for the Local Project Manager (LPM) and the PE.

## Panel of Experts - Members and CCS Training

One of the objectives of the Baja CAP process was to help build state capacity in technical analysis related to climate action planning. To this end, the PE was formulated at the outset of the CAP process. 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 work load of actually conducting the technical analysis on the selected policy recommendations. Following is a list of the Local Project Manager and Members of the Panel of Experts and their affiliations. Also presented is a brief summary of the training initiatives provided to the PE by the CCS Team.

Local Project Manager- Dr. Carlos A. de la Parra Rentería- Local Coordinator

Members of the Baja Panel of Experts:

- Dr. Rigoberto García Ochoa, Panel of Experts, Energy Generation/Residential, Commercial and Industrial
- Dr. Alejandro Brugués Rodríguez, Panel of Experts. Macro-economic Analysis
- Mrs. Carolina del Rosario Sánchez Gastélum, Panel of Exerts, Agriculture, Forestry and Other Land Use/Waste Management
- Mrs.. Claudia Marcela Achoy López, Panel of Experts. Transportation and Land Use
- Mrs. Mayra Patricia Melgar López, Data Compilation
- Mr. Federico Antonio Martínez Aguilar, Panel of Experts. /Residential, Commercial and Industrial/Agriculture, Forestry and Other Land Use/Waste Management

<u>CCS Training of the Panel of Experts</u>:

CCS provided several in-person training sessions for the members of the PE, and others. Following is a short summary of each of the training sessions:

- Mitigation Policy Design Workshop- Three members of the CCS Team travelled to Tijuana to provide the first training session on September 30, 2013. The focus of this workshop was to provide training to the Panel of Experts and other invited participants in the CCS step-wise CAP 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 recommendation. This was an extra training session requested by the LPM that was not part of the original scope and that was paid for by BECC. 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 Tijuana for this training session that was held on January 14- 15, 2014. The focus of this session was to provide detailed instruction in the micro-economic analysis of the policy options in each sector. Sessions addressed the CAP Quantification Memo (focusing on quantification of the net costs and GHG effects of direct 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.

- Macro-Analysis Introductory Session for Baja Panel of Experts- At the request of the LPM and the PE, the CCS Team provided an introductory training session for the PE on February 12, 2014 at the University of Southern California (USC) in Los Angeles, CA. For this session, the LPM and members of the PE travelled to USC to meet with Dr. Adam Rose and Dr. Dan Wei of USC in person and with two representatives of REMI (Chris Brown and Rod Motamedi) via teleconference. The focus of this workshop was to provide the PE with an introduction to the REMI Model, an overview of the macro-economic analysis process and tools and examples of the use of the REMI Model and macro-economic analysis in the climate planning process.

- Climate Mitigation Policy Macro-Economic Analysis Training Workshop- CCS Team member Dr. Adam Rose from USC and REMI staff member Chris Brown travelled to Tijuana to provide this training workshop on May 21-22, 2014. Dr. Dan Wei from USC participated via video conference. The focus of this session was to describe the general concepts and key features of the REMI Model as it would be used in BC, to present an overview of the macro-economic analysis process, to present several macro policy analysis examples, and to do hands on work on several policies in BC. The participants also discussed mechanisms for addressing finer degrees of resolution of inputs and outputs and reached agreement on a work-sharing approach for performing the macro economic analysis for the BC CAP.

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.

## Advisory Group and Technical Work Groups

Advisory Group

At the outset of the Phase 2 CAP process SPA formed an Advisory Group (AG) which was to be responsible for participating as stakeholders in the process, helping to formulate policy designs and for reviewing and approving the results of the analyses prepared by the Panel of Experts (PE) and CCS. The AG consists of 12-15 members, about one to three advisors per sector, which are specialists in climate change and in the various sectors. The members come from the three levels of government, business, academia and civil society and their task is to support the provision of information.

One official meeting of the AG was held in August 2013 to help start the Phase 2 process. They reviewed initial lists of potential priority policy options for consideration in Phase 2. It was anticipated that they would also hold additional meetings to assist with the design and analysis of policy options and eventually to discuss and approve results and build consensus. During the start-up following the first AG meeting the Local Project Manager (LPM) sought to utilize a more informal approach of consultation with the AG while the technical work proceeded.

Technical Work Groups

At the outset of the Phase 2 CAP process six sector based Technical Work Groups (TWGs) were formed to help advise the AG and PE. They consisted of approximately 4-6 members each and met once following the first AG meeting. They did not meet formally again after September 2013. Based on direction from the LPM some of these individuals became informal advisers to the Panel of Experts on specialized topics and specific inquiries. For example, data of the most recent production of wheat straw per hectare in the Mexicali Valley, final energy consumption in the industrial sector of Baja California or any specific methodology. These individuals are the most knowledgeable persons in the productive and social sectors, they are specialists in their activities. They are public officials of one of the three levels of government, entrepreneurs, members of the academia or of a civil society organization.

## Overview of the Phase 2 Micro-Economic Analysis Methodology and Results

Micro-economic analysis addresses two main impacts for climate action planning: net energy and GHG impacts; and net direct societal costs. As indicated above, 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: initial year of implementation through 2030;
- 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 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. The only exception here for the BC CAP was to address the potential GHG implications of black carbon (BC) reductions associated with Policy TLU-1. Background information needed to understand the GHG reduction potential (on a $CO_2e$ basis) was provided separately to PE members);
- 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 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 efficiency measures;
- Financial base year: 2012;
- Discounting or time value of assets: 5 %/yr real and 7 %/yr nominal, applied to net flows of costs or savings over the BC CAP planning horizon (implementation year – 2030);
- Full energy-cycle impacts: 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: a method for directly comparing the costs of one technology against another.

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 BC CAP later in this Chapter.

Figure 3-1 provides a causal chain similar to those developed for each of the policies analyzed for the CAP (and documented in the associated policy templates in Appendices C-G). The causal chain identifies each of the GHG impacts (green or red shaded boxes), including those that would be quantified during micro-economic analysis (those with the star symbol). Here implementation of the policy will reduce direct emissions of methane at the landfill, indirectly reduce grid-based power requirements and the associated GHGs from power plants, and indirectly reduce upstream GHGs from the fuel supply of the power plants. Small amounts of emissions from combustion of landfill gas and during construction would not be quantified in this example.

**Figure 3-1. Causal Chain of GHG reductions for a Landfill Gas Management Policy**

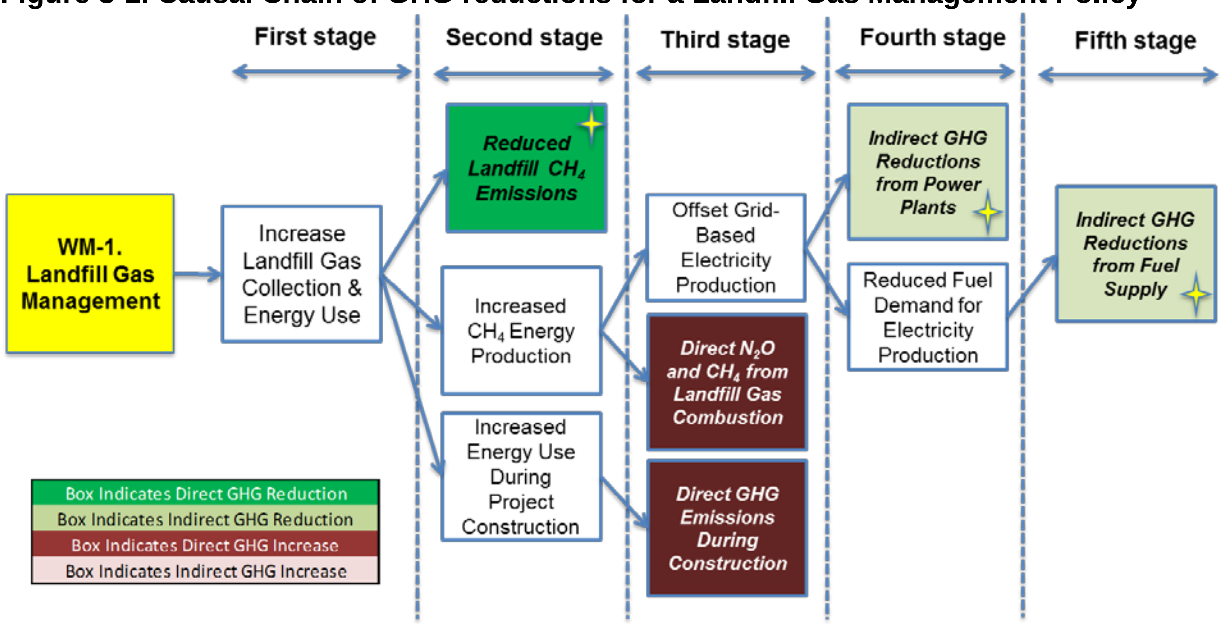
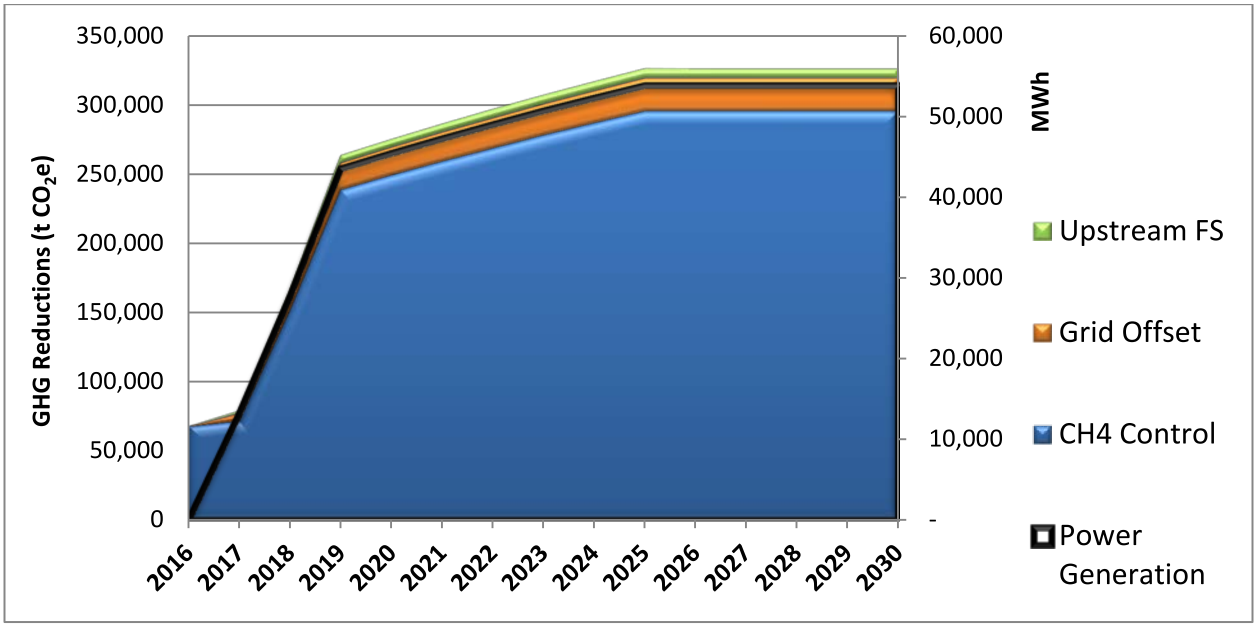



Figure 3-2 below provides a summary of the total GHG reductions calculated for the BC CAP policy promoting landfill gas management (WM-1). Most of the reductions shown are for direct control of landfill $CH_4$ emissions. As more power is produced from these projects, GHG reductions associated with Grid Offsets add some incremental reductions. Finally, although difficult to see in this chart, GHG emissions associated with the upstream fuel supply (FS; i.e. upstream of the power plant) are also reduced as a result. This would include for example, energy use during natural gas extraction and processing and methane leaks during natural gas transmission.

**Figure 3-2. Total GHG Reductions for WM-1**




Although all of the emission reductions shown in Figure 3-2 cannot be expected to occur within the geographic boundaries of BC (i.e. upstream FS), the PE has elected to use the full energy-cycle reductions to calculate the cost effectiveness of each policy and to assess total CAP reductions against the GHG baseline.

Table 3-1 below provides a summary of the micro-economic analysis for all CAP policies. These results have been adjusted for both intra- and inter-sector policy overlaps and interactions. In some cases, such as the biofuels policies, there are both supply- and demand-side policies that appear in different sectors. As noted in the table, the complete energy-cycle GHG reductions and net societal costs have been reported in the associated demand-side policy. Hence, these linked supply- and demand-side policies should be thought of as policy packages: e.g. "Transportation Biofuels Package" (AFOLU-4/WM-4/TLU-2) and "Energy Supply Diversification, including Biomass" (AFOLU-3/ES-2).

**Table 3-1. Summary of BC CAP Micro-Economic Analysis of Policies and Results**

| Policy ID | Policy Name | 2020 Annual Reductions ($TgCO_2e$) | 2030 Annual Reductions ($TgCO_2e$) | Cumulative 2015-2030 ($TgCO_2e$) | NPV Costs/ Savings 2015-2030 ($2012MM) | Cost Effectiveness ($2012/$tCO_2e$) |
|---|---|---|---|---|---|---|
| ES-1 | Micro-Hydro Renewable Energy Generation | 0.047 | 0.065 | 0.78 | $231 | $294 |
| ES-2 | Energy Supply Diversification | 0.94 | 1.3 | 16.0 | $6,814 | $425 |
| ES-3 | Distributed Energy Supply for Building | 0.013 | 0.019 | 0.22 | $6.9 | $31 |
| ES-4 | Photovoltaic Panel Electricity Generation | 0.018 | 0.025 | 0.30 | $150 | $505 |
| **Energy Supply Sector Totals** | | **1.0** | **1.5** | **17** | **$7,201** | **$415** |
| RCII-1 | Energy Efficiency: Residential Shell Improvement | 0.019 | 0.019 | 0.26 | ($309) | ($1,172) |
| RCII-2 | Energy Efficiency: New Housing Appliances | 0.016 | 0.016 | 0.43 | ($290) | ($675) |
| RCII-3 | Energy Efficiency: Existing Buildings | 0.58 | 0.58 | 8.2 | ($10,952) | ($1,342) |
| RCII-4 | Finance Incentives for Machinery Energy Efficiency | 0.27 | 0.73 | 6.1 | ($11,771) | ($1,915) |
| RCII-5 | Solar Water Heaters on Housing | 0.44 | 0.44 | 6.1 | ($8,800) | ($1,435) |
| RCII-6 | Flow Water Heaters for Residential Sector | 0.14 | 0.14 | 2.0 | ($3,095) | ($1,559) |
| **Residential, Commercial, Industrial & Institutional Sector Totals** | | **1.5** | **1.9** | **23** | **($35,217)** | **($1,523)** |
| TLU-1 | Black Carbon Control Measures | 0.046 | 0.000 | 0.30 | $60 | $196 |
| TLU-2 | Alternative Fuels | 0.03 | 0.08 | 0.77 | ($188) | ($242) |
| TLU-3 | On-road Fleet Efficiency | 0.00 | 0.01 | 0.07 | ($81) | ($1,150) |
| TLU-4 | Increase efficiency in urban mobility | Dropped from final CAP results. | | | | |
| TLU-5 | Smart Growth Planning | 0.011 | 0.036 | 0.28 | ($480) | ($1,716) |
| TLU-6 | Energy Efficient Government Fleet | 0.000084 | 0.00011 | 0.0015 | $2.3 | $1,609 |
| **Transportation & Land Use Sector Totals** | | **0.10** | **0.12** | **1.4** | **($686)** | **($480)** |
| AFOLU-1 | Manure Management: Non-Dairy Livestock | 0.00037 | 0.00037 | 0.0048 | $3.4 | $714 |

| Policy ID | Policy Name | 2020 Annual Reductions ($TgCO_2e$) | 2030 Annual Reductions ($TgCO_2e$) | Cumulative 2015-2030 ($TgCO_2e$) | NPV Costs/ Savings 2015-2030 ($2012MM) | Cost Effectiveness ($2012/$tCO_2e$) |
|---|---|---|---|---|---|---|
| AFOLU-2 | Manure Management: Dairies | 0.020 | 0.021 | 0.27 | $31 | $117 |
| AFOLU-3 | Utilization of Wheat Straw | N/A; GHG reductions and costs are reported with the ES-2 policy totals. | | | | |
| AFOLU-4 | Bioethanol Production from Sweet Sorghum | N/A; GHG reductions and costs are reported with the TLU-2 policy totals. | | | | |
| AFOLU-5 | Livestock Grazing Management | 0.07 | 0.12 | 1.31 | $1,117 | $855 |
| AFOLU-6 | Urban Forestry | 0.00005 | 0.0006 | 0.0034 | $17 | $5,514 |
| **Agriculture, Forestry and Other Land Use Sector Totals** | | **0.090** | **0.14** | **1.58** | **$1,169** | **$739** |
| WM-1 | Landfill Gas Management | 0.27 | 0.32 | 3.9 | $258 | $67 |
| WM-2 | Indirect Potable Water Re-Use | 0.025 | 0.035 | 0.43 | ($226) | ($532) |
| WM-3 | Water Reclamation | 0.041 | 0.071 | 0.76 | ($415) | ($545) |
| WM-4 | Biodiesel Production | N/A; GHG reductions and costs are reported with the TLU-2 policy totals. | | | | |
| **Waste Management Sector Totals** | | **0.34** | **0.43** | **5.1** | **($383)** | **($76)** |
| **Total Integrated Plan Results** | | **3.0** | **4.1** | **49** | **($27,916)** | **($575)** |

These policy option recommendations and analyses are a product of decisions by members of the Baja California Climate Action Plan (CAP) Panel of Experts (PE) and Local Project Manager (LPM) developed through training and technical assistance by The Center for Climate Strategies (CCS). Following review of the Phase 1 work and subsequent policy prioritization efforts by the Secretaria de Proteccion al Ambiente (SPA), PE members and the LPM selected these policies as priorities for initial development and analysis in the CAP with informal input from technical workgroup members and the SPA. With CCS training and technical assistance, PE members developed the policy option templates, including policy design parameters (timing, level of effort, coverage of parties, implementation mechanisms), and analysis choices (best available data sources, methods, and assumptions), and then produced a direct impact (microeconomic) analysis for each policy. The results of these analyses were compiled by CCS at a stand-alone and integrated level to construct individual and total impacts for the CA that provided inputs to the indirect (macro-economic) impacts covered in Chapter 9.

Figure 3-3 and the associated tabular results below provide a summary of the CAP 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. Notably, the TLU sector policies produced very small reductions in comparison to their contribution to BAU emissions (the transportation sector is expected to contribute 50% of BAU emissions in 2030; see Chapter 2). The AFOLU and WM sectors also produce small reductions; however, collectively, they contribute only 8% of the State's forecasted 2030 emissions.

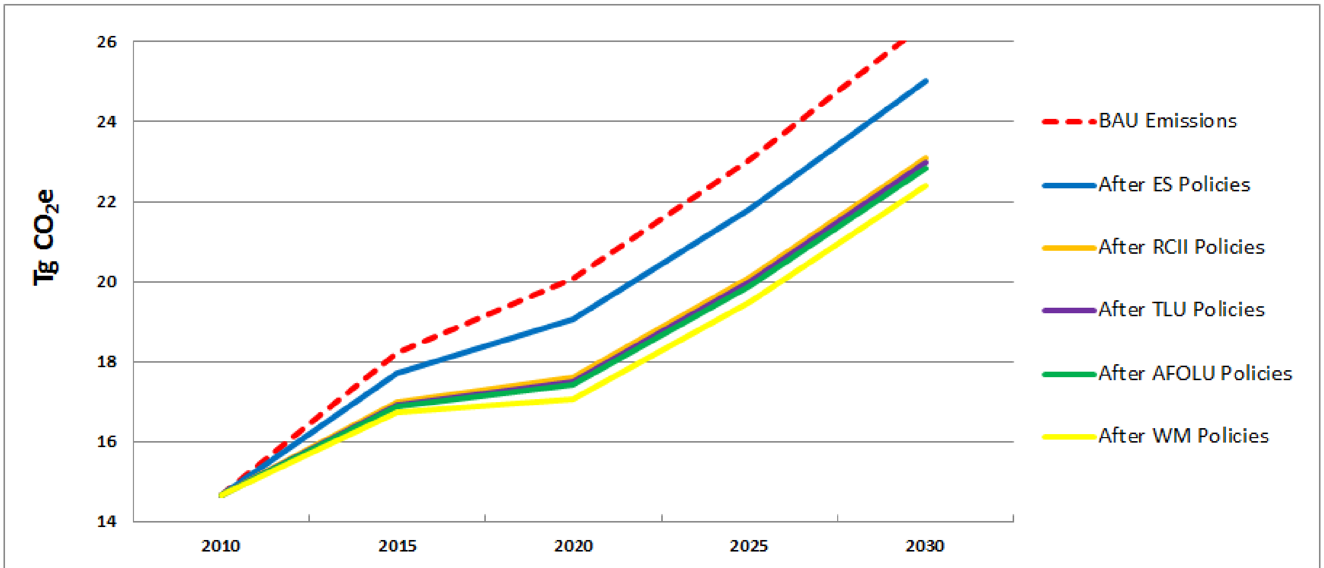
Figure 3-4 provides the marginal abatement cost curve for the CAP policies. Policies are ranked by their cost effectiveness along the Y-axis. The length of the line for each policy indicates its contribution to reductions in 2030 BAU emissions (on a percentage basis). As shown at the far right of the chart, the total reductions for the CAP policies are estimated to be about 15% of BAU emissions in 2030. About half of these reductions are expected to come from policies that achieve a net savings in societal costs (all policies to the left of ES-3 in Figure 3-4).

### *Details on Integrating Policy Interactions and Overlaps*

Policy interactions and overlaps that occur within a sector (*intra*-sector) are noted within each sector appendix. The methods used to adjust GHG reductions and costs for these intra-sector interactions/overlaps are detailed in the applicable appendix and are also noted in the sector chapters that follow.

A number of *inter*-sector interactions occur where policies are focused on renewable fuel supplies in one sector and on consumption of renewable fuels in another sector. As previously indicated, these interactions have been addressed by calculating the overall biofuels package results within one policy (the demand-side policy of the package), so that reductions or costs are not double-counted.

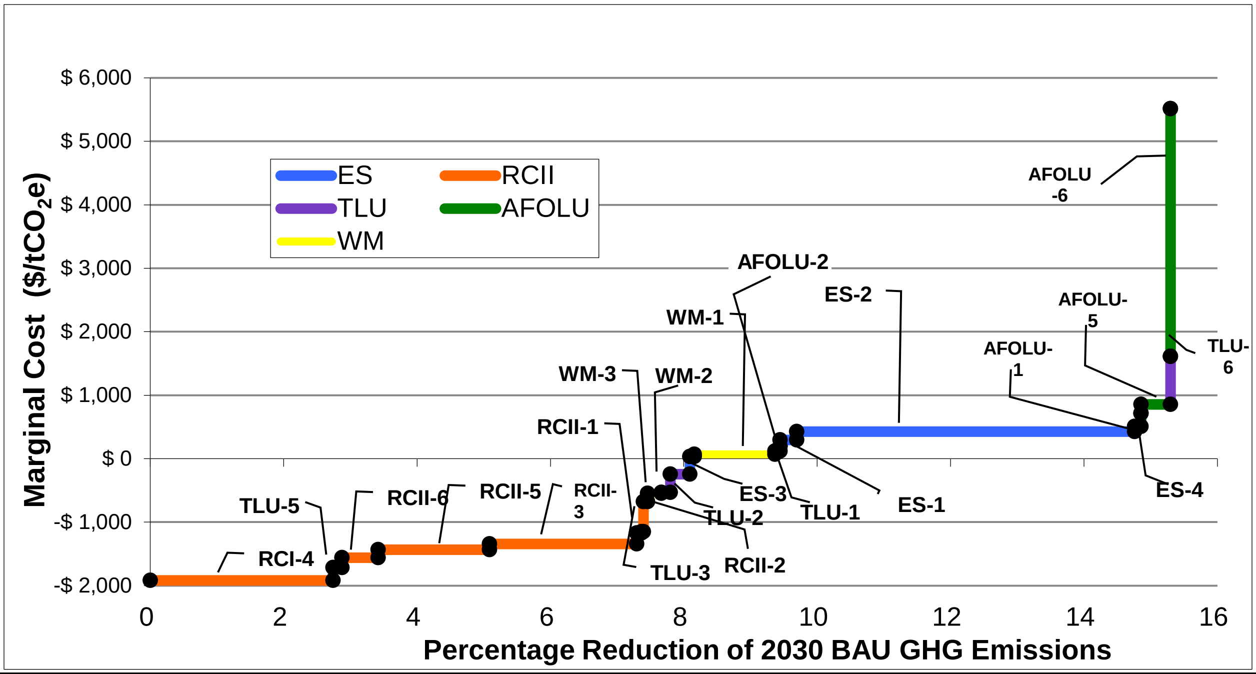
### Figure 3-3. BC CAP GHG Policy Reductions by Sector




| Net Emissions (Tg $CO_2e$) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **1990** | **1995** | **2000** | **2005** | **2010** | **2015** | **2020** | **2025** | **2030** |
| Projected GHG Emissions | 7.3 | 10.2 | 12.4 | 13.1 | 14.7 | 18.2 | 20.1 | 23.0 | 26.5 |
| Reductions from Recent Actions | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Projected GHG Emissions After Recent Actions | 7.3 | 10.2 | 12.4 | 13.1 | 14.7 | 18.2 | 20.1 | 23.0 | 26.5 |
| Plan Reductions: ES Sector | | | | | 0.00 | *0.51* | 1.02 | *1.24* | *1.45* |
| Projected Emissions with ES Policies | | | | | 14.7 | 17.7 | 19.1 | 21.8 | 25.0 |
| Plan Reductions: RCII Sector | | | | | 0.00 | *0.74* | 1.47 | *1.70* | *1.93* |
| Projected Emissions with ES/RCII Policies | | | | | 14.7 | 17.0 | 17.6 | 20.1 | 23.1 |
| Plan Reductions: TLU Sector | | | | | 0.00 | *0.05* | 0.10 | *0.11* | *0.12* |
| Projected Emissions with ES/RCII/Industry/TLU Policies | | | | | 14.7 | 16.9 | 17.5 | 20.0 | 23.0 |
| Plan Reductions: AFOLU Sector | | | | | 0.00 | *0.0* | 0.09 | *0.11* | *0.14* |
| Projected Emissions with ES/RCII/Industry/TLU/AF Policies | | | | | 14.7 | 16.9 | 17.4 | 19.9 | 22.8 |
| Plan Reductions: WM Sector | | | | | 0.00 | *0.17* | 0.34 | *0.38* | *0.43* |
| Projected Emissions with All Policies | | | | | 14.7 | 16.7 | 17.1 | 19.5 | 22.4 |
| ***Total GHG Reductions from Plan Policies*** | | | | | *0.00* | *1.5* | *3.0* | *3.5* | *4.1* |
| **Emissions After Quantified Plan Policies** | **7.3** | **10.2** | **12.4** | **13.1** | **14.7** | 15.2 | **17.1** | **19.5** | **22.4** |

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) when the demand sector policies are achieving reductions in power demand through energy efficiency or are adding renewable resources to the grid. The impacts and costs of all of the power related policies (both supply and demand) 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 from the grid (as a result of energy efficiency or new capacity 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, wouldn’t 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.

**Figure 3-4. Marginal Abatement Cost Curve for the BC CAP**




| | | | | |
|---|---|---|---|---|
| ES-1. Micro-Hydro Renewable Energy | RCII-2. EE: New Housing | TLU-1. Black Carbon Measures | AFOLU-1. Manure Management: Non- | WM-2. Indirect Potable Water |
| ES-2. Energy Supply Diversification | RCII-3. EE: Existing Buildings | TLU-2. Alternative Fuels (includes | AFOLU-2. Manure Management: Dairies | WM-3. Water Reclamation |
| ES-3. Distributed Energy Supply for | RCII-4. EE: Finance Incentives | TLU-3. On-Road Fleet Efficiency | AFOLU-5. Livestock Grazing Management | |
| ES-4. Photovoltaic Panel Electricity | RCII-5. Solar Water Heaters on | TLU-4. Increase Efficiency in Urban | AFOLU-6. Urban Forestry | |
| RCII-1. EE: Residential Shell Improvement | RCII-6. Flow Water Heaters for | TLU-6. Energy Efficient Government | WM-1. Landfill Gas Management | |

For the BC CAP, the marginal resource mix was defined as consisting of all of the natural gas powered generation in the State. The natural gas powered generation plants are nearly all combined-cycle units that are expected to produce about 98% of the total natural gas powered generation in 2020. These are the generation resources that are most likely to respond (i.e. lower output) due to changes in demand or the addition of new renewable resources. Figure 3-5 shows the BAU net electricity generation forecast by fuel type.

For the CAP policies, all GHG impacts were measured against a BAU carbon intensity for natural gas generation (0.444 $tCO_2e/MWh$) and associated system costs of $618/MWh. If the total system-wide impact of all CAP policies (electricity savings + new generation – new demand) exceeds the marginal resource mix, then the values used initially for carbon intensity and avoided costs would need to be adjusted. These adjustments would account for a different set of resources (resources beyond just natural gas) that would be turned down or decommissioned to accommodate the changes of the plan policies.

Figure 3-6 provides a comparison of the marginal resource mix and the total CAP system impacts. As shown in the chart, the total impacts stay just below the marginal resource mix through the end of the planning period. Therefore, no adjustments were needed to address changes to the marginal resource mix and the associated carbon intensity of power produced and avoided system costs. As a result, no further adjustments were needed to address inter-sector interactions/overlaps between electricity supply and energy demand policies.

**Figure 3-5. BAU Net Electricity Generation Forecast**

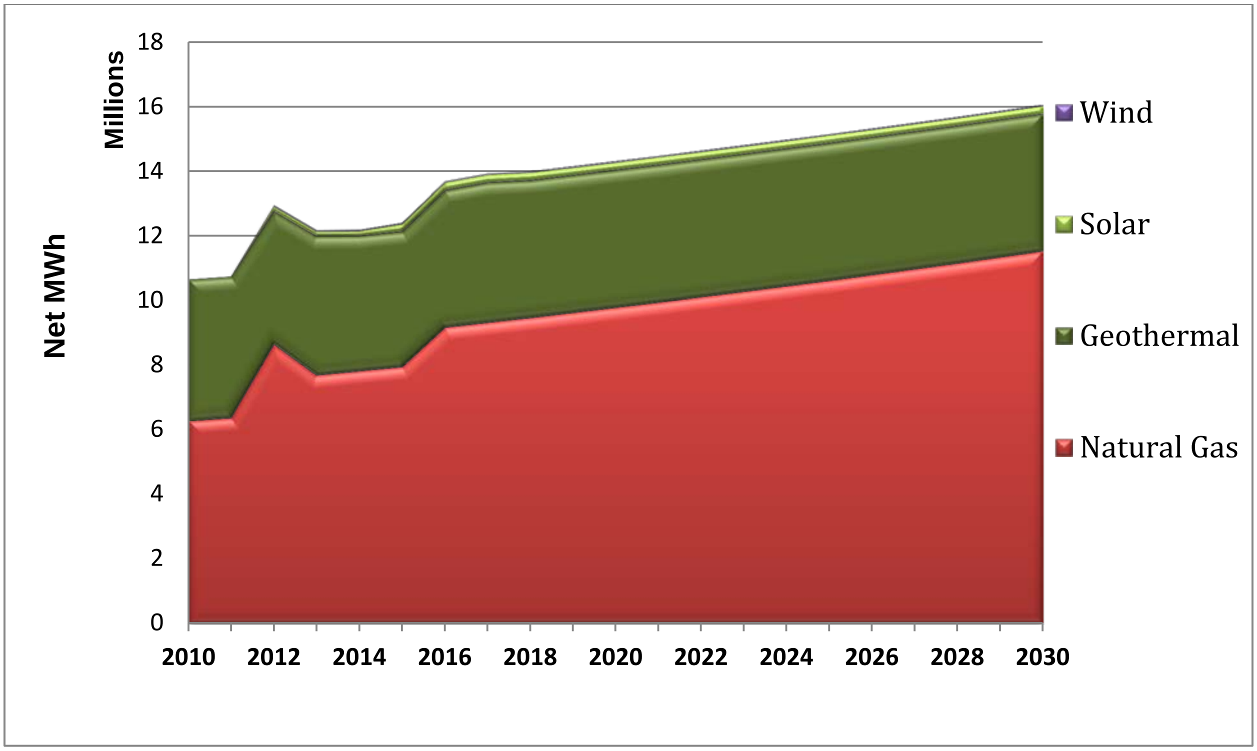
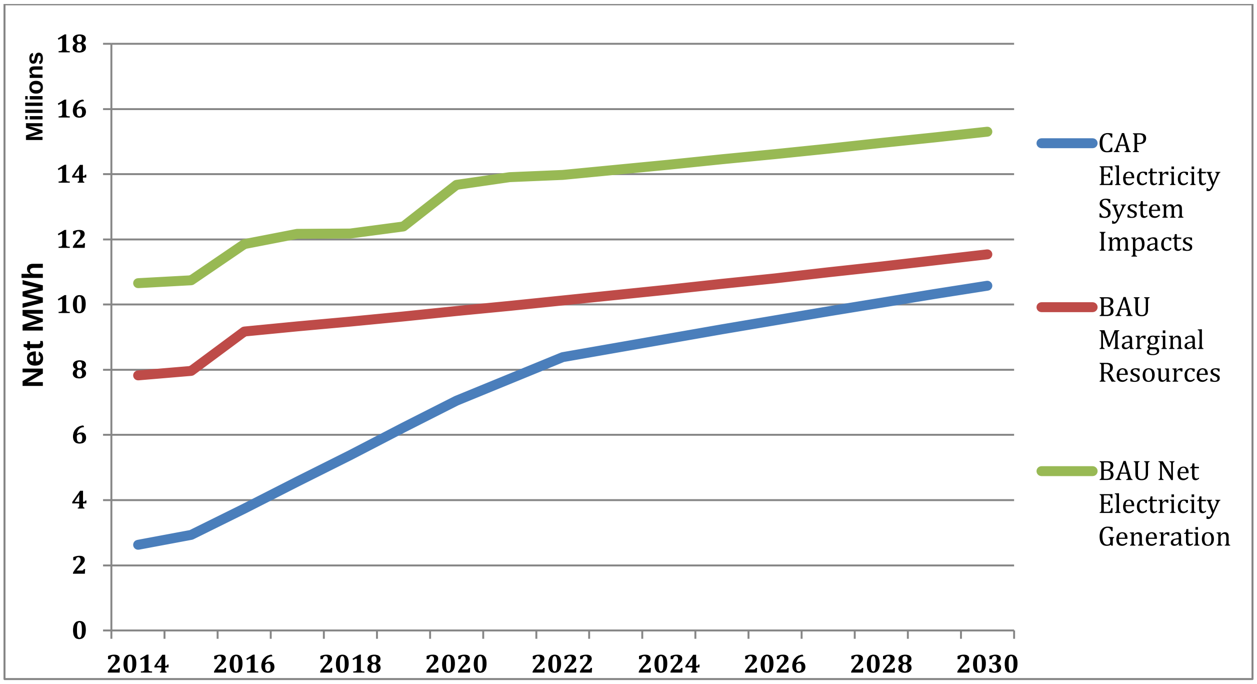



**Figure 3-6. Total CAP Electricity System Impacts Compared to the Marginal Resource Mix**



## Overview of the Macro-Economic Analysis Methodology and Results

The major focus of economic analysis of environmental policy and legislation until recently has been on the direct impacts of individual mitigation policies or the complete set of CAP policies Some of these policies can result in cost-savings directly to those who implement them, but they also provide gains to their customers if the savings are passed on in the form of lower prices. It is also likely that some other policies will incur additional costs to businesses, households, non-profit institutions, and government operations, and the likely cutback in economic activity will also affect their suppliers.

Complicating the situation are various types of indirect effects stemming from economic interdependence. Increases in demand ripple through the economy generating a set of successive rounds of positive supplier multiplier effects. Cost savings are passed along to several rounds of customers to add further to the stimulus. Decreases in demand will have their own ripple effects on different sets of suppliers and customers in an analogous negative way. The extent of the many types of linkages in the economy and macro-economic impacts is extensive and cannot be traced by a simple set of calculations. It requires the use of a sophisticated model that reflects the major structural features of an economy, the workings of its markets, and the interactions between them.

In this study, we adapt the Regional Economic Models, Inc. (REMI) Policy Insight Plus (PI+) Model to analyze the macro-economic impacts of the Baja California CAP. REMI PI+ Model is the most widely used macro-econometric forecasting and policy impact analysis model in the U.S. In recent years, REMI has developed its REMI PI+ Model for many countries, including China, Korea, Brazil, Mexico, Italy, Spain, and others. At its core, the Baja California REMI Model uses a 32-industry input-output (I-O) model developed based on the data found in the World Input-Output Database (WIOD). The I-O feature enables us to analyze the interactions between sectors (ordinary multiplier effects) stemming from the direct shocks of the mitigation policies. However, the REMI Model is superior to an I-O model by incorporating the responses of the producers and consumers to price signals in the simulation. The REMI Model also brings into play features of labor and capital markets, as well as trade of Baja California with other states in Mexico or with other countries, including changes in competitiveness.

A major refinement we made to the BC REMI Model is to disaggregate the utility sector into three sub-sectors. In the WIOD I-O table, electric power generation, natural gas distribution, and water treatment and supply are aggregated into one single utility sector. It is essential to have the three sectors separated since many GHG mitigation policies incur direct impacts to one specific utility sub-sector or to more utility sub-sectors in different ways. We applied the Custom Industry Function in the REMI Model and utilized the data from the 170-sector detailed I-O table constructed by the Mexico National Institute of Statistics and Geography (INEGI) to disaggregate the utility sector into the three sub-sectors.

The major input data of the macro-economic impact modeling are the direct costs and savings of the GHG mitigation policies analyzed in the microeconomic analysis of Baja CAP. Before undertaking any economic simulations, we first translate the micro-level costs/savings results for each policy to REMI Model inputs. This step involves the selection of appropriate policy levers in the REMI PI+ Model to simulate the policy's shocks. The input data include sectoral spending and savings over the full policy planning horizon (through 2030) of the analysis:

- Change in upfront capital investment by sector;
- Change in annualized capital cost by sector;
- Change in O&M expenditure by sector;
- Change in fuel expenditures by fuel type by sector;
- Program implementation and administrative costs;
- Proportion of public funding and private debt financing; and
- Federal or state government support.

In addition, in cases where these costs/savings and some conditions relating to the implementation of the policy options are not specified in the micro-analysis or are not known with certainty, we supplement the micro-economic quantification results with additional data and assumptions for the REMI modeling. A detailed list of the supplemental assumptions is presented in Chapter 9.

In this study, we first run REMI simulations for each of the 22 policy options/bundles individually in a comparative static manner, i.e., one at a time, holding everything else constant. Next, we run a simultaneous simulation in which we assume that all the policy options are implemented together. Differences in the results of the simple summation of individual options and the simultaneous run arise from non-linearities and/or synergies in the REMI Model.

We also run sensitivity tests to analyze how the changes in some key assumptions would affect the macro-economic impact analysis results of a major GHG mitigation option. The sensitivity analyses provide us insights on how changes in policy designs can potentially improve the macro-economic performance of the GHG mitigation options.

Chapter 9 summarizes the analysis of the macro-economic impacts of 22 GHG mitigation/ sequestration policy options/policy bundles on the Baja California state economy. We used a state of the art macroeconometric model, the Regional Economic Models, Inc. Policy Insight Plus (REMI PI+) Model to perform this analysis. The data used in this study are based on the microeconomic impact analysis of the cost and saving estimates associated with the mitigation options, and are supplemented by a set of macro-economic modeling assumptions.

The macro-economic analysis results indicate that, as a group, the recommended GHG mitigation policy options/policy bundles yield a positive impact on the Baja California economy. On net, the combination of the 22 policy options/bundles are expected to result in an increase in employment of about 1,680 new jobs per year during the planning period from 2014 to 2030 and yield an increase in GSP of about $9.85 billion pesos in NPV.

Table 3-2 presents a summary of the projected impacts on Gross State Product (GSP) of each of the policy option/bundles for each sector. The last row of the table presents the results for the simultaneous run.

**Table 3-2. Summary of Gross State Product Impacts by Sector (Difference from Baseline Levels) (Millions of 2012 Pesos)**

| Scenario/Sector | 2015 | 2020 | 2025 | 2030 | NPV |
|---|---|---|---|---|---|
| Subtotal – ES Sector | $0 | $975 | -$3,004 | -$2,760 | -$3,772 |
| Subtotal – RCI Sector | $475 | $1,282 | $1,710 | $2,534 | $14,163 |
| Subtotal – AFOLU Sector | $0 | -$61 | -$26 | $48 | -$303 |
| Subtotal – WM Sector | $0 | -$22 | -$39 | $44 | $79 |
| Subtotal – TLU Sector | $10 | -$35 | -$92 | -$127 | -$202 |
| **Summation Total** | **$486** | **$2,140** | **-$1,451** | **-$261** | **$9,967** |
| **Simultaneous Total** | **$486** | **$2,141** | **-$1,475** | **-$311** | **$9,853** |

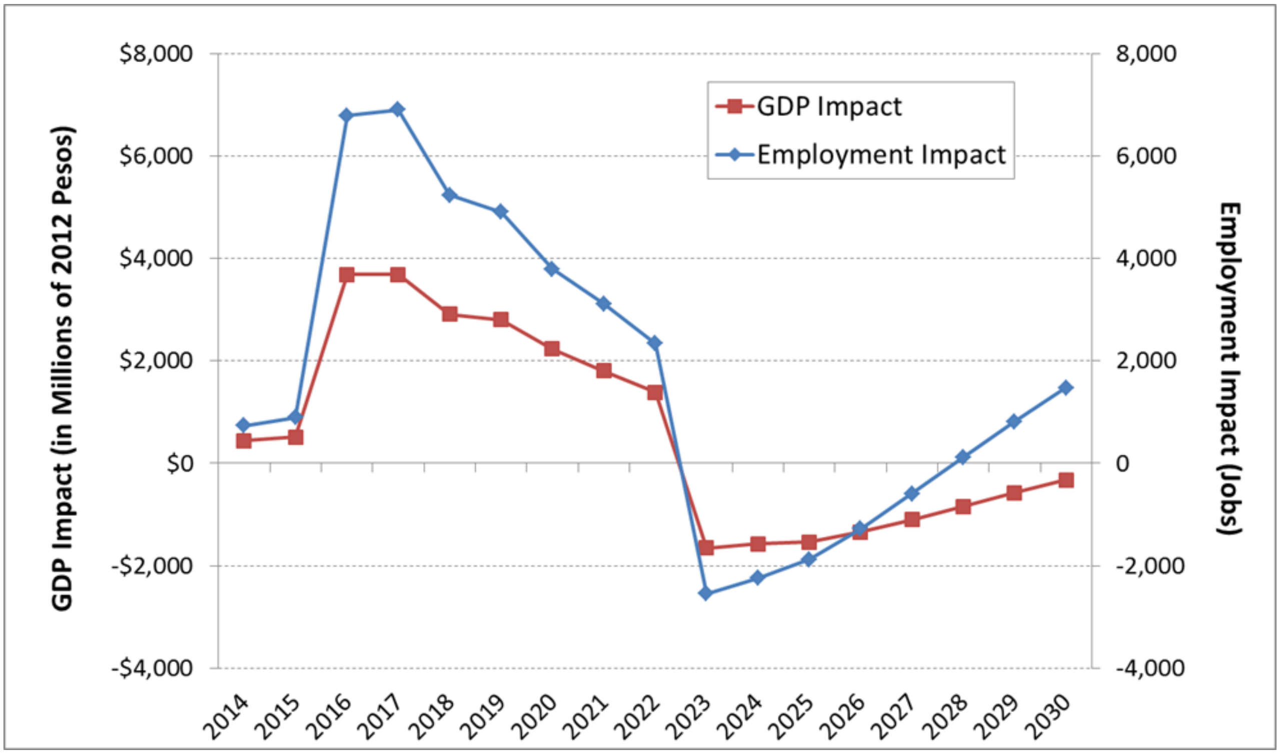
Table 3-3 presents a summary of the projected employment impacts for each sector. The last row of the table presents the results for the simultaneous run.

**Table 3-3. Summary of Employment Impacts by Sector (Difference from Baseline Levels) (Number of Jobs)**

| Scenario/Sector | 2015 | 2020 | 2025 | 2030 | Jobs/ Year |
|---|---|---|---|---|---|
| Sub-total- ES Sector | 0 | 1,787 | -4,936 | -3,598 | -905 |
| Sub-total- RCII Sector | 863 | 2,600 | 3,776 | 5,543 | 2,994 |
| Sub-total- AFOLU Sector | 0 | -432 | -294 | -43 | -242 |
| Sub-total- WM Sector | 0 | -75 | -118 | 12 | -31 |
| Sub-total- TLU Sector | 31 | -83 | -240 | -303 | -90 |
| **Summation Total** | **894** | **3,797** | **-1,812** | **1,611** | **1,726** |
| **Simultaneous Total** | **894** | **3,794** | **-1,881** | **1,470** | **1,680** |

Figure 3-7 presents the yearly GSP and employment impacts of the simultaneous run (detailed results of the simultaneous run are presented in Chapter 9).

**Figure 3-7. Integrated Yearly GSP and Employment Impacts of the 22 Policies/Policy Bundles**




The results highlight the following impacts of the GHG mitigation options on the Baja California economy:

- The investment in GHG mitigation policies are estimated to generate significant positive impacts to the Baja California state economy during the upfront investment period of the various projects (primarily between 2015 and 2022, though different policies have different starting years and initial investment periods);

- Both the GSP and employment impacts become negative starting from 2023 when the initial investment of the various policies is completed. At this point, the production of capital equipment has peaked, and the increased annual capital cost (due to the payback of the initial investment) starts to dominate the overall impact;

- The savings resulting from the implementation of energy efficiency related policies increase overtime, and, by 2028, the net employment impact is projected to become positive again, while the net GSP impact approaches zero by the target year 2030 (in general, employment impacts are more positive than GSP impacts in percentage terms, because of the relative labor intensity of the mitigation options);

- The employment gain is projected to be 1,680 jobs per year over the entire planning period;

- The net GSP gain is projected to be about $9.9 billion (2012 pesos) in NPV by 2030. Although the yearly GSP impacts are projected to be negative between 2023 and 2030, the substantial GSP gains in the earlier years more than offset the negative impacts in later years, and thus lead to the overall positive GSP impacts in NPV over the entire planning period; and

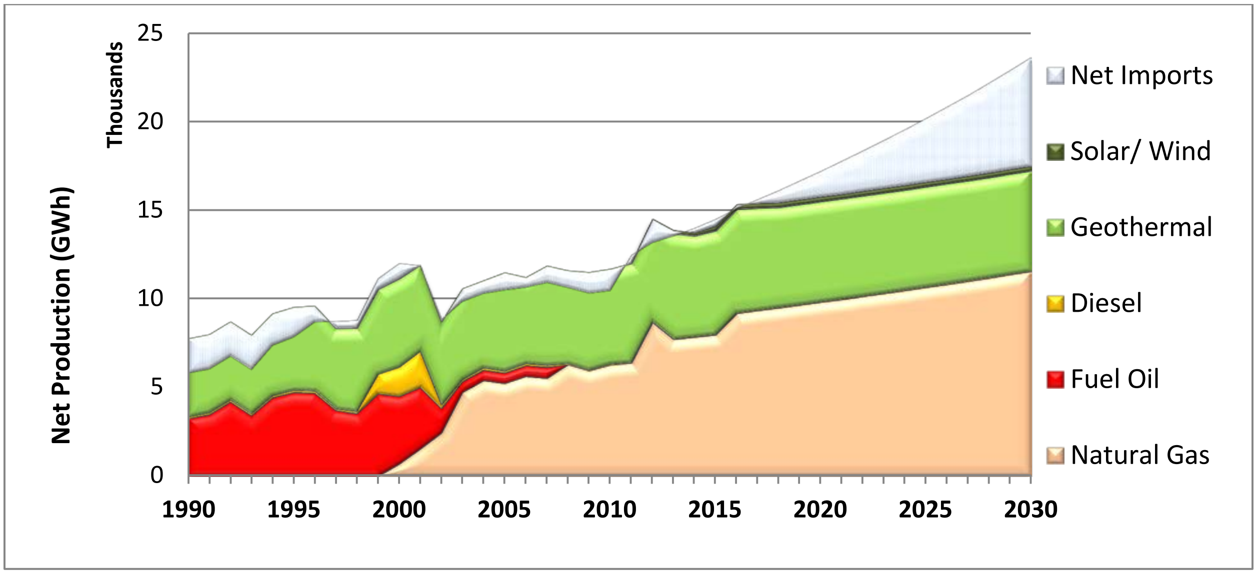
- The net disposable personal income gain is projected to be about $11.4 billion (2012 pesos) in NPV over the planning period.

# 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). In BC, only the PS and FS sectors are relevant. In 2010, the ES Sector (i.e. electricity or power supply) in Baja California comprised 21 percent of total net greenhouse gas (GHG) emissions across all sectors and is projected to comprise 24 percent by 2030. Emissions growth in the sector from 1990-2030 is relatively high, at about 3.6 percent per year. As shown in Figure 4-1, primary energy sources in the ES sector include power generation from fossil fuels and naturally occurring renewable energy sources (geothermal sources).[14] Regarding the FS subsector, Baja California does not produce or process any type of oil and, as there are no proven reserves, and also produces no natural gas. Baja California is strictly a consumer of fuel, mainly for electricity generation and transportation. The municipalities with higher energy are Tijuana and Mexicali, both representing 82% of the state total.

**Figure 4-1. Power Supply for Baja California (1990-2030)**



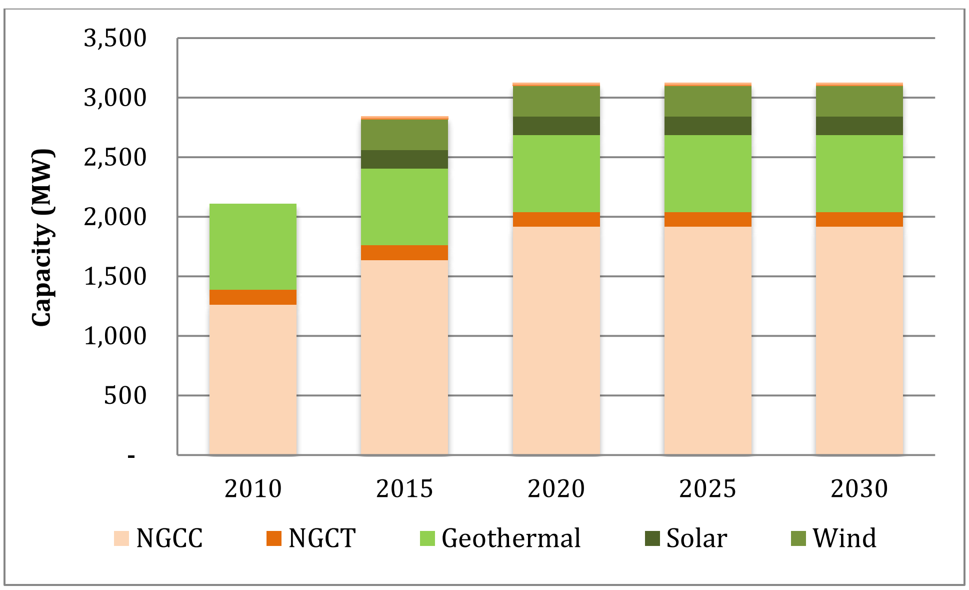

[14] The ES baseline data shown in this chapter are updated from the initial work done for BC and documented in Appendix A (i.e. the 2010 CCS GHG I&F report). The reader should expect to see slight differences in the values shown in that earlier work.

Currently, and through the planning period, the main fossil fuel used to generate power is natural gas. Net imports are positive during most years and increase slightly over time, with much larger shares expected in the 2025-2030 time-frame. Compared to Mexico national data, Baja California ES emissions per capita and per unit of gross state product are slightly lower than the national average (see Chapter 2).

Fuel oil and diesel oil declined as a source of energy continuously through 2007. Fuel oil was eliminated as a source of energy by 2008, and diesel oil dropped from about 10-15 percent in the early 2000's to only about 1 percent of total production by 2007. Natural gas expanded from 0 percent of supply in 1999 to over 65 percent of projected supplies by 2030. This corresponds to an increase in natural gas generation to over 11,500 GWh by 2030, or nearly 10% per year from 2000 to 2030.

Figure 4-2 provides a summary of the current and project in-State generation sources for BC. Natural gas-fired combined-cycle (NGCC) plants provide nearly two-thirds of the capacity of the generation fleet throughout the forecast period. A small amount of natural gas combustion turbine (NGCT) capacity is also expected to remain in place. Geothermal power production is over 20% of the total in-State capacity through the forecast period.

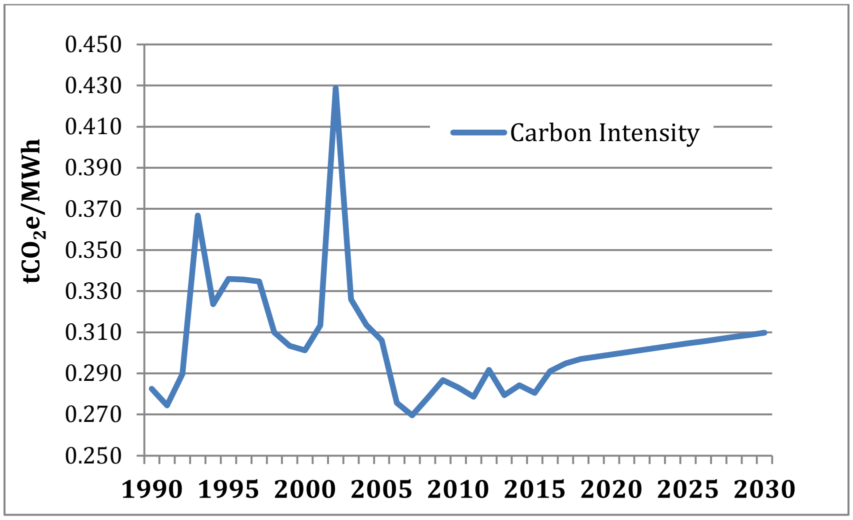
**Figure 4-2. Power Generation Sources in Baja California**




The combined result of natural gas and geothermal expansion and fuel and diesel oil decline is a reduction of the GHG intensity for the sector through around 2010 (see Figure 4-3); however, with continued reliance on natural gas, the trend will be toward increasing carbon intensity for in-State power production through 2030. Further, with increasing need for imports to meet expected demand (likely also supplied by natural gas), on a delivered MWh-basis, the carbon intensity will be slightly higher than shown here. The electricity network in the State of Baja

California is independent of the national network and is connected by two 230 KV lines for export to California, United States. This external demand is met by private companies generating electricity.

**Figure 4-3. Power Supply Carbon Intensity, Production-Based (excludes net imports)**



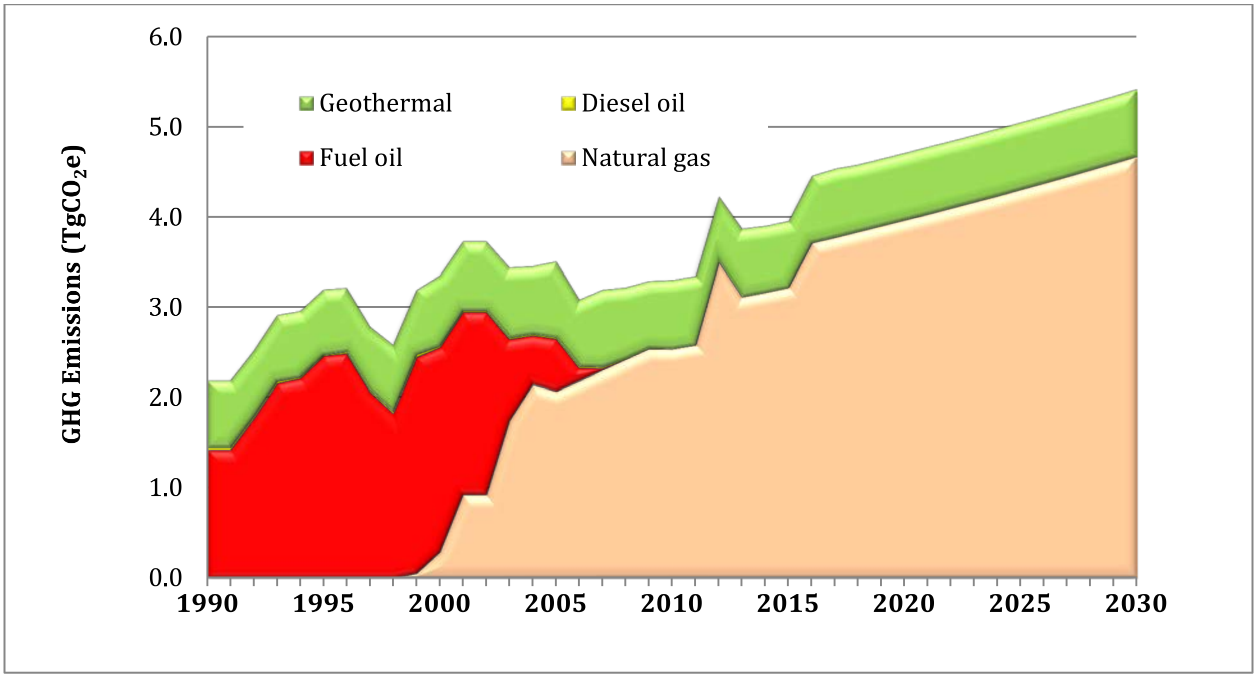

ES sector GHG emissions (Figure 4-4) have grown significantly since 1990 and play a major role in the projected high growth rate of overall emissions for Baja California through 2030. A variety of low emissions policy actions are needed to stabilize and reduce ES sector emissions. Measures to reduce GHGs from the sector that were evaluated in this planning process include shifts to renewable energy (solar and small hydro) and low emitting fossil supplies (natural gas) for both centralized and distributed energy systems. The policy to diversify the centralized power generation (power plants) and distribution (grid) system (ES-2) dominates future emissions reduction options for the State with over 90 percent of all supply-side policy options (discussed further below).

In comparison, centralized supply sources from other options (ES-1, -3, -4) do not heavily affect overall generation mix through 2030, but 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 expanded development and scale up of renewable-energy sources, such as biomass and wind power, 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 State of Baja California has already ventured into the use of alternative energy such as wind, which occurs in the Rumorosa, in the town of Tecate and consists of 5 turbines of 2,000 kW producing more than 27,000 MWh per year avoiding emitting 14,000 tons of $CO_2$ with clean energy. Also, the state has a geothermal plant in Cerro Prieto and is the second largest worldwide geothermal field. This field produces over 40% of all the energy generated for distribution in the State.

**Figure 4-4. Power Supply GHG Emissions, Production-Based (excludes net imports)**




Due to geographical and infrastructural characteristics of Baja California, tidal energy is one of the alternatives that could be exploited in the State. A capacity of 800 MW has been suggested for tidal energy in the Gulf of California[15], which would contribute to reducing GHG emissions.

One of the most attractive alternative energy sources in the State is solar energy, since there are areas considered to have a "high incidence of solar radiation" with more than 5.8 kWh/$m^2$/day. Specifically, is the municipality of Mexicali where power generation using solar panels reduces the use of nonrenewable energy sources and also reduces the electricity shortage statewide. The use of small-scale (micro) hydrological resources has been shown to have a small potential for wide-scale use in BC (<75 MW based on previous studies).

[15] Muñoz G. and Vázquez B. 2012. Inventario de Gases de Efecto Invernadero del Estado de Baja California: Periodo 1900-2005. El Colegio de la Frontera Norte. http://www2.inecc.gob.mx/sistemas/peacc/descargas/inventario_gei_bc.pdf.

An option less explored, at least at the state level, is one based on the use of agricultural residues as bioenergy potential for Baja California. There is an estimated potential of 2,739,272 GJ/year mainly in the Mexicali Valley as one of the main generators of agricultural residues of the state.[16] For this planning process, the policy bundle of AFOLU-3 (Utilization of Wheat Straw) and ES-2 (State Energy Matrix Diversification) explores both the supply- and demand-side issues for using wheat straw and a biomass resource for power production.

The alternatives for generating electricity in Baja California 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 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 Baja California are high, and some of the most carbon intense sources (fuel oil and diesel oil) have already been eliminated as the natural gas share of overall electricity supply has expanded 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 life 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, Baja California has statewide general policy to diversify the energy supply matrix that could be further defined and developed (through policy option ES-2) to stimulate low carbon shifts in centralized sources (power plants), but it has not yet fully planned or implemented these changes (this report recommends such measures). Expanded planning and analysis could help address policy and investment information needs needed to support these shifts.

Distributed energy systems, such as small hydro and 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 Baja California, and they will require local government

[16] Valdez Vásquez et al, 2010.

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

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

- ES-1. Small Hydro Renewable Energy Generation. This policy expands generation of electrical energy in Baja California via the construction and operation of small hydroelectric plants, taking advantage of water flow, primarily from existing canals in the State, or other forms of running water that provide the necessary water pressure for electricity generation. Currently these water resources are underutilized for power production.
- ES-2. State Energy Matrix Diversification. The objective of this policy is to diversify the energy matrix, give greater stability, sustainability and increase supply current of energy, reduce hydrocarbons consumption and reduce Greenhouse Gas emissions.
- ES-3. Distributed Renewable Energy Generation in State Buildings. This policy expands the use and distribution of renewable energy in public buildings in Baja California for systems and facilities capable of producing their own energy.
- ES-4. Distributed Renewable Energy Generation in Residential Buildings. This policy expands the generation and use of renewable energy in the residential sector of Baja California through the purchase and installation of photovoltaic panels and reduces the emission of greenhouse gases associated with the consumption of electricity from fossil fuels.

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-2) provides over 92 percent of all emissions reductions from the four 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**

| | | *GHG Reductions* | | | *Base Year 2012$* | |
|---|---|---|---|---|---|---|
| | | **Annual Reductions** | | **2030 Cumulative** | **NPV 2016-2030** | **Cost Effectiveness** |
| **Policy ID** | **Policy Name** | **2020 $TgCO_2e$** | **2030 $TgCO_2e$** | **$TgCO_2e$** | **$Million** | **$/tCO₂e** |
| ES-1 | Small Hydro Renewable Energy | 0.05 | 0.07 | 0.8 | $231 | $294 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Generation | | | | | |
| ES-2 | State Energy Matrix Diversification | 0.9 | 1.3 | 16.0 | $6,814 | $425 |
| ES-3 | Distributed Renewable Energy Generation in State Buildings | 0.01 | 0.02 | 0.2 | $7 | $31 |
| ES-4 | Distributed Renewable Energy Generation in Residential Buildings | 0.018 | 0.025 | 0.296 | $150 | $505 |
| **Totals Before Adjusting for Overlap** | | **1.0** | **1.5** | **17** | **$7,201** | **$1,254** |

## 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.[17] 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.

Analysis of the impacts of ES measures is reported at a stand-alone (ES sector only) level in Table 4-1 above. Due to the low levels of distributed generation associated with three options (ES- 1, -2, -3), little overlap exists within the ES sector. Therefore, the results shown in Table 4-2 below showing results following intra-sector overlap adjustments are the same as those shown in Table 4-1.

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

| | | *GHG Reductions* | | | *Base Year 2012$* | |
|---|---|---|---|---|---|---|
| | | **Annual Reductions** | | **2030 Cumulative** | **NPV 2016-2030** | **Cost Effectiveness** |
| **Policy ID** | **Policy Name** | **2020 $TgCO_2e$** | **2030 $TgCO_2e$** | **$TgCO_2e$** | **$Million** | **$/tCO_2e$** |
| ES-1 | Micro-Hydro Renewable Energy Generation | 0.047 | 0.065 | 0.78 | $231 | $294 |
| ES-2 | Energy Supply Diversification | 0.94 | 1.3 | 16 | $6,814 | $425 |
| ES-3 | Distributed Energy Supply for Building | 0.013 | 0.019 | 0.22 | $7 | $31 |
| ES-4 | Photovoltaic Panel Electricity Generation | 0.018 | 0.025 | 0.30 | $150 | $505 |

[17] 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.

| | | | | | |
|---|---|---|---|---|---|
| **Total After Intra-Sector Interactions /Overlap** | **1.0** | **1.5** | **17.3** | **$7,201** | **$1,254** |

The state energy matrix (option ES-2) covers all sources of centralized power generation. Expansion of distributed renewable generation (options ES-1, -3, and -4) could reduce the level of need for centralized power and the impact of ES-2 by off-setting 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-2 option within the sector (92 percent of total emissions reductions), policy options ES-1, -3, and -4 are expected to have a minor overlapping effect.

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 the integrative effects of ES and all demand-side measures are explored in Chapter 3. In summary, 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 the overlap of supply- and demand-based policies. As discussed in Chapter 3, the marginal resource was defined as all natural gas 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

Four ES policies were analyzed for the BC CAP. 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. Small Hydro Generation

This policy expands the generation of electrical energy in Baja California via the construction and operation of small hydroelectric plants, taking advantage of water flow, primarily from existing canals in the State, or other forms of running water that provide the necessary water pressure for electricity generation. Currently these water resources are underutilized for power production.

This aims to provide the State clean-sourced electricity, taking advantage of available resources without affecting the environment, while simultaneously benefiting the public. These benefits are reflected in the reduction of fossil fuels imported by Baja California, which leads to a decrease in fossil fuel consumption costs and the reduction of Greenhouse Gas emissions that produced by the generation of electricity, including gasses such as carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$).

## ES-2. State Energy Matrix Diversification

The current mix centralized power generation relies largely on fossil fuels that generate GHG emissions and significantly deplete air quality. Due to high dependency on oil and the emissions which result from energy production in Baja California, there is a need for a policy that will diversify the energy matrix of the State to include a larger percent of renewable energy sources that do not affect the environment.

The State of Baja California has potential resources that can be utilized as for diversification of energy sources, such as: bioenergy, solar energy, geothermal energy, hydropower, wind power and various forms of ocean energy (tidal, waves and marine currents). The objective of this policy is to diversify the energy matrix, give greater stability, sustainability and increase supply current of energy, reduce hydrocarbons consumption and reduce Greenhouse Gas emissions.

## ES-3. Distributed Renewable Energy Generation in State Buildings

This policy expands the use and distribution of renewable energy in public buildings in Baja California for systems and facilities capable of producing energy, and reduces Greenhouse Gas emissions from existing fossil based sources.

This policy makes an inventory of buildings owned by the State Government that could be equipped with panels to capture solar energy. The purpose of this policy is not only to reduce energy costs, with the consequent reduction of emissions, but to lead by example and position the State Government as a model to promote the use of renewable sources existing in the State.ES-4. Distributed Renewable Energy Generation in Residential Buildings

This policy expands the generation and use of renewable energy in the residential sector of Baja California through the purchase and installation of photovoltaic panels and reduces the emission of greenhouse gases associated with the consumption of electricity from fossil fuels.

Given the costs of purchasing the equipment, the state's participation in financing or support programs will encourage the use of panels in the residential sector and, in turn, their sale and production, and their expanded use in the market place.

# 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 3 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 14% of Baja California's net GHG emissions as of 2010—a total of just about 2.1 $TgCO_2e$. Direct emissions from these sectors result principally from the on-site combustion of natural gas, liquefied petroleum gas (LPG), and distillate 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 utility industry. Also, leaks of methane from natural gas transmission and distribution systems are included in this category. These gases contributed an additional about 0.5 $TgCO_2e$, or about 3% of total Baja California emissions in 2010.

Finally, in addition to direct emissions from combustion of fuels and industrial processes in the RCII sectors, nearly all of the electricity sold in the Baja California is consumed in buildings as the result of residential, commercial, institutional and industrial activity. Emissions associated with producing the electricity consumed in Baja California were over 20% (3.0 $TgCO_2e$) of the state's gross GHG emissions in 2010.[18] Fuel use, industrial process emissions, and electricity account for about 35% of the state's total net GHG emissions. Baja California's future GHG emissions therefore will depend significantly on future trends in the consumption of 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. Figure 5-2 also provides direct emissions; however these are for industrial non-combustion (process) emissions. Figure 5-3 provides indirect (consumption-based) emissions estimates for electricity consumption. As indicated in Figure 5-4, most

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

electricity consumption occurs in the RCII sectors, so most of the emissions associated with production of electricity can be attributed to the RCII sector.[19]

**Figure 5-1. RCII Fuel Combustion GHG Emissions Baseline**

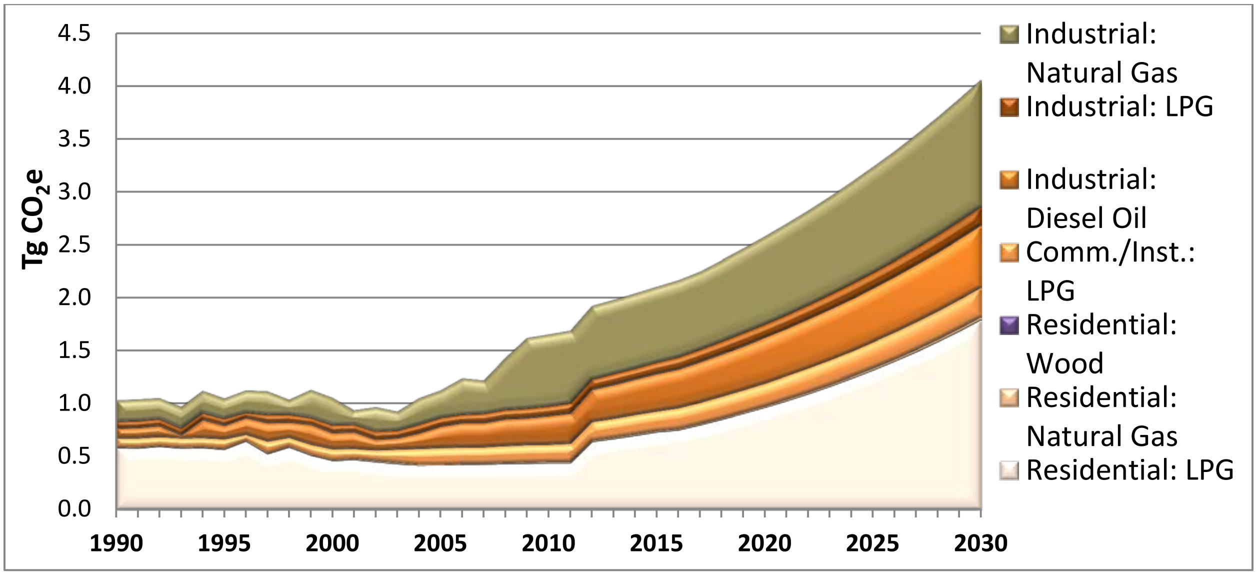
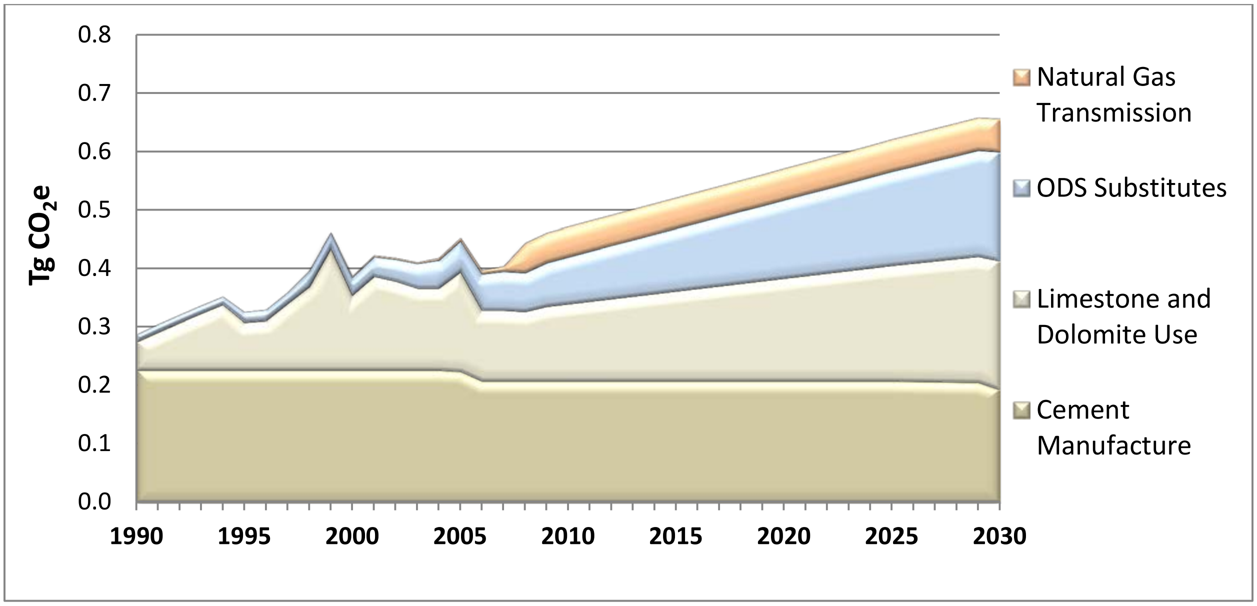
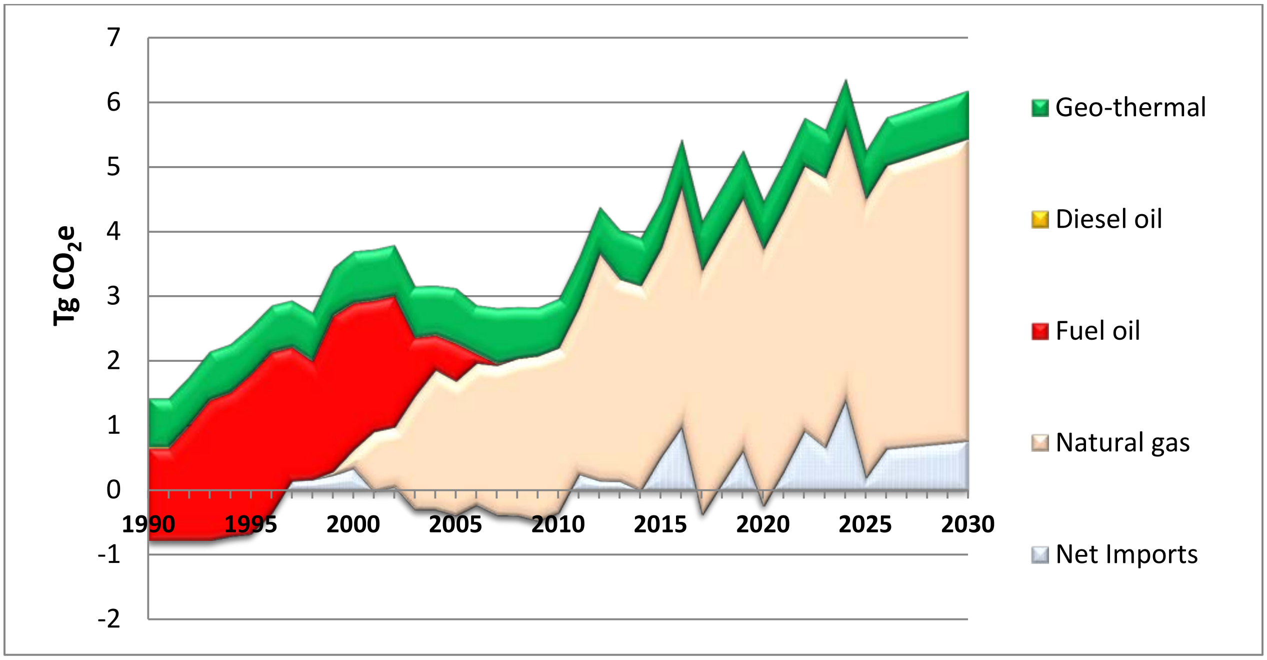



**Figure 5-2. Industrial Process GHG Emissions Baseline**




[19] 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.

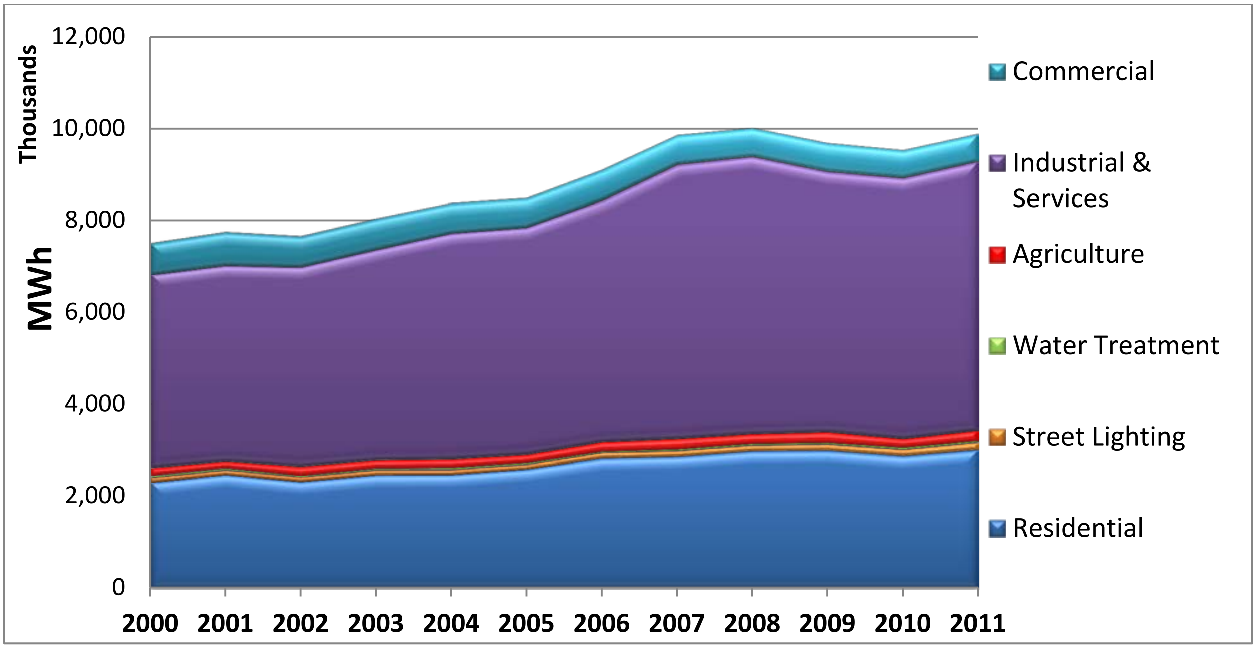
**Figure 5-3. Electricity (Consumption-basis) GHG Baseline**




The three sources of RCII emissions are forecasted to increase by approximately 4.0% annually between 2010 and 2030, but this estimate masks large changes within emission sources. Indirect emissions from electricity consumption and industrial process emissions are projected to account for most of the sector's growth in gross GHG emissions during this period. GHG emissions from the electricity sector grow at about 3.6% annually due to forecasted demand and the increase in natural gas generation shown in Figure 5-3. Emissions associated with industrial processes are expected to rise annually by about 1.7% between 2010 and 2030. Emissions from direct fuel combustion (LPG, petroleum, wood, and natural gas) are expected to increase by about 1.4% per year over the 2010-2030 period.

Figure 5-4 below provides some recent electricity sales data by sector. For the commercial subsector, data were not provided for 2007-2011, so these were trended based on the historical data. As shown in the chart, most of the consumption occurs within the residential, commercial and industrial (including services) subsectors. Roughly, one-third of consumption occurs in the residential sector, while the bulk of the other two-thirds occurs in the industrial/commercial sectors. Note that, with the exception of street lighting, institutional consumption is likely included in the industrial and services subsector.

**Figure 5-4. Electricity Sales by Sector**




## Key Challenges and Opportunities

The principal means to reduce RCII emissions in Baja California include improving energy efficiency, substituting electricity, LPG and natural gas with lower-emission generation resources (such as solar photovoltaic and wind generation), and various strategies to decrease the emissions associated with electricity production (i.e. "de-carbonizing" the electric grid; see Energy Supply chapter). 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.

Baja California'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 Baja California 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 six policy options for the residential, commercial, and industrial sectors detailed in Table 5-1.[20] 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 Tg $CO_2$e per year by 2030. A cumulative savings of over 21 Tg$CO_2$e from 2014-2030;
- Net cost savings of approximately $32.1 billion through 2030 on a net present value basis. The weighted average cost savings of these policies is about $1,529 per metric ton of $CO_2$e.

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

| | | *GHG Reductions* | | | *Base Year 2012$* | |
|---|---|---|---|---|---|---|
| | | **Annual Reductions** | | **2030 Cumulative** | **NPV 2016-2030** | **Cost Effectiveness** |
| **Policy ID** | **Policy Name** | **2020 Tg$CO_2$e** | **2030 Tg$CO_2$e** | **Tg$CO_2$e** | **$Million** | **$/t$CO_2$e** |
| RCII-1 | Housing Shell Improvements in New Residential Buildings | 0.019 | 0.019 | 0.26 | ($309) | ($1,172) |
| RCII-2 | Energy Efficiency Expansion in New Housing Design through Efficient Appliances | 0.016 | 0.016 | 0.43 | ($290) | ($675) |
| RCII-3 | Energy Efficiency Expansion in LPG and Electricity Consumption for Existing Buildings in the Residential and Commercial Sector | 0.58 | 0.58 | 8.2 | ($10,952) | ($1,342) |
| RCII-4 | Finance Incentives for Machinery Energy Efficiency | 0.27 | 0.73 | 6.1 | ($11,771) | ($1,915) |
| RCII-5 | Solar Water Heaters on Housing | 0.44 | 0.44 | 6.1 | ($8,800) | ($1,435) |
| RCII-6 | Tankless Water Heaters for the Residential Sector | 0.14 | 0.14 | 2.0 | ($3,095) | ($1,559) |
| | **Totals** | **1.3** | **1.8** | **21** | **($32,122)** | **($1,520)** |

[20] 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. Specifically, each of the policies was defined by addressing a specific type of energy use or sector. RCII-1 & -2 (Housing Shell Improvements and New Housing Design respectively) both target new residential buildings only. However, RCII-1 targets building shell measures to reduce electricity only, while RCII-2 only targets a 15% reduction in both electricity and gas use from building appliances. RCII-3 targets a 15% electricity and LPG reduction in existing commercial and residential buildings. RCII-5 & -6 (solar and tankless water heaters respectively) target renewable energy or more efficient water heating units in new and existing housing. RCII-4 targets industrial energy consumption only.

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**

| | | *GHG Reductions* | | | *Base Year 2012$* | |
|---|---|---|---|---|---|---|
| | | **Annual Reductions** | | **2030 Cumulative** | **NPV 2016-2030** | **Cost Effectiveness** |
| **Policy ID** | **Policy Name** | **2020 $TgCO_2e$** | **2030 $TgCO_2e$** | **Tg $CO_2e$** | **$Million** | **$/t$CO_2e$** |
| RCII-1 | Housing Shell Improvements in New Residential Buildings | 0.019 | 0.019 | 0.26 | ($309) | ($1,172) |
| RCII-2 | Energy Efficiency Expansion in New Housing Design through Efficient Appliances | 0.016 | 0.016 | 0.43 | ($290) | ($675) |
| RCII-3 | Energy Efficiency Expansion in LPG and Electricity Consumption for Existing Buildings in the Residential and Commercial Sector | 0.58 | 0.58 | 8.2 | ($10,952) | ($1,342) |
| RCII-4 | Finance Incentives for Machinery Energy Efficiency | 0.27 | 0.73 | 6.1 | ($11,771) | ($1,915) |
| RCII-5 | Solar Water Heaters for the Residential Sector | 0.44 | 0.44 | 6.1 | ($8,800) | ($1,435) |
| RCII-6 | Tankless Water Heaters for the Residential Sector | 0.14 | 0.14 | 2.0 | ($3,095) | ($1,559) |
| | **Total After Intra-Sector Interactions /Overlap** | **1.3** | **1.8** | **21** | **($32,122)** | **($1,520)** |

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 at the end of Chapter 3. Briefly, the results indicated that the total change to the electricity supply system brought on through implementation of all CAP policies was not large enough to exceed the total system marginal resource (for BC, this is total natural gas generation). Therefore, there was no need to make any inter-sector overlap adjustments between the RCII and ES policies.

The policy recommendations described briefly below, and in more detail in Appendix E, 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 Climate Action Plan 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 Baja California'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

Six RCII policies were analyzed for the BC CAP. Following is a short summary of each policy. Appendix E 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. Housing Shell Improvements in New Residential Buildings

This policy is designed to reduce the electricity consumption intensity of new buildings through improvements ordered by NOM 020 codes in design and construction, as well as in their end use. Construction and design modification can significantly reduce energy consumption; these actions can reduce a building's energy demand, including the direct and indirect effects of energy extraction, processing, transport and transmission. Therefore, GHG emissions can be reduced. The policy targets a 23% Reduction of electrical use per square meter of new Residential Building space over the years 2014-2020.

## RCII-2. Energy Efficiency Expansion in New Housing Design through Efficient Appliances

This policy is designed to reduce the energy intensity of new buildings through improvements in appliance efficiency to reduce electricity and Liquefied Petroleum Gas (LPG) consumption. Efficiency and end uses improvements can significantly reduce energy consumption; this action can reduce a building's energy demand, including the direct and indirect effects of energy extraction, processing, transport and transmission. Therefore, GHG emissions can be reduced.

The policy targets a 15% reduction of electrical and LPG use per square meter of new Residential Building space over the years 2014-2020.

## RCII-3. Energy Efficiency Expansion in LPG and Electricity Consumption for Existing Buildings in the Residential and Commercial Sector

This policy is designed to reduce the energy intensity of existing residential and commercial buildings through improvements in energy efficiency to reduce electricity and LPG consumption. Efficiency and end uses improvements can significantly reduce energy consumption; this action can reduce a building's energy demand, including the direct and indirect effects of energy extraction, processing, transport and transmission. Therefore, GHG emissions can be reduced.

The policy targets a 15% reduction in electrical and LPG use per square meter of existing Residential and Commercial Building space over the years 2014-2020.

## RCII-4. Financial Incentives for Energy Efficiency of Electricity Consumption in Industrial Sector

This policy is designed to improve energy efficiency in processes associated with industrial equipment and machinery used in industrial processes, services and trade. These kinds of equipment further increase energy consumption if they are not efficient and therefore also increase the amount of GHG emissions. Both the objectives and mechanisms of this policy are focused on reducing energy consumption and greenhouse gas emissions by way of strategies that involve training, tax incentives and poor equipment replacement.

The policy targets a reduction in electrical intensity in industrial production to 0.043kWh/MX$ over the years 2016-2022 from 0.043kWh/MX$ in 2010, a 13% reduction.

## RCII-5. Solar Water Heaters on Housing

This policy seeks to harness solar energy through the installation of solar water heaters. The installation will occur on existing and new households. This policy is intended to reduce consumption of LPG or electricity used to heat water in the houses, which leads to a reduction in GHG emissions through the use of renewable energy. At the same time, the quantity of LPG or electricity to be purchased is reduced.

The policy targets a reduction in LPG consumption used for water heating in new and existing residential buildings by 45% between 2016-2020.

## RCII-6. Continuous Flow (Tankless) Water Heaters for the Residential Sector

Focused on new and existing residential buildings, this policy aims at the efficient use of LPG for heating water by installing flow water heaters. This technology reduces the volume of LPG consumed in the houses without altering the amount of water and reduces GHG emissions.
The policy targets the installation of flow water heaters in 35% of new and existing residential buildings between 2016-202

# 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 8.3 $TgCO_2e$. The largest contributors were on-road gasoline and on-road diesel combustion, accounting for 66% and 22% of total sector emissions, respectively. The Transportation sector GHG baseline is shown in Figure 6-1 below.

Between 1990 and 2010, total transportation emissions more than doubled. The fastest growing source through the 1990-2010 time period was marine vessels with an annual growth rate of 8.5%, though this segment contributes less than 4% of the transportation sector emissions across the temporal series. The next fastest growing segment was on-road gasoline with a mean annual growth rate of 4.9%.

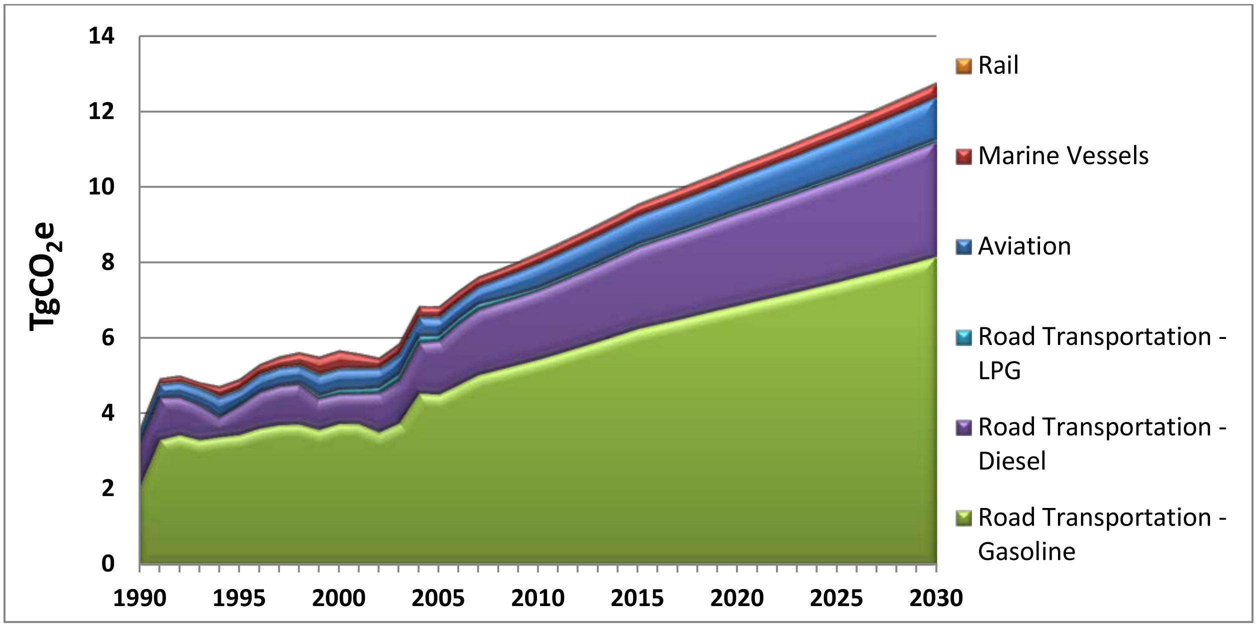
Total transportation emissions are expected to reach 13 $TgCO_2e$ by 2030 representing a 358% increase from 1990 or a 155% increase from 2010. In 2030, on-road gasoline emissions are expected to account for 64% of total sector emissions followed by on-road diesel (23%) and aviation gasoline (9%). Smaller sources will account for the remaining 3% of sector emissions and include the movement of marine vessels, on-road LPG vehicles, and rail.

The US-Mexico border has a particular economic and social dynamic different from the rest of the country. "Seventy percent of bilateral trade crosses the border through freight transport, meaning that the border region is literally the place where "the rubber hits the road "in bilateral relations."[21] 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

[21] Gobierno del Estado de Baja California. Programa para mejorar la Calidad del Aire de la Zona Metropolitana de Tijuana, Tecate y Playas de Rosarito 2012-2020. http://www.semarnat.gob.mx/archivosanteriores/temas/gestionambiental/calidaddelaire/Documents/ProAire%20ZMT2.pdf

diesel vehicles, construction and agriculture machinery are the three largest GHG emitters in the Mexican side of the border region.[22] According to PROAIRE of the Metropolitan Area of

**Figure 6-1. Transportation GHG Emissions by Fuel Source**




Tijuana (ZMT), heavy vehicles on the road are the largest emitters of nitrogen oxides ($NO_x$) and $CO_2$, and also contribute a considerable share of particulate matter less than 10 microns (PM10) compared to other emission sources. The GHG emissions associated with fuel sales on the Mexican side of the border would be included in the BC baseline; however, emissions from fuels sold on the US side of the border would not be included.

Besides the commercial flow on the road, there is a large flux of people moving from Baja California to California and vice-versa, and this flow is mostly of private vehicles. The large use of private vehicles is also due to the lack of efficient and safe public transport options, with the result that the mobility needs of the growing population of the ZMT has caused an increase of tax on private vehicles.[23]

The border region supports the purchase of second-hand vehicles to be imported and can circulate in Baja California and in the rest of the country; however, the mechanical conditions of many of these vehicles are not the most environment-friendly, since, among other things, they

[22] 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

[23] Rehovot, S.A. de C.V. 2012. Proyecto de Transporte Masivo Tronco-Alimentador "Corredor 1 Puerta México- El Florido", Tijuana, Baja California, México. http://www.fonadin.gob.mx/work/sites/fni/resources/LocalContent/781/6/ACB_PuertaMexico.pdf

have a very low performance compared to new vehicles, causing an increase in fuel consumption and emissions.

Both the economic activities of the region and the rapid population growth have an impact on the mobility of the people, and also on the way they settle. The ZMT records a complex issue of building houses irregularly due to groups of people that decide to build their own houses in areas not suitable for urban development.[24]

The State of Baja California shares with other big cities in the country some of the main problems in transportation; however, its geographical, demographic and economic conditions translate these problems in an opportunity to re-design public transportation policies and set emissions reduction goals.

## Key Challenges and Opportunities

Baja California has substantial opportunities to reduce GHG emissions from transportation sources. The principal approaches to reducing GHG emissions are:

- Utilizing less carbon-intensive fuels, which produce less GHG emissions per unit of energy provided;
- Improving vehicle efficiency; and
- Reducing travel volume or shifting travel to more energy-efficient modes of transit.

One of the most promising opportunities pertains to bringing alternative fuels to the transportation market. Alternative fuels derived from biomass, cellulosic residues, and energy crops have been identified by governments and academics as the best near-term opportunity to reduce dependence on fossil fuels and achieve GHG emissions reductions from transportation sector. There is little technological barrier for the initial introduction of biofuels in the current transportation system because conventional gasoline- and diesel-fueled vehicles can use low-level blends of biofuels, such as a blend of up to 15% ethanol in gasoline and up to 20% biodiesel in diesel, depending on manufacturer's certifications. Alternative-technology vehicles can also use more concentrated biofuels blends with ethanol content of up to 85%. The type of biofuel and the mix ratio with fossil fuels are key determinants of a vehicle's GHG emissions.

Modernizing fleet segments of the Baja California vehicle fleet offers another path for mitigating GHGs and other harmful pollutants such as particulate matter (PM) and black carbon (BC). Through various incentive programs, vehicle owners may retire old vehicles with new vehicles that have a much improved environmental and fuel efficiency performance. Some of the policies in the study target fleet segments that qualify as "worst offenders" on the basis of their environmental performance, including heavy duty diesel trucks with a model year between 1988 and1997, and passenger vehicles older than 20 years.

[24] Rehovot, S.A. de C.V. 2012. Proyecto de Transporte Masivo Tronco-Alimentador "Corredor 1 Puerta México- El Florido", Tijuana, Baja California, México. http://www.fonadin.gob.mx/work/sites/fni/resources/LocalContent/781/6/ACB_PuertaMexico.pdf.

BC emissions reductions and estimates of their carbon dioxide equivalence were quantified as the GHG benefits for T-1. Some reviewers will note that BC emissions generally were not quantified and reported within the baseline, and so their reductions should not be accounted within the CAP. Since these reductions are fairly small and to provide some context for policies that can specifically address BC emissions, they were left in the overall emissions reductions quantified for the BC CAP. If BC emissions continue to be an area of interest, future CAP revisions should include a quantification of BC emissions for inclusion in the baseline.

Reducing vehicle kilometers traveled (VKT), particularly of single-occupancy vehicles (SOVs), is crucial to mitigating GHG emissions from transportation. Developing smarter land-use and transportation development patterns that reduce trip length and support transit, carpooling, ride sharing, biking, and walking can contribute substantially to this goal. A variety of pricing policies and incentive packages can also help to reduce VKT. Developing better planning methods and regulations, and increasing funding of multiple modes of transportation will be key components in achieving these goals. Possible challenges include the need for sustained capital investments and coordination with multiple actors including citizens groups, developers and government agencies over the long term.

## Overview of Plan Recommendations and Estimated Impacts

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. The results shown for the T-2 analysis covering alternative fuels use also captures the biofuels supply-side impacts from policies AFOLU-4 (bioethanol production) and WM-4 (biodiesel production). This includes the net carbon content of each biofuel, along with the costs to produce each (hence, net GHG reductions and societal costs are not reported separately for the supply-side policies).

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

| | | *GHG Reductions* | | | *Base Year 2012$* | |
|---|---|---|---|---|---|---|
| | | **Annual Reductions** | | **2030 Cumulative** | **NPV 2016-2030** | **Cost Effectiveness** |
| **Policy ID** | **Policy Name** | **2020 $TgCO_2e$** | **2030 $TgCO_2e$** | **$TgCO_2e$** | **$Million** | **$/t$CO_2e$** |
| T-1 | Black Carbon Control Measures | 0.046 | 0.000 | 0.30 | $60 | $196 |
| T-2 | Alternative Fuels | 0.034 | 0.078 | 0.77 | ($291) | ($376) |
| T-3 | Onroad Fleet Efficiency | 0.003 | 0.008 | 0.070 | ($81) | ($1,150) |
| T-4 | Increase Efficiency in Urban Mobility | *Not quantified* | | | | |
| T-5 | Smart Growth Planning | 0.011 | 0.036 | 0.28 | ($480) | ($1,716) |
| T-6 | Energy Efficient Government Fleet | 0.000084 | 0.00011 | 0.0015 | $2.3 | $1,609 |
| | **Totals Before Overlap Adjustment** | **0.095** | **0.12** | **1.4** | **($789)** | **($552)** |

## Overlaps Discussion

The total effect of the policies, when implemented together, may differ from the sum of the individual effects had they been implemented separately when they target the same source (e.g., gasoline combustion). In order to account for intra-sector interactions, adjustments were made to the emission reduction assessed for the stand-alone policies presented in Table 6-1. In general, the overlap among policies was very small, and the adjustments to the 2030 cumulative emissions were revised downward by less than 0.1%. Therefore, the revisions often cannot be seen in the overlap-adjusted results shown in Table 6-2.

- TLU-1 focuses on Black Carbon Control, therefore, it has no overlap with any other options;
- TLU-2 addressing alternative fuels overlaps with T-3 through T-6, but is assumed to occur first, and therefore there are no overlap reductions for this policy;
- TLU-3 is a vehicle efficiency program covering only very old vehicles within the main fleet. This policy overlaps with TLU-2, and was the GHG savings were adjusted down accordingly;
- TLU-4 looks at hybrid buses, and only overlaps with TLU-2. The GHG savings were adjusted down accordingly;
- TLU-5 reduces VMT, and has overlaps with TLU-2, -3, -4 and -6. The GHG savings were adjusted downward to reflect these overlaps;
- TLU-6 examines fleet vehicles only, and only overlaps with TLU-2. The GHG savings were adjusted down accordingly.

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

| | | *GHG Reductions* | | | *Base Year 2012$* | |
|---|---|---|---|---|---|---|
| | | **Annual Reductions** | | **2030 Cumulative** | **NPV 2016-2030** | **Cost Effectiveness** |
| **Policy ID** | **Policy Name** | **2020 $TgCO_2e$** | **2030 Tg** | **$TgCO_2e$** | **$Million** | **$/$tCO_2e$** |
| T-1 | Black Carbon Control Measures | 0.046 | 0.000 | 0.30 | $60 | $196 |
| T-2 | Alternative Fuels | 0.034 | 0.078 | 0.77 | ($291) | ($376) |
| T-3 | Onroad Fleet Efficiency | 0.003 | 0.008 | 0.070 | ($81) | ($1,154) |
| T-4 | Increase efficiency in urban mobility | *Not quantified* | | | | |
| T-5 | Smart Growth Planning | 0.011 | 0.036 | 0.28 | ($480) | ($1,723) |
| T-6 | Energy Efficient Government Fleet | 0.000083 | 0.00011 | 0.0015 | $2.3 | $1,615 |
| | **Total After Intra-Sector Interactions /Overlap** | **0.095** | **0.12** | **1.4** | **($789)** | **($553)** |

# Transportation and Land Use (TLU) Policy Descriptions

Six TLU policies were analyzed for the BC 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. In several cases, these savings exceed any costs to comply with regulation or to implement new programs.

## TLU-1. Black Carbon

Black Carbon (BC) is the most strongly light-absorbing component of particulate matter (PM), and is formed from the incomplete combustion of fossil fuels, biofuels, and biomass. BC has a very negative impact on the health of the population, since remains suspended in the atmosphere for days and/or weeks; and also causes global warming. Recent studies indicate that the reduction of BC could be an effective short-term method to mitigate global warming.[25]

This policy aims at reducing BC emissions from the heavy duty diesel trucks (over 3 tons) of the vehicle fleet circulating in the State. BC emission reductions are achieved by installing PM filters on the most polluting segment of the heavy duty diesel vehicle fleet, that is, those vehicles with model year between 1988 and 1994. Emission control is estimated at over 90%.
This policy is designed to reduce GHG emissions from low efficiency motor vehicles in circulation in the State of Baja California. Energy efficient technologies in new vehicles increase Km/L performance and thus generate GHG reduction in the atmosphere.
Due to the geographic location of Baja California and the preferential tariff scheme, a large number of vehicles enter Baja California from the United States. These used vehicles have a vehicle age ranging from 5 to 10. This translates into a vehicle fleet that does not incorporate new efficiency technologies for emissions reduction. The economic problems that the population face to acquire new vehicles allow these imported vehicles to remain in circulation.
This policy intends to remove from the fleet vehicles older than 20 years.

[25] U.S. EPA. *2012 Report to Congress on Black Carbon*. March 2012. http://www.epa.gov/blackcarbon/2012report/fullreport.pdf

## TLU-2. Alternative Fuels

In recent years the demand for gasoline and diesel has increased as a result of, among other factors, the behavior of the automotive market, the extension of credit to purchase new cars and the import of used vehicles, etc. According to the State Inventory of Emissions of Greenhouse Gases in the State of Baja California, Carbon Dioxide ($CO_2$) is the main greenhouse gas (GHG) emitted in the transport sector equal to 98% of the volume of emissions. This demand-side policy is linked to two supply-side policies: AFOLU-4 (bioethanol production; and WM-4 (biodiesel production).

This policy objectives and mechanisms aim at promoting the use of biofuels (bioethanol and biodiesel) that will displace fossil fuels and thus reduce GHG emissions from the transportation sector. This policy focuses on blending biofuels with conventional fossil fuels to mixing ratios that do not require vehicle engine retrofits, such as 10% blend of ethanol with gasoline (i.e., E10) and 20% blend of biodiesel with conventional diesel (i.e., B20). The source of bioethanol is sweet sorghum, and the source of biodiesel is recycled oils of hotels and restaurants.

## TLU-3. On-road Fleet Efficiency

This policy is designed to reduce GHG emissions from low efficiency motor vehicles in circulation in the State of Baja California. Energy efficient technologies in new vehicles increase Km/L performance and thus generate GHG reduction in the atmosphere.

Due to the geographic location of Baja California and the preferential tariff scheme, a large number of vehicles enter Baja California from the United States. These used vehicles have a vehicle age ranging from 5 to 10 years. This translates into a vehicle fleet that does not incorporate new efficiency technologies for emissions reduction. The economic problems that the population faces to acquire new vehicles allow these imported vehicles to remain in circulation.

This policy is designed to remove the segment of the fleet that is the most fuel inefficient, that is, vehicles older than 20 years.

## TLU-4. Increase Efficiency in Urban Mobility

This policy aims at increasing the efficiency in urban mobility focused mainly on modernizing the public bus fleet. The upgrade includes the replacement of buses used in mass transit from old, energy inefficient and high polluting buses with new, energy-efficient, and less polluting ones. A fleet of modern buses in addition can incentivize participation in the use of public transport and a reduction in the number of private cars on the road.

Due to the complexity of the issues involved, this policy was not quantified in time for use in this report.

## TLU-5. Smart Growth Planning

This policy aims at establishing urban growth strategies involving both intelligent urban planning and the integration of the different actors of the urban environment. By promoting denser population centers and balancing the demand for jobs and housing, the average number of trips and trip distances can be significantly reduced, which results in a decrease of GHGs and other criteria pollutants.

## TLU-6. Energy Efficient Government Fleet

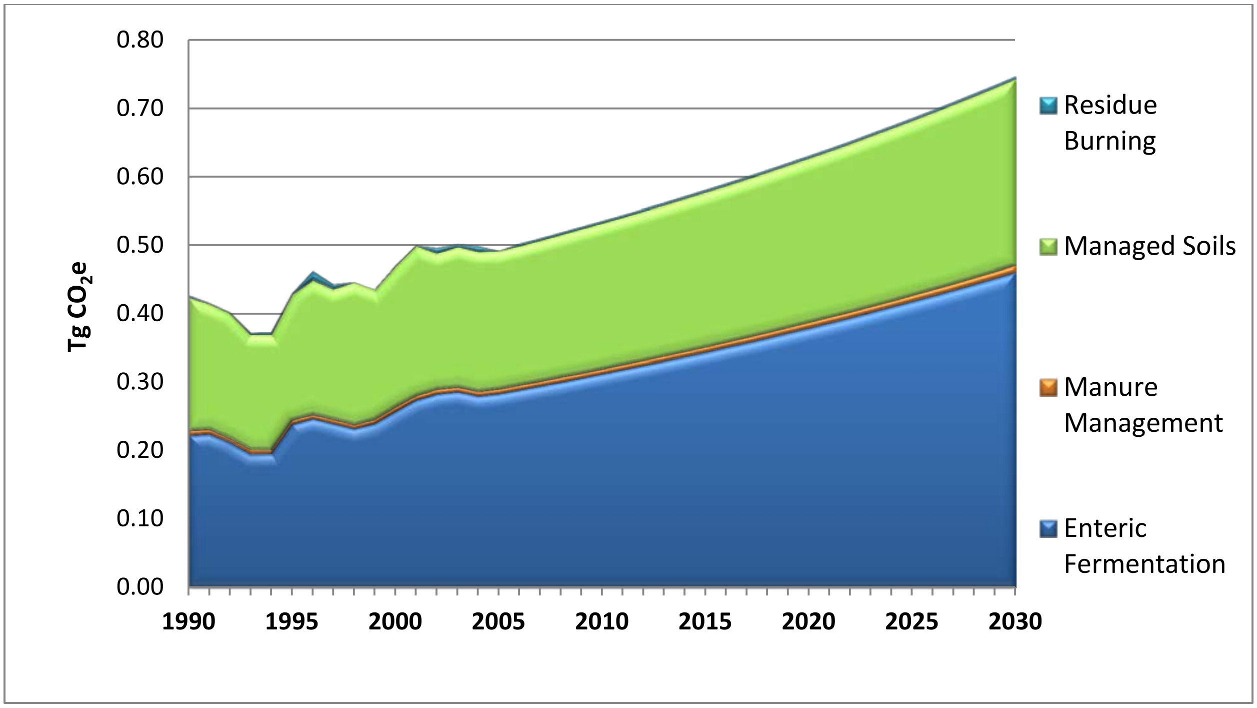
Motor vehicles that use fossil fuels like gasoline and diesel are major emitters of greenhouse gases (GHG). The increased use of efficient vehicles leads to a saving of petroleum fuels, and by extension, a reduction of GHG emissions. The government has the potential to "lead by example", that is why this policy is aimed at the government of Baja California to reduce GHG emissions from the official vehicle fleet, by mandating the procurement of hybrid vehicles through an amendment of the regulations.

# 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. In addition, emissions of $N_2O$ and $CH_4$ from crop residue burning add small amounts to the sector totals (these are small enough that they are difficult to see in the baseline chart below.

**Figure 7-1. BC Agriculture GHG Baseline**




Emissions from the livestock management subsector include $CH_4$ from manure management and from enteric fermentation (mainly cattle). As shown in Figure 7-1, the manure management emissions are very small contributors to sector level emissions. This is due to both the dry climate of BC, as well as the methods of manure management. Enteric fermentation emissions along with managed soils are the predominant sources of GHGs for BC.

Overall, the Agriculture sector contributes only a small amount of BC's GHG emissions. In 2005, the sector contributed about 4% of state-wide emissions. This is expected to decrease to a contribution of less than 3% by 2030. 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 with the exception of liquefied petroleum gas (LPG) combustion in agriculture (in 2005, about 0.02 Tg $CO_2e$ were emitted). Diesel fuel is the more expected common fuel for use in agriculture, especially crop production. This usage is expected to be captured as part of the commercial or industrial fuel use documented for those other sectors. Since a full accounting of fuel use could not be made for all fuels, the emissions were excluded from Figure 7-1.

The Forestry & Other Land Use (FOLU) is provided in Figure 7-2 below. As with Agriculture, its net contribution to state-wide GHG emissions is quite small (just over 1% in 2005). This is still the case in BC where the sector is shown to be a net source of GHGs, rather than a sink. Forest carbon flux is shown to be positive (i.e. a net release of carbon to the atmosphere). As further documented in the 2010 GHG I&F report by CCS, this is due to estimated annual forest disturbances and removals being greater than annual biomass growth (see Appendix A).

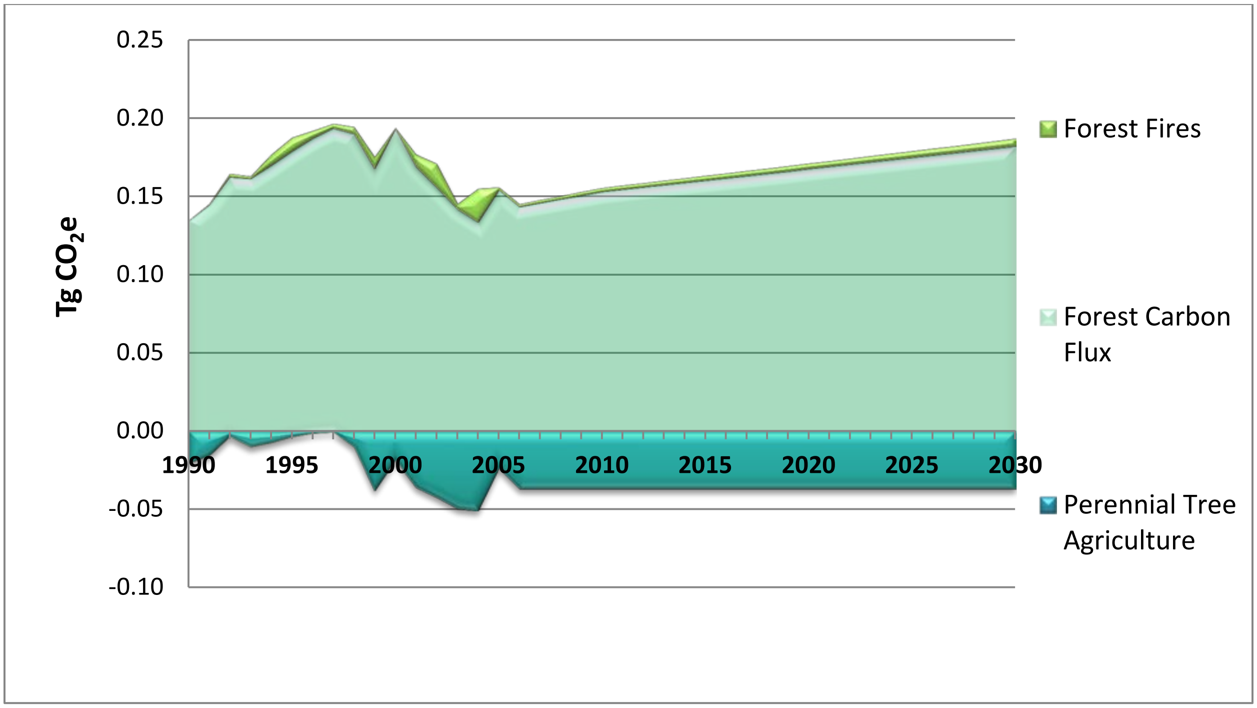
Additional sources of emissions in the FOLU sector are non-$CO_2$ emissions ($CH_4$ and $N_2O$) from wildfires and net carbon flux in perennial agriculture (i.e. orchards). For wildfires, the $CO_2$ emissions are biogenic and therefore treated as neutral in terms of climate forcing. The perennial agriculture emissions are 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 BC 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 BC 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 the BC Climate Action Plan (as described later in this chapter).

The agricultural sector of the State of Baja California and the nation is weak and this is reflected in low productivity, competitiveness and profitability. It is therefore essential to implement strategic measures to strengthen the sector, create jobs and increase farmers' income.

The main agricultural products of Baja California nationwide are onions, tomatoes, strawberries, garlic, wheat, cotton and beef, among others. The most prominent challenges in the sector are promoting sustainable production, with the use of technological changes, especially those that require a limited use of water (mainly in irrigation areas with water shortages) and have a greater demand on the market. It is also seeking to promote the conversion to crops with higher productivity and competitiveness in the sector.

**Figure 7-2. BC FOLU GHG Baseline, Net Emissions**




The livestock subsector also presents some economic, environmental and social problems. Key issues in livestock in Baja California are profitability, increased inputs (especially in the case of milk production), marketing, and the low added value accruing to the producers. Also the treatment of excreta has become an issue, less evident than the others, but no less important.

Therefore, the State Government has considered various actions to address some of the above issues. Among them: improve the hygiene and safety of the agricultural products to maintain competitive advantage in the markets status; promote domestic products; update the legal framework to ensure a sustainable use of soil and water resources; establish a program that addresses technology, efficient use of water, and training and financing; among others.

Agricultural and livestock activities, as well as change in land use statewide are not the biggest GHG emitters. However, it is important to consider strategies for reducing GHG emissions from these activities.

Emissions from livestock are the most significant, equal to 3.2%. This category includes emissions of methane and nitrous oxide from manure management, indirect $N_2O$ emissions from nitrogen leaching followed by the application of manure and nitrogen volatilization.

Agricultural burning emits 1.6% of the total, but ranks second in the sector. These fires are mainly made in the Guadalupe Valley and wheat straw is the main incinerated biomass; studies show that nearly 80% of wheat straw is burned.

Management of agricultural soils emits 1.3%. To calculate these figures nitrogen from the decomposition of crop residues, nitrogen fixing crops, and the application of synthetic fertilizers were considered.

Emissions from forest management and commercial tree plantations, loss of vegetation due to urbanization, increased agriculture, among others, accounted for about 1.0%.

## Key Challenges and Opportunities

Given their overall contributions to state-wide emissions, at first glance, the Agriculture & FOLU sectors would seem to represent minimal opportunities for GHG reductions. However, a key difference between these sectors and the "energy sectors" (ES, RCII, Transportation) is that some actions conducted within AFOLU will serve to reduce emissions in other sectors, as well as within the sector. Several examples follow:

- Management of livestock manure: when combined with energy recovery, anaerobic digestion of manure can be used to generate electricity or useful heat, which then offsets grid-based power and ES sector fossil fuel use;
- Urban forest management/expansion: when the urban canopy is expanded with strategic siting of new trees to offer energy savings benefits in buildings, there is a net increase in carbon sequestration, as well as offsets in grid-based power use and/or fossil fuel use in the RCII sector; and
- Crop residues or purpose-grown crops can be used as feedstocks for production of power or liquid fuels (primarily transportation fuels). When these biofuels are consumed by end users in the ES and transportation sectors, GHG reductions occur to the extent that fossil fuels are offset.

It is these types of actions that offer the best opportunities for net GHG reductions and the associated economic benefits in BC. The set of policies selected by the PEACC are in-line with the themes outline above and are described further below. Additional areas for future consideration of policy analysis are soil carbon management and nutrient management.

## Overview of Plan Recommendations and Estimated Impacts

Six policies were developed and analyzed within the AFOLU sector:

- *AFOLU-1. Manure Management: Non-Dairy Livestock*: This policy seeks to optimize the management of livestock manure from swine using anaerobic digestion (AD) to produce biogas for direct use or electricity to offset use of grid-based power. Application of processed manure to crop fields will also be optimized in order to match crop nutrient requirements with applications of these organic fertilizers in order to reduce GHG emissions and use of commercial fertilizers.
- *AFOLU-2. Manure Management: Dairy Cattle:* This policy proposes to use dairy manure in AD projects to produce electricity and bio-fertilizer. As with AFOLU-1, management

of manure in AD projects will reduce methane emissions and the electricity produced will offset grid-based power use along with the associated GHGs.

- *AFOLU*-3. *Utilization of Wheat Straw:* This policy aims to take advantage the wheat straw available in the Mexicali Valley, for use as biomass fuel for power generation under Policy ES-2 (State Energy Matrix Diversification).
- *AFOLU*-4. *Bioethanol Production from Crops.* As with AFOLU-3, this is another supply-side policy addressing the production of sweet sorghum in the Mexicali Valley to produce bioethanol for use in the TLU-2 (Alternative Fuels) policy.
- *AFOLU*-5. *Livestock Grazing Management.* The main objective of this policy is to reduce animal load in order to improve damaged ground, reduce soil erosion, and improve vegetative cover, where this damage has occurred as a result of over-grazing. Improved vegetative growth will increase levels of carbon sequestration in soils and plant material.
- *AFOLU-6. Urban Forestry.* This policy will expand urban forest cover in the State to promote higher levels of carbon sequestration and, to the extent that trees are strategically located to provide shading benefits for buildings, reductions in cooling load will be another energy/GHG benefit.

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, except for the biofuels policies AFOLU-3 and -4, the total annual 2030 GHG reductions would be 0.14 $TgCO_2e$ and the cumulative reductions would be 1.6 $TgCO_2e$ from 2016-2030. Net societal implementation costs would be 1.15 billion pesos ($2012). Implementation costs for the suite of policies (CE = $730) is fairly high due to the influences of AFOLU-1 (low reduction potential); AFOLU-5 (high costs for grazing density management); and AFOLU-6 (low reduction potential).

## Overlaps Discussion

No intra-sector overlaps were identified among the AFOLU policies. However, inter-sector overlaps or interactions do exist among CAP policies. For the bioenergy supply-side policies (AFOLU-3 and -4), the full GHG reductions and costs are provided in the associated demand-side policy. For AFOLU-3, Utilization of Wheat Straw, the carbon content and costs of biomass produced for use as a fuel in power generation were quantified as used as input to the analysis of Policy ES-2 (State Energy Matrix Diversification). Similarly, for AFOLU-4, Bioethanol Production from Sweet Sorghum, the annual bioethanol production volumes, carbon content and production costs were quantified and provided as input to the demand-side policy, TLU-2 (Alternative Fuels).

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

| Policy ID | Policy Name | GHG Reductions: Annual Reductions 2020 $TgCO_2e$ | GHG Reductions: Annual Reductions 2030 $TgCO_2e$ | GHG Reductions: 2030 Cumulative $TgCO_2e$ | Base Year 2012$: NPV 2016-2030 $Million | Base Year 2012$: Cost Effectiveness $/tCO₂e |
|---|---|---|---|---|---|---|
| AFOLU-1 | Manure Management: Non-Dairy Livestock | 0.00037 | 0.00037 | 0.0048 | $3.4 | $714 |
| AFOLU-2 | Manure Management: Dairies | 0.020 | 0.021 | 0.27 | $31 | $117 |
| AFOLU-3[a] | Utilization of Wheat Straw | *N/A; Results are reported with the ES-2 policy totals.* | | | | |
| AFOLU-4[b] | Bioethanol Production from Sweet Sorghum | *N/A; Results are reported with the TLU-2 policy totals.* | | | | |
| AFOLU-5 | Livestock Grazing Management | 0.069 | 0.12 | 1.3 | $1,117 | $855 |
| AFOLU-6 | Urban Forestry | 0.000049 | 0.00063 | 0.0034 | $17 | $5,514 |
| **Totals** | | **0.090** | **0.14** | **1.6** | **$1,151** | **$730** |

[a] As described in the text, the AFOLU-3 analysis results are not reported here. The biomass production volume, its carbon content, and production costs were estimated and then used within the ES-2 analysis, where the biomass fuel resulting from this policy is consumed (addressing both supply and demand).
[b] AFOLU-4 reductions not reported here. Ethanol production volumes, carbon content, and production costs were estimated and then used in the TLU-2 analysis, where net GHG benefits are determined for both policies (addressing supply and demand).

Other possible inter-sector overlaps include the energy savings benefits calculated for AFOLU-6 and the policies addressing building energy consumption in the RCII sector: RCII-1 (Improve Design and Construction of New Residential Buildings); RCII-2 (Energy Efficiency Expansion in Residential Appliances); and RCII-3 (Energy Efficiency Expansion in Existing Buildings). There is some potential for overlap of the energy savings benefits of AFOLU-6 achieved through reduced cooling demand via shading with expanded urban forest canopy; however, the overlap would only occur in situations where this new expanded canopy was co-located with some energy efficiency improvement brought on by implementation of RCII-1, -2, or -3. Given the small nature of the overlap and the lack of readily-available data to assess the potential level of overlap, no adjustments were made to either the AFOLU-6 or RCII policy analyses.

As a result of the methods used to align bio-energy supply and demand policies and to address any other intra- or inter-sector overlaps, the results shown in Table 7-2 below show no change from the stand-alone results shown in Table 7-1 above. 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 3.5 provides a discussion of how these types of electricity system interactions were addressed for all sectors. In summary, the assessment of electricity system impacts did not indicate a need to adjust any of the AFOLU microeconomic analysis results.

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

| Policy ID | Policy Name | GHG Reductions | | | Base Year 2012$ | |
|---|---|---|---|---|---|---|
| | | Annual Reductions | | 2030 Cumulative | NPV 2016-2030 | Cost Effectiveness |
| | | 2020 $TgCO_2e$ | 2030 $TgCO_2e$ | $TgCO_2e$ | $Million | $/t$CO_2e$ |
| AFOLU-1[a] | Manure Management: Non-Dairy Livestock | 0.00037 | 0.00037 | 0.0048 | $3.4 | $714 |
| AFOLU-2[a] | Manure Management: Dairies | 0.020 | 0.021 | 0.27 | $31 | $117 |
| AFOLU-3[a,b] | Utilization of Wheat Straw | *N/A; Results are reported with the ES-2 policy totals.* | | | | |
| AFOLU-4[a,c] | Bioethanol Production from Sweet Sorghum | *N/A; Results are reported with the TLU-2 policy totals.* | | | | |
| AFOLU-5[a] | Livestock Grazing Management | 0.069 | 0.12 | 1.3 | $1,117 | $855 |
| AFOLU-6[a] | Urban Forestry | 0.000049 | 0.00063 | 0.0034 | $17 | $5,514 |
| **Totals** | | **0.090** | **0.14** | **1.58** | **$1,151** | **$730** |

[a] No intra-sector overlaps identified.
[b] As described in the text, the AFOLU-3 analysis results are not reported here. The biomass production volume, its carbon content, and production costs were estimated and then used within the ES-2 analysis, where the biomass fuel resulting from this policy is consumed (addressing both supply and demand).
[c] AFOLU-4 reductions not reported here. Ethanol production volumes, carbon content, and production costs were estimated and then used in the TLU-2 analysis, where net GHG benefits are determined for both policies (addressing supply and demand).

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

Six AFOLU policies were analyzed for the BC CAP. 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. Manure Management: Non-Dairy Livestock

This policy seeks to optimize the management and use of livestock manure from swine managed at production units (PUs) of medium to large scale (>300 head). To optimize manure management, anaerobic digestion (AD) will be promoted to obtain biogas for direct use (medium PU), electricity to offset use of grid-based power (large PU) and bio fertilizer (both farms). Application of processed manure to crop fields will also be optimized in order to match crop nutrient requirements with applications of these organic fertilizers in order to reduce GHG emissions and use of commercial fertilizers

## AFOLU-2. Manure Management: Dairy Cattle

This policy proposes to use dairy manure generated in the dairy farms (Production Units >500 heads) in Baja California to produce electricity and bio-fertilizer. To optimize manure management, it is recommended to install AD with engine-generator sets, which will be used to process the manure to reduce methane emissions as compared to BAU and to produce electricity to offset grid-based use.

## AFOLU-3. Utilization of Wheat Straw

This policy aims to take advantage the wheat straw available in the Mexicali Valley, for use as biomass fuel for power generation. The implementation of this policy will decrease agricultural residue burning, which is a common practice among Mexicali farmers. Therefore, implementation of this policy will decrease emissions of $N_2O$, $CH_4$, and air pollutants generated by this activity; and, when used as a fuel for power generation, will offset fossil fuel use. This is expected to have a direct impact on air quality in the region and on the health of the population which shares this atmospheric basin.

AFOLU-3 is the first aspect of policy implementation (i.e. the “supply-side”); and it focuses on the avoided burning, collection and transportation of wheat straw. Greenhouse gas reductions and costs of power generation using the AFOLU-3 feedstock will be addressed under the “demand-side” policy ES-2: State Energy Matrix Diversification.

## AFOLU-4. Bioethanol Production from Crops

This is a supply-side policy addressing the production of sweet sorghum in the Mexicali Valley to produce bioethanol. The bioethanol generated will be used as a source of biofuel for a bioethanol mix in the transportation sector in Baja California (e.g. 10% or higher ethanol blends in gasoline). AFOLU-4 promotes the use of sustainable agricultural practices in sweet sorghum production, which has relatively low use of fertilizer and water compared to conventional crops. Furthermore, this new agricultural production represents another option to farmers in the region during the spring/summer agricultural cycle.

The production and use of bioethanol as a fuel will lead to a reduction of carbon dioxide ($CO_2$) emissions generated by transportation sector, which accounts for more than half of the total GHG emissions in the State. As a supply-side policy, the AFOLU-4 analysis includes the calculation of GHG emissions and costs of: 1) sorghum cultivation; 2) harvesting; 3) transport; and 4) the biorefinery processing to produce bioethanol. These results were then used as inputs to estimate the full energy-cycle emissions and costs for use of this bioethanol within the demand-side TLU-2 (Alternative Fuels) policy.

## AFOLU-5. Livestock Grazing Management

To reduce environmental impacts of raising cattle on Baja California rangelands, the main objective of this policy is to reduce animal load in order to improve damaged ground, reduce soil erosion, and improve vegetative cover, where this damage has occurred as a result of over grazing.

## AFOLU-6. Urban Forestry

This policy seeks to take advantage of vacant lots found within the cities in Baja California, in order to reforest them and increase the surface area of vegetation in the State, while at the same time, building green corridors to help connect the cities´ parks and gardens. Given that the urban green area per capita in Baja California is below the recommended standards (9 $m^2$/inhabitant), implementation of this policy will promote compliance with these standards. Additional urban forest cover in the State will promote higher levels of carbon sequestration and, to the extent that trees are strategically located to provide shading benefits for buildings, reductions in cooling load will be another energy/GHG benefit.

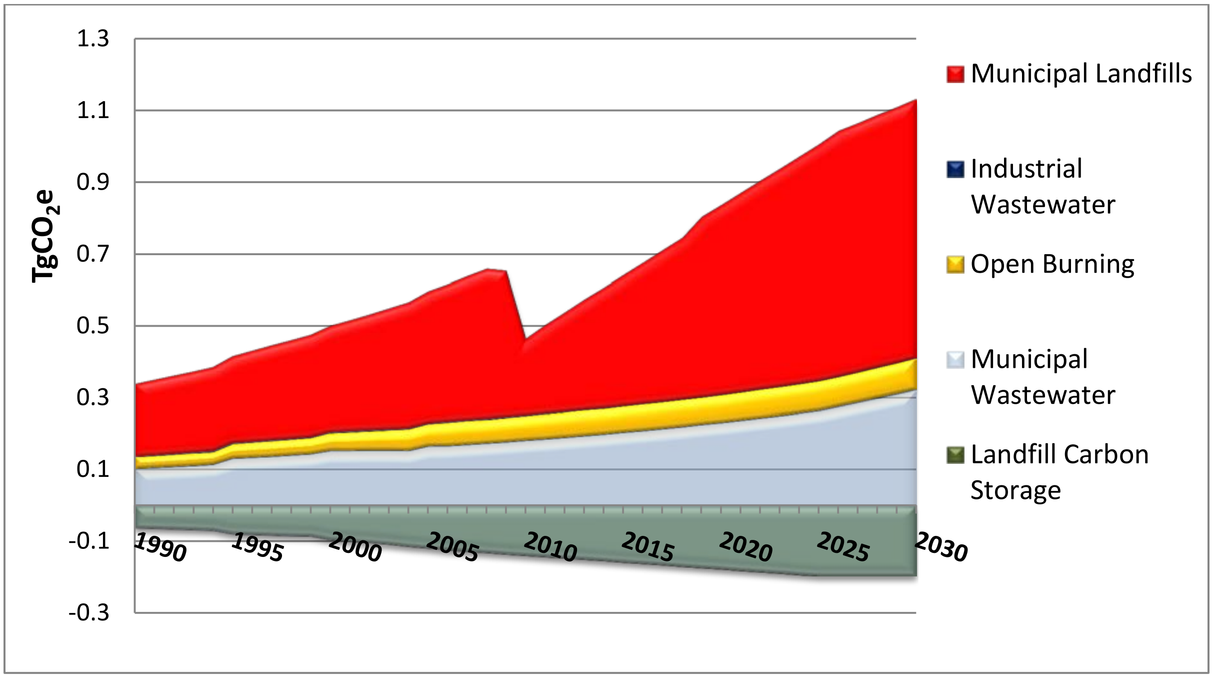
# Chapter 8
# Waste Management (WM) Sector

## 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 Baja California, 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. Methane emissions from solid waste landfills contribute about 36% of the gross emissions in 2010 (0.22 $TgCO_2e$). The contributions from this source are expected to grow to about 54% (0.72 $TgCO_2e$) by 2030. The other large contributor is municipal wastewater treatment ($CH_4$ and $N_2O$ emissions from the treatment process). Gross emissions contributions were about 52% in 2010 (0.32 $TgCO_2e$) and are expected to contribute around 39% (0.52 $TgCO_2e$) in 2030.

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




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.

Overall, the WM sector contributes a small amount of the total State-wide emissions. The sector contributed a little over 3% to the 2010 emissions totals, and in 2030, the contribution is expected to grow only slightly to over 4% 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) 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.

Municipal Solid Waste (MSW) management is a sensitive environmental issue that directly impacts terrestrial and aquatic systems, and therefore also affects the flora and fauna. The production of municipal solid waste in the State of Baja California has increased considerably in recent years.

It is estimated that the approximate production of MSW at the state level is 1.32 kg / per capita / day. However, the main problem is that much of this waste is deposited in illegal dumping and does not receive proper treatment. According to the National Institute of Statistics and Geography (INEGI) in Tijuana only 43% of the waste generated is collected, in Mexicali 27%, 22% in Ensenada, and 8% in Tecate and Playas de Rosarito; this situation increases the contamination of soil, water and air due to methane production and the fact that in some cases this waste is incinerated.

The use of methane in the landfill "Valle de Verde " located in the municipality of Tijuana is among the most significant actions of the government of the State of Baja California and the municipality of Tijuana. This project was supported by Global Methane Initiative and the US Environmental Protection Agency (USEPA). The avoided annual emissions are approximately 197 $tCO_2e$.

The drinking water in Baja California is a big challenge for the State Water Commission (CEA) and the four state public utility commissions of the State. First, Mexicali requires high amounts of water for agriculture activities carried out with inefficient irrigation techniques; and second, most of the water consumed in Tijuana, Tecate and Playas de Rosarito comes from the Colorado River, a resource that runs through the Colorado River –Tijuana aqueduct. This water runs 125 kilometers, rises 1.061 meters in Rumorosa and requires the energy of six pumping stations, representing the highest rates of consumption of electrical energy per volume of water supplied in the country. In addition, the energy needed for purification and transmission to households has to be factored in.

The use of wastewater for irrigation of public and private green areas, for formation of lakes, or to increase the volume of water in dams, are strategic activities for the use of this resource. Figures from the State Water Commission reveal that 98% of the total wastewater generated is treated in the plants installed in Baja California. Currently there are only projects for the use of 30% for irrigation of green areas, fodder crops in the Mexicali Valley and cooling industrial boilers.

## Key Challenges and Opportunities

The WM sector has some similar issues relative to GHG mitigation as noted in the previous chapter for the AFOLU sector. While the WM sector appears to contribute minimally to State-wide direct GHG emissions as compared to the "energy sectors", energy use related emissions are not included in the WM baseline due to the current level of detail available in the underlying data (e.g. details in sector level electricity consumption; lack of data for transportation fuel use for attribution to specific end users). Therefore, baseline GHG emissions for the sector are somewhat higher than indicated in Figure 8-1.

Similar to AFOLU, mitigation actions taken by the WM sector offer opportunities for reducing emissions both within the sector and in other sectors. Examples of both types of approaches follow:

- Within sector reductions:
    - Landfill $CH_4$ controls;
    - Energy efficiency programs at wastewater treatment plants; and
    - Shifts in solid waste management approaches: e.g. composting instead of waste combustion.
- Outside of sector reductions:
    - Use of landfill $CH_4$ or wastewater treatment plant biogas for useful energy purposes (power or direct heat);
    - Conversion of wastes into biofuels to offset fossil fuel use in the ES, RCII and/or Transportation sectors (e.g. waste vegetable oil to biodiesel conversion; biomass to energy conversion); and
    - Closed landfills and land around wastewater treatment plants often provides good opportunities for renewable energy projects (e.g. solar or wind).

The initial WM policies selected by the PEACC are consistent with the approaches outlined above. These policies are described in more detail below and in Appendix G. For future policy development, additional solid waste management programs to address source reduction, re-use, recycling, and organics management (e.g. composting or anaerobic digestion) should be considered. In particular, for solid waste management, there are significant embedded emissions within the components of the waste stream that are reduced when waste materials are source reduced (not generated in the first place), re-used, or recycled.

## Overview of Plan Recommendations and Estimated Impacts

Four policies were developed and analyzed within the WM sector:

- *WM-1. Landfill Gas Management:* This policy seeks to capture methane from landfills of Tijuana, Mexicali and Ensenada to reduce GHG emissions and to generate electricity with connection into the public grid;

- *WM-2. Indirect Potable Water Re-Use:* This policy supports projects that re-use wastewater that has been partially treated and then pumped to reservoirs for storage. After final treatment and re-use of this water, total energy use as compared to water sourced and pumped from distant sources is reduced.
- *WM-3. Water Reclamation:* This policy promotes the use of treated wastewater for irrigation of urban green areas, thereby saving on total water consumption and costs, as well as the energy required to source water for irrigation needs. Net reductions in energy use will provide GHG reductions.
- *WM-4. Biodiesel Production:* This policy aims to take utilize waste vegetable oil (WVO) from the restaurant sector to produce biodiesel for a 2% blend (B2) for use in the Baja California´s transportation sector. This will offset fossil diesel use producing net GHG reductions. This policy focuses on supply-side (production) costs/energy/GHG impacts. Output from the analysis is used in a demand-side policy, TLU-2 (Alternative Fuels), to determine overall GHG and cost impacts for production and consumption of biodiesel.

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, except for the biofuel policy WM-4, the total annual 2030 GHG reductions would be 0.43 $TgCO_2e$ and the cumulative reductions would be 5.1 $TgCO_2e$ from 2016-2030. Collectively, these policies would produce net societal savings upon implementation of 383 million pesos ($2012). These costs are presented on a net present value (NPV) basis using a financial base year of 2012. The net savings produce a negative cost effectiveness value across all policies of -$76/$tCO_2e$ due to the energy savings achieved via implementation of WM-2 and WM-3.

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

| Policy ID# | Policy Name | GHG Reductions: Annual Reductions 2020 $TgCO_2e$ | GHG Reductions: Annual Reductions 2030 $TgCO_2e$ | GHG Reductions: 2030 Cumulative $TgCO_2e$ | Base Year 2012$: NPV 2016-2030 $Million | Base Year 2012$: Cost Effectiveness $/$tCO_2e$ |
|---|---|---|---|---|---|---|
| WM-1 | Landfill Gas Management | 0.27 | 0.32 | 3.9 | $258 | $67 |
| WM-2 | Indirect Potable Water Re-Use | 0.025 | 0.035 | 0.43 | ($226) | ($532) |
| WM-3 | Water Reclamation | 0.04 | 0.07 | 0.76 | ($415) | ($545) |
| WM-4[a] | Biodiesel Production | *N/A; This is a renewable fuel supply policy; results are exported for integration with the demand-side policy, TLU-2* | | | | |
| | **Totals** | **0.34** | **0.43** | **5.1** | **($383)** | **($76)** |

[a] WM-4 reductions not reported here. Biodiesel production volumes, carbon content, and production costs were estimated and then used in the TLU-2 analysis, where net GHG benefits and societal costs are determined for both policies (addressing supply and demand).

For the supply-side biofuels policy, WM-4, the microeconomic analysis focused on the costs and energy/GHG implications of producing biodiesel from WVO for consumption within the State. Costs of producing biodiesel per liter of fuel were supplied to the TLU sector analysts as input into the TLU-2 (Alternative Fuels) analysis, along with the carbon content of this fuel ($tCO_2e/TJ$), so that the full impacts of renewable fuel supply and demand could be determined. Therefore, the costs and net GHG impacts of WM-4 are captured within the results reported for TLU-2.

## Overlaps Discussion

No intra-sector overlaps were identified among the WM policies. Inter-sector overlaps or interactions among CAP policies, however, do exist. For the bioenergy supply-side policy (WM-4), the full GHG reductions and costs are provided in the associated demand-side policy, TLU-2. For AFOLU-4, Biodiesel Production, the annual biodiesel production volumes, carbon content and production costs were quantified and provided as input to the overall TLU-2 analysis.

As a result of the methods used to align bio-energy supply and demand, the results shown in Table 8-2 below show no change from the stand-alone results shown in Table 8-1 above. The other area where there can be inter-sector interactions is in situations where a WM policy has an estimated electricity system impact (e.g. new renewable energy or energy efficiency). These occur in policies WM-2 and -3, where electricity savings are achieved upon implementation. Section 3.5 provides a discussion of how these types of electricity system interactions were addressed for all sectors. In summary, the assessment of electricity system impacts did not indicate a need to adjust any of the WM microeconomic analysis results.

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

| Policy ID# | Policy Name | GHG Reductions: Annual Reductions 2020 $TgCO_2e$ | GHG Reductions: Annual Reductions 2030 $TgCO_2e$ | GHG Reductions: 2030 Cumulative $TgCO_2e$ | Base Year 2012$: NPV 2016-2030 $Million | Base Year 2012$: Cost Effectiveness $/$tCO_2e$ |
|---|---|---|---|---|---|---|
| WM-1[a] | Landfill Gas Management | 0.27 | 0.32 | 3.87 | $258 | $67 |
| WM-2[a] | Indirect Potable Water Re-Use | 0.03 | 0.04 | 0.43 | ($226) | ($532) |
| WM-3[a] | Water Reclamation | 0.04 | 0.07 | 0.76 | ($415) | ($545) |
| WM-4[a,b] | Biodiesel Production | *N/A; This is a renewable fuel supply policy; results are exported for integration with the demand-side policy, TLU-2* | | | | |
| | **Totals** | **0.34** | **0.43** | **5.1** | **($383)** | **($76)** |

[a] No intra-sector overlaps identified.
[b] WM-4 reductions not reported here. Biodiesel production volumes, carbon content, and production costs were estimated and then used in the TLU-2 analysis, where net GHG benefits are determined for both policies (addressing supply and demand).

# Waste Management (WM) Policy Descriptions

Four WM policies were analyzed for the BC CAP. 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 Gas Management

This policy seeks to capture $CH_4$ from landfills in Tijuana, Mexicali and Ensenada to generate electricity with connection into the public grid run by the Federal Electricity Commission. The capture of methane achieves multiple benefits: reduces direct emissions of methane; offsets the use of non-renewable resources, such as oil, coal, and natural gas used in the production of electricity; and provides revenues for landfill owner/operators. The carbon dioxide produced from landfill methane combustion is considered to be carbon neutral.

## WM-2. Indirect Potable Water Re-Use

This policy promotes the use and management of indirectly treated wastewater in Tijuana. Indirect water re-use is accomplished by partially treating wastewater and pumping this to a local reservoir for future re-use. This allows for multiple uses of the original water resource, which reduces the municipality´s need to source water from distant sources and reduce the associated energy/GHG implications and supply costs.

## WM-3. Water Reclamation

This policy promotes the use of treated wastewater for irrigation of urban green areas, thereby saving on total water consumption and costs. Reduced water consumption will result in net reductions in energy use to source water for irrigation purposes, along with the associated GHG emissions. Use of reclaimed water will help to preserve or enhance the cities´ green spaces and conserve the population´s drinking water supply.

In order to comply with this policy, a wastewater irrigation systems network must be put in place exclusively to distribute treated wastewater to urban green areas in Baja California. It will be crucial to monitor the quality of the water being distributed, through constant surveillance efforts to ensure compliance with the NOM-003-SEMARNAT-1996 (Official Mexican Standard-003, issued by SEMARNAT in 1966).

## WM-4. Biodiesel Production from Waste Vegetable Oil

This policy aims to take advantage of the WVO from the restaurant sector to produce biodiesel for a 2% blend (B2) for use in the Baja California´s transportation sector. The restaurant sector in Baja California generates about 10,000,000 liter of WVO per year. The implementation of this policy will help reduce the use of fossil diesel and the associated the emissions of fossil-based $CO_2$, $N_2O$ and $CH_4$ generated as a result of fossil fuel production and consumption. Full implantation of this policy could promote the gradual increase of higher biodiesel content mixtures (B10, B20 and B80, B100), as additional feedstocks and production methods are identified.

WM-4 is the first part of the entire analysis (supply-side) covering biodiesel production and consumption. It includes the coverage of policy needs to address increasing supply volumes. The analysis of WM-4 includes estimates of annual production volumes, the associated carbon content of the fuel, and biodiesel production costs. These results were then used as input to the demand-side policy, TLU- 2 (Alternative Fuels), where the full results of both supply and demand-based policies are provided.

# Chapter 9
# Macro-economic Impacts of Policy Recommendations

## Introduction

### The Regional Economic Models, Inc. (REMI) Model

The Regional Economic Models, Inc. (REMI) Policy Insight Plus (PI$^+$) Model was adapted to analyze the macro-economic impacts of the BC CAP. Several modeling approaches can be used to estimate the total regional economic impacts of climate change policy, including both direct (on-site) effects and various types of indirect (off-site) effects. These include: input-output (I-O), computable generated equilibrium (CGE), mathematical programming (MP), and macro-econometric (ME) models. Each has its own strengths and weaknesses.[26]

In this study, the REMI PI+ macro-econometric model was chosen for several reasons: 1) it is superior to the others in terms of its forecasting ability, which is important when we analyze the economic impacts of climate change policies over the course of the future 15 years; 2) it is comparable to CGE models in terms of analytical power, accuracy, and transparency; 3) members of the research team have used the model successfully in similar analyses in many U.S. states, including Florida, Pennsylvania, Michigan, Wisconsin, New York and California.[27] The research team has also facilitated capacity building in China with the use the REMI Model to analyze the macro-economic impacts of sub-national low-carbon development policies.
The REMI Model has evolved over the course of 30 years of refinement.[28] It is a packaged program but is built with a combination of national and region-specific data. In the U.S., government agencies in practically every state have used a REMI Model for a variety of purposes, including evaluating the impacts of the change in tax rates, the exit or entry of major

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[26] Rose, A. and Miernyk, W. 1989. "Input-Output Analysis: The First Fifty Years," *Economic Systems Research* 1(2): 229-71; Partridge, M.D. and D.S. Rickman. 2010. "CGE Modelling for Regional Economic Development Analysis," *Regional Studies* 44(10): 1311-28.

[27] Miller, S., Wei, D., and Rose, A. 2010. *The Macro-economic Impact of the Michigan Climate Action Council Climate Action Plan on the State's Economy*. Report to Michigan Department of Environmental Quality. http://www.climatestrategies.us/ewebeditpro/items/O25F22416.pdf.; Rose, A., Wei, D., and Dormady, N. 2011. "Regional Macro-economic Assessment of the Pennsylvania Climate Action Plan," *Regional Science Policy and Practice* 3(4): 357-79; Wei, D. and Rose, A. 2011. *The Macro-economic Impact of the New York Climate Action Plan: A Screening Analysis*. Report to New York State Energy Research and Development Authority; Rose, A. and Wei, D. 2012. "Macro-economic Impacts of the Florida Energy and Climate Change Action Plan," *Climate Policy* 12(1): 50-69; Wei, D. and Rose, A. 2014. "Macro-economic Impacts of the California Global Warming Solutions Act on the Southern California Economy," *Economics of Energy & Environmental Policy* 3(2): 101-118.

[28] Treyz, G. 1993. *Regional Economic Modeling: A Systematic Approach to Economic Forecasting and Policy Analysis*. Boston: Kluwer; REMI. 2014. REMI Model Online Documents. http://www.remi.com/; REMI. 2014. REMI Model Online Documents. http://www.remi.com/.

businesses in particular or economic programs in general, and, more recently, the impacts of energy and/or environmental policy actions. In recent years, REMI has developed its REMI Policy Insight PI+ Model for many countries, including China, Korea, Brazil, Mexico, Italy, Spain, and others.

A detailed discussion of the major features of the REMI Model is presented in Appendix H and a general summary of the model follows here.. A macro-econometric forecasting model covers the entire economy, typically in a "top-down" manner, based on macro-economic aggregate relationships such as consumption and investment. REMI differs somewhat in that it includes some key relationships, such as exports, in a bottom-up approach. At its core, the Baja California REMI Model uses a 32-industry input-output model developed based on the data found in the World Input-Output Database (WIOD).[29] Finely-grained sectoring detail is important in a context of analyzing the impacts of GHG mitigation actions, where various policy options were fine-tuned to a given sector or where they directly affect several sectors somewhat differently. A major issue associated with the WIOD I-O table is that it has an aggregated utility sector, which combines electricity power generation and supply, natural gas supply, and water treatment and supply together. In the next section, we explain in detail how we disaggregate the utility sector into the three sub-sectors using the Custom Industry (CI) Function in the REMI Model.

The Baja California REMI Model possesses many other desirable features. The macro-economic character of the model is able to analyze the interactions between sectors (ordinary multiplier effects) but with some refinement for price changes not found in I-O models. In other words, the REMI model incorporates the responses of the producers and consumers to price signals in the simulation. In contrast, in a basic input-output model, the change in prices is not readily taken into account. More specifically, a basic input-output model separates the determinants of quantity and prices, i.e., price changes will not generate any substitution effects in an I-O analysis, while the REMI model is capable of capturing this and other price-quantity interactions. The REMI Model also brings into play features of labor and capital markets, as well as trade of Baja California with other states in Mexico or with other countries, including changes in competitiveness.

The econometric feature of the model refers to two considerations. The first is that the model is based on inferential statistical estimation of key parameters based on pooled time series data of the study region (some other macro-economic impact models use "calibration," based on a single year's data). This gives the REMI PI+ model an additional capability of being better able to extrapolate the future course of the economy, a capability that many other models lack. The major limitation of the REMI PI+ model versus the others is that it is pre-packaged and not readily adjustable to any unique features of the case in point. The other models, because they are based on less data and a less formal estimation procedure, can more readily accommodate data changes in technology that might be inferred, for example from engineering data. However, our assessment of the REMI PI+ Model is that these adjustments were not needed for the purpose at hand.

[29] World Input-Output Database (WIOD). 2014. *Introduction to World Input-Output Database*. http://www.wiod.org/new_site/home.htm.

## Discussion of the Input-Output Matrices Used in BC REMI Model

The Mexico Input-Output matrices used to develop the BC REMI Model are obtained from the World Input-Output Database (WIOD). The WIOD project was originally funded by the European Commission as part of the 7th Framework Programme. The development of the World and national input-output tables was under Theme 8 of the Programme: Socio-Economic Science and Humanities. WIOD provides national Input-Output tables for the time period from 1995 to 2011 for 27 EU countries and 13 other major countries around the world.[30]

The construction of the WIOD I-O tables is based on official national statistics and data obtained from National Accounts of each country. First, the national Supply and Use Tables (SUTs) are used as the core data of developing the I-O tables. Second, the National Accounts are used as the benchmark. Finally, time series data on industrial output and value added, imports and exports, as well as final demand by consumption category were obtained from the National Accounting Statistics to generate the time series of SUTs.[31]

## Disaggregation of the Utility Sector in the BC REMI Model

A major refinement that was made to the BC REMI Model was to disaggregate the utility sector into three sub-sectors. In the WIOD input-output table, electric power generation, natural gas distribution, and water treatment and supply are aggregated into one single utility sector. It is very essential to have the three sectors separated since many GHG mitigation policy options incur direct impacts to one specific utility sub-sector or to more utility sub-sectors in different ways. For example, the RPS policy results in impacts on the capital, O&M, and fuel costs of the power generation sector, and can also impact the natural gas supply sector if natural gas is used as the fuel of the displaced generation technology.

The CI Function allows the user to begin from the base of the utilities industry to completely customize the relevant column I-O vector, productivity, and compensation rate to match the custom sector. In this case, the relevant information of each disaggregated utility sector from the 170-sector detailed I-O table constructed by Mexico National Institute of Statistics and Geography (INEGI) was obtained. After the establishment of the CI sectors, the user can introduce shocks on these CI sectors to the model. This helps addresses the majority of the concern with having an aggregate sector when the user needs to consider the operation of one or more of its subsectors. The enhanced model is able to trace the impact of the CI on the remainder of the economy being modeled, including feedback effects. With the incorporation of the detailed technical coefficient vector of the custom industry, shocks to this new industry create the first round of effects for output, employment, compensation, and intermediate demand. Then successive rounds of backward (demand-side) impacts are calculated based on the normal I-O approach.

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[30] WIOD, 2014. *Introduction to World Input-Output Database*. http://www.wiod.org/new_site/home.htm.

[31] Dietzenbacher, E., B. Los, R. Stehrer, M. Timmer, and G. de Vries. 2013. "The Construction of World Input-Output Tables in the WIOD Project," *Economic Systems Research* 25(1): 71-98.

One limitation of the application of the custom industry function is that only the “Industry Sales” policy variable is available for the new Custom Industry. Other regular REMI policy variables for an industry, such as Capital Cost, Production Cost, etc., are not available for the custom industry, due to the fact that the industry is not described in the baseline, so it is not fully developed with cost data, trade flows, etc. In Appendix H, the detailed approaches used to compensate for this limitation of the CI sectors is described.

## Input Data Preparation and REMI Simulation Methodology

### Summary of Microeconomic Analysis Results

The main data source for the macro-economic modeling is the microeconomic impact quantification results of individual GHG mitigation and sequestration policy options conducted by sectoral analysts from the Center for Climate Strategies (CCS) and researchers from El Colegio de la Frontera Norte. Table 9-1 summarizes the estimated impacts (GHG mitigation potentials and costs/savings) of the GHG mitigation and sequestration options recommended and quantitatively analyzed in BC CAP. In total, the 25 policy options can generate nearly $28 billion (in 2012 Mexican pesos) cost savings in net present value (NPV) terms and reduce 49 million tons of carbon dioxide-equivalent ($CO_2$e) GHG emissions during the 2014-2030 period. The weighted average cost-effectiveness of the options (using GHG reduction potentials as weights) is about minus $575 per metric ton of carbon dioxide equivalent emissions removed. The minus sign means implementing these options on average would yield overall cost savings.

### REMI Model Input Development

The micro level quantification analysis of the costs/savings of the GHG mitigation policy options was limited to the direct (microeconomic or partial equilibrium) effects of implementing the policy options. For example, the direct costs of an energy efficiency option include the energy customers’ expenditure on energy efficiency equipment and devices. The direct benefits of this policy option include the savings on energy bills of the customers.

Before performing the analysis of the macro-economic (or general equilibrium) impacts of the options in the REMI Model, key micro impact quantification results for each policy option are translated to inputs to the REMI Model. This step involves the selection of appropriate policy levers in the REMI PI+ Model to simulate the policy’s changes. The input data include sectoral costs and savings over the full time horizon (2014-2030) of the analysis. In Appendix Tables H-1 to H-4, we choose four example options, RCII-3 Energy Efficiency Expansion in Existing Buildings, ES-3 Distributed Energy Supply for Building, AFOLU-1 Manure Management: Non-Dairy Livestock, and TLU-3 On-road Fleet Efficiency, to illustrate how we translate, or map, the microeconomic results of options from different sectors into REMI economic variable inputs.

**Table 9-1. Microeconomic Analysis of the GHG Mitigation and Sequestration Options**

| Policy Option Number | Policy Option Description | 2030 Cumulative TgCO₂e | NPV 2015-2030 Million $ | Cost Effective-ness $/tCO₂e |
|---|---|---|---|---|
| RCII-1 | Save 23% Electricity Consumption on New Residential Buildings through housing shell Improvements, year target 2020 | 0.3 | -$309.0 | -$1,172.0 |
| RCII-2 | Energy Efficiency Expansion in New Housing Design | 0.4 | -$290.0 | -$675.0 |
| RCII-3 | Energy Efficiency Expansion in LPG and Electricity Consumption for Existing Buildings of Residential and Commercial Sector | 8.2 | -$10,952.0 | -$1,342.0 |
| RCII-4 | Finance Incentives for Machinery Energy Efficiency | 6.1 | -$11,771.0 | -$1,915.0 |
| RCII-5 | Solar Water Heaters on Housing | 6.1 | -$8,800.0 | -$1,435.0 |
| RCII-6 | Flow Water Heaters for Residential Sector | 2.0 | -$3,095.0 | -$1,559.0 |
| ES-1 | Micro-Hydro Renewable Energy Generation | 0.8 | $231.0 | $294.0 |
| ES-2 | Energy Supply Diversification | 16.0 | $6,814.0 | $425.0 |
| ES-3 | Distributed Energy Supply for Building | 0.2 | $6.9 | $31.0 |
| ES-4 | Photovoltaic Panel Electricity Generation | 0.3 | $150.0 | $505.0 |
| WM-1 | Landfill Gas Management | 3.9 | $258.0 | $67.0 |
| WM-2 | Indirect Potable Water Re-Use | 0.4 | -$226.0 | -$532.0 |
| WM-3 | Water Reclamation | 0.8 | -$415.0 | -$545.0 |
| AFOLU-1 | Manure Management: Non-Dairy Livestock | 0.0 | $3.4 | $714.0 |
| AFOLU-2 | Manure Management: Dairies | 0.3 | $31.0 | $117.0 |
| AFOLU-5 | Livestock Grazing Management | 1.3 | $1,117.0 | $855.0 |
| AFOLU-6 | Urban Forestry | 0.0 | $17.0 | $5,514.0 |
| TLU-1 | Black Carbon Control Measures | 0.3 | $60.0 | $196.0 |
| TLU-2 | Alternative Fuels | 0.8 | -$188.0 | -$242.0 |
| TLU-3 | On-road Fleet Efficiency | 0.1 | -$81.0 | -$1,150.0 |
| TLU-5 | Smart Growth Planning | 0.3 | -$480.0 | -$1,716.0 |
| TLU-6 | Energy Efficient Government Fleet | 0.0 | $2.3 | $1,609.0 |
| **Total** | | **49.0** | **-$27,916.0** | **-$575.0** |

* Negative values represent a net cost savings. $/tCO$_2$e stands for dollars per metric ton of carbon dioxide equivalent.

## Major Modeling Assumptions

The major data sources for the macro-economic impact analysis are the microeconomic quantification results on the direct costs and savings of the GHG mitigation/sequestration options. However, we supplement these with additional data and assumptions in the REMI analysis in cases where these costs/savings and some conditions relating to the implementation of the options are not specified in the micro analysis or are not known with certainty. Below is the list of major assumptions we adopted in the analysis. Some of these assumptions are general ones we have used in other studies of this type.[32] Table 9-2 presents those assumptions that are tailored to individual GHG mitigation/sequestration options of Baja California.

[32] Miller et al., 2010; Rose et al., 2011; Wei and Rose, 2011; Rose and Wei, 2012; Wei and Rose, 2014.

1. It is assumed that zero of the in-region private capital investment will displace ordinary private investment in plant and equipment. In other words, 100% of the GHG mitigation investment is additive to the state economy.
2. It is assumed that capital investment expenditures for power generation are split 60:40 between sectors that produce generating equipment and the construction sector for large power plants (such as NG-fired power plants), and 80:20 for smaller installations (mainly renewables).
3. The percentages of renewable electricity generation equipment and energy-efficient appliances and equipment that are purchased from producers within Baja California are assumed to be same as the average in-region production rate of such equipment, i.e., the REMI default Regional Purchase Coefficients (RPCs) for the relevant equipment manufacturing sectors for Baja California are used in the analysis.
4. Based on the baseline forecast conducted by the micro analysis team, on average, about 8.5% of the electricity consumed in Baja California will be imported during the planning period. This indicates that the RPC of the electricity generation sector of Baja is about 91.5%. However, the power company in Baja is a federal agency. Therefore, part of the direct impacts from the reduction of output and labor income in the electricity generation sector (due to electricity savings from the GHG mitigation options) will leak to outside of the state (shouldered by México City for example). To reflect this, an RPC of 80% was used for the electricity generation sector in Baja.
5. For some of the RCII options, both the option costs and energy savings are computed for the residential, commercial, industrial, and/or institutional sectors in the microanalysis. For the commercial and industrial sectors, the microanalyses only provide the aggregated costs and savings for the entire commercial sector and the entire industrial sectors. Since in the REMI model, capital cost and production cost variables can only be simulated for individual commercial sectors or industrial sectors, we distributed these costs and savings among the 32 REMI sectors using baseline gross output as weights.
6. Other assumptions for individual policy options, especially for funding sources, are presented in Table 9-2. These assumptions are based on the expert judgments of the Panel of Experts.

## Simulation Set-Up in REMI

Figure 9-1 shows how a policy simulation process is undertaken in the REMI Model. First, a policy question is formulated. Second, external policy variables that embody the effects of the policy are identified (e.g., for the policy of energy efficiency expansion in existing buildings, the relevant policy variables would include increased spending on building retrofits and energy-efficient appliances and the resulting savings from reduced consumption of electricity and other fuels). Third, baseline values for all the policy variables are used to generate the baseline, or "control", forecast. In REMI, the baseline forecast uses the most recent data available (i.e., 2009 data for Baja California) and the external policy variables are set equal to their baseline values.

Fourth, an alternative forecast is generated by changing the values of the external policy variables.

### Table 9-2. Additional Assumptions Used in REMI Analysis for Individual Policy Options/Policy Bundles

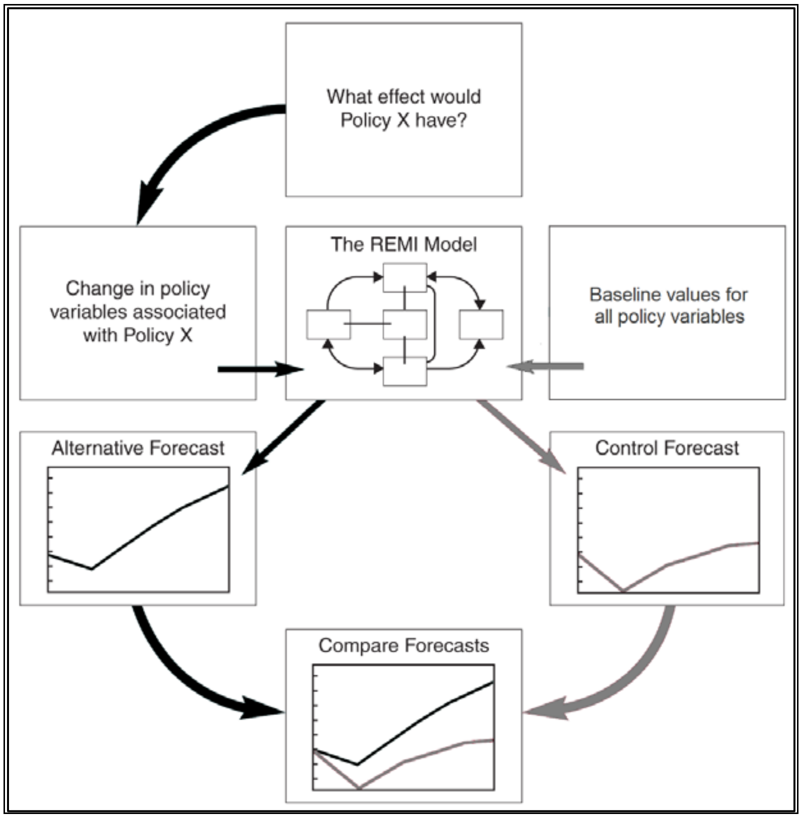
| Policy Option Number | Policy Option Description | Assumptions |
|---|---|---|
| RCII-1 | Save 23% Electricity Consumption on New Residential Buildings through Housing Shell Improvements, year target 2020 | • Split of capital investment costs: 70% household savings, 20% bank financing by residential sector, 10% state government support |
| RCII-2 | Energy Efficiency Expansion in New Housing Design | • Split of capital investment costs: 85% residential sector and 15% Construction sector<br>• Zero percent of the capital investment is through debt financing |
| RCII-3 | Energy Efficiency Expansion in LPG and Electricity Consumption for Existing Buildings of Residential and Commercial Sector | • The capital expenditure is split 30% to building retrofits and 70% to energy-efficient appliances<br>• 100% of the capital and administrative costs are borne by residential and commercial sectors<br>• 20% of the retrofit investment is financed and zero of the appliance investment is financed |
| RCII-4 | Finance Incentives for Machinery Energy Efficiency | • 100% of the capital and administrative costs are borne by residential and commercial sectors<br>• 50% of the investment on energy-efficient machinery is financed |
| RCII-5 | Solar Water Heaters on Housing | • Split of capital investment costs: 60% residential sector and 40% state government support<br>• All program administrative costs will pass through onto the residential sector. |
| RCII-6 | Flow Water Heaters for Residential Sector | • 100% of the capital and administrative costs are borne by residential sector<br>• Zero percent of the investment on flow water heaters is financed |
| ES-1 | Micro-Hydro Renewable Energy Generation | • 60% of the capital investment is covered through debt financing and the other 40% is covered through equity |
| ES-2/AFOLU-3 | Energy Supply Diversification/Utilization of Wheat Straw | • All costs (O&M, fuel, transport costs) are borne by the Ag sector; no government cost share<br>• 60% of the capital investment on renewable generation is covered through debt financing and the other 40% is covered through equity |
| ES-3 | Distributed Energy Supply for Building | • Assume zero debt financing |
| ES-4 | Photovoltaic Panel Electricity Generation | • 100 percent of the investment is financed |
| WM-1 | Landfill Gas Management | • All costs/savings are borne/accrued by municipal governments<br>• 50% of the capital investment is covered through debt financing |
| WM-2 | Indirect Potable Water Re-Use | • 10% of the capital investment is covered by state government funding and 90% is financed by the water utility company through an entity such as NADBank |
| WM-3 | Water Reclamation | • Capital expenditures are split 70% to tubing and 30% to pump<br>• 65% of the capital investment is covered by state government funding and 35% by international fund |
| AFOLU-1 | Manure Management: Non-Dairy Livestock | • All costs are borne by the livestock production sector; no government cost share<br>• 100% capital investment is covered through debt financing |

| Policy Option Number | Policy Option Description | Assumptions |
|---|---|---|
| AFOLU-2 | Manure Management: Dairies | • Split of capital investment costs: 50% federal government support, 25% state government support, 25% Ag sector private investment<br>• 100% of the Ag sector investment is through debt financing |
| AFOLU-5 | Livestock Grazing Management | • Split of capital investment costs: 10% state government support and 90% by Ag sector private investment<br>• 100% of the Ag sector investment is through debt financing |
| AFOLU-6 | Urban Forestry | • Split of capital investment costs: 20% state government support and 80% by residential sector private investment<br>• 10% of the residential sector investment is through debt financing |
| TLU-1 | Black Carbon Control Measures | • All capital investment cost is borne by truck owners |
| TLU-2/AFOLU-4/WM-4 | Alternative Fuels/ Bioethanol Production from Sweet Sorghum/ Biodiesel Production | • For the bioethanol production, federal government funding covers $20 M of the capital cost of the bio-refinery; the rest of the cost is borne by the Chemicals sector<br>• 100% of the capital investment of the Chemicals sector is covered through debt financing<br>• For biodiesel production, all costs are borne by the State government<br>• Gasoline savings are split 50/50 between private vehicles and commercial vehicles<br>• Attribute all of the diesel activity to commercial vehicles<br>• Capital cost of blending facility is borne by the Chemicals sector; 50% is covered through debt financing |
| TLU-3 | On-road Fleet Efficiency | • All funding is assumed to come from federal government<br>• For the cash the government paid to the consumers for their retired old cars, it is assumed that 48% of the cash will be spent on transport purposes, and the rest 52% will be distributed among all consumption goods and services |
| TLU-5 | Smart Growth Planning | • Assume zero debt financing |
| TLU-6 | Energy Efficient Government Fleet | • Assume zero debt financing |

Usually, the changing values of these variables represent the direct effects of the simulated policy scenario. For example, in our analysis of the Energy Efficiency option, the investments to building retrofit and energy-efficiency appliances and equipment, and the energy savings were based on the technical assessment associated with implementing this GHG mitigation option. Fifth, the effects of the policy scenario are measured by comparing the baseline forecast and the alternative forecast. Sensitivity analysis can be undertaken by running a series of alternative policy forecasts with different assumptions on the values of the policy variables.

In this study, we first run the REMI model for each of the 22 policy options/bundles *individually* in a comparative static manner, i.e., one at a time, holding everything else constant. Next, we run a *simultaneous* simulation in which we assume that all the policy options are implemented together. Then the simple summation of the effects of individual options is compared to the simultaneous simulation results to determine whether the “whole” is different from the “sum” of the parts. Note that before performing the simulations in REMI, intra-sector and inter-sector overlaps between policy options are eliminated by the micro analysts as much as possible to avoid double counting. Therefore, differences between the summation total and the simultaneous total can be explained by the non-linearities and/or synergies of the REMI Model. The latter would stem from complex functional relationships in the REMI Model.

**Figure 9-1. Process of Policy Simulation in REMI**




Source: REMI, 2014.

## REMI Modeling Results

### Basic Aggregate Results

**A. Macro-economic Impacts of Individual Policy Options/Policy Bundles**

Tables 9-3 and 9-4 present the summary results of the Gross State Product (GSP) impacts and employment impacts of the 22 policy options or policy bundles for key years and for Net Present Value (NPV) and average job impact per year, respectively. In Table 9-3, the numbers represent the difference in GSP compared with the baseline level from the implementation of the recommended policies. The GSP impacts are presented for both key years (in terms of impact in those years) and the net present value (NPV) over the entire planning period. In Table 9-4, the employment impacts are also presented for the key years and for an average job impacts over the planning period in the last column. In terms of employment impacts of average jobs per year, 10 out of the 22 policies/policy bundles yield positive impacts. In terms of the NPV of GSP impacts, 9 out of the 25 policies/policy bundles yield positive impacts.

Appendix Tables H5 to H26 present the detailed macro-economic impacts of each of the 22 quantified policies/policy options. RCII-4 Finance Incentives for Machinery Energy Efficiency results in the highest positive impacts on the economy—an NPV of $10.4 billion gains in GSP and an average annual increase of about 2,394 jobs. In 2030, the GSP increase resulted from RCII-4 is estimated to be $2.6 billion, or an increase of 0.23% from the baseline level. The employment is estimated to increase by 5.4 thousand jobs, or an increase of 0.31% from the baseline level. The policy bundle ES-2/AFOLU-3 Energy Supply Diversification and Utilization of Wheat Straw yields the highest negative impacts to the economy—an NPV of $3.0 billion decrease in GSP and a loss of 773 jobs per year. In 2030, the decreases in GSP and employment stemming from the implementation of ES-2 are estimated to be $2.4 billion and 3.2 thousand jobs, respectively, which represent reductions of 0.22% and 0.18% from the respective baseline levels. The simulation results indicate that options in the RCII sector are expected to result in the highest positive impacts to the Baja California economy. Options in the ES sector are expected to result in the highest negative employment and GSP impacts to the Baja California economy. The WM options aggregately are estimated to generate slight positive economic impacts, while the AFOLU and Transportation policies/policy options are estimated to generate slight negative economic impacts, respectively. The major reason for the negative impacts of the energy supply options is the high capital cost of renewable alternatives compared with the displaced technologies. The major option that leads to the overall negative impact from the Transportation sector is the policy bundle TLU-2/AFOLU-4/WM-4, largely because of the high capital and operating costs associated with the bioethanol production from sweet sorghum.

Our preliminary analysis results on the macro-economic impacts of the GHG mitigation and sequestration policy options in the BC CAP are in general similar to those found in our previous studies.[33] Energy efficiency and industrial process improvements generate more positive impacts to the economy because the savings from reduced energy expenditures help lower the production cost of businesses and increase the purchasing power of households. In our previous studies, we found that renewable and alternative energy supply is likely to generate positive economic impacts in some of the U.S. states, such Florida and even in Michigan,[34] but this was under conditions of relatively high gas prices prevailing in 2009–10 and projections into the future on that basis. In our recent study for Southern California, we found negative impacts from the RPS. Another important factor explaining the less attractive macro-economic performance of the renewable and alternative energy supply options is that projections of capital and operating costs of renewable electricity generation are not expected to decline as much as in previous forecasts.[35]

[33] Miller et al., 2010; Rose et al., 2011; Wei and Rose, 2011; Rose and Wei, 2012; Wei and Rose, 2014
[34] Rose and Wei, 2012; Miller et al., 2010
[35] Wei and Rose, 2014

**Table 9-3. Gross State Product Impacts (Difference from Baseline Levels) (Millions of 2012 Pesos)**

| Scenario/Policy | 2015 | 2020 | 2025 | 2030 | NPV |
|---|---|---|---|---|---|
| ES-1 | $0 | -$11 | -$219 | -$201 | -$751 |
| ES-2/AFOLU-3 Bundle | $0 | $908 | -$2,669 | -$2,446 | -$3,034 |
| ES-3 | $0 | $31 | -$54 | -$53 | -$25 |
| ES-4 | $0 | $47 | -$62 | -$59 | $38 |
| **Subtotal - ES** | $0 | $975 | -$3,004 | -$2,760 | -$3,772 |
| RCII-1 | $3 | -$10 | -$21 | -$25 | -$122 |
| RCII-2 | $2 | -$4 | -$12 | -$15 | -$59 |
| RCII-3 | $142 | $67 | -$141 | -$242 | -$92 |
| RCII-4 | $0 | $627 | $1,605 | $2,591 | $10,401 |
| RCII-5 | $208 | $346 | $131 | $104 | $2,238 |
| RCII-6 | $120 | $256 | $147 | $119 | $1,797 |
| **Subtotal - RCI** | $475 | $1,282 | $1,710 | $2,534 | $14,163 |
| AFOLU-1 | $0 | $0 | $0 | -$1 | -$5 |
| AFOLU-2 | $0 | $22 | -$10 | -$7 | $6 |
| AFOLU-5 | $0 | -$83 | -$15 | $58 | -$298 |
| AFOLU-6 | $0 | $0 | -$1 | -$1 | -$6 |
| **Subtotal - AFOLU** | $0 | -$61 | -$26 | $48 | -$303 |
| WM-1 | $0 | -$63 | -$102 | -$71 | -$456 |
| WM-2 | $0 | -$2 | $10 | $19 | $40 |
| WM-3 | $0 | $43 | $53 | $96 | $496 |
| **Subtotal - WM** | $0 | -$22 | -$39 | $44 | $79 |
| TLU-1 | $0 | -$1 | $0 | $0 | -$4 |
| TLU-2/AFOLU-4/WM-4 Bundle | $0 | -$76 | -$154 | -$204 | -$662 |
| TLU-3 | $0 | $14 | $17 | $19 | $134 |
| TLU-5 | $11 | $28 | $44 | $58 | $330 |
| TLU-6 | -$1 | $0 | $0 | $0 | $0 |
| **Subtotal - TLU** | $10 | -$35 | -$92 | -$127 | -$202 |
| | | | | | |
| **Summation Total** | **$486** | **$2,140** | **-$1,451** | **-$261** | **$9,967** |
| | | | | | |
| **Simultaneous Total** | **$486** | **$2,141** | **-$1,475** | **-$311** | **$9,853** |

**Table 9-4. Employment Impacts (Difference from Baseline Levels) (number of jobs)**

| Scenario/Policy | 2015 | 2020 | 2025 | 2030 | Jobs Per Year |
|---|---|---|---|---|---|
| ES-1 | 0 | -31 | -338 | -251 | -134 |
| ES-2/AFOLU-3 Bundle | 0 | 1,683 | -4,451 | -3,228 | -773 |
| ES-3 | 0 | 56 | -67 | -55 | -2 |
| ES-4 | 0 | 79 | -80 | -64 | 3 |
| **Subtotal – ES** | 0 | 1,787 | -4,936 | -3,598 | -905 |
| RCII-1 | 14 | 1 | -20 | -19 | -7 |
| RCII-2 | 6 | 5 | -5 | -7 | 0 |
| RCII-3 | 354 | 379 | 20 | -54 | 165 |
| RCII-4 | 0 | 1,397 | 3,474 | 5,423 | 2,394 |
| RCII-5 | 302 | 439 | 110 | 62 | 216 |
| RCII-6 | 187 | 379 | 197 | 138 | 225 |
| **Subtotal – RCI** | 863 | 2,600 | 3,776 | 5,543 | 2,994 |
| AFOLU-1 | 0 | -1 | -1 | -1 | -1 |
| AFOLU-2 | 0 | 33 | -2 | 6 | 6 |
| AFOLU-5 | 0 | -464 | -290 | -46 | -247 |
| AFOLU-6 | 0 | 0 | -1 | -2 | -1 |
| **Subtotal - AFOLU** | 0 | -432 | -294 | -43 | -242 |
| WM-1 | 0 | -116 | -176 | -94 | -84 |
| WM-2 | 0 | 0 | 14 | 24 | 8 |
| WM-3 | 0 | 41 | 44 | 82 | 45 |
| **Subtotal – WM** | 0 | -75 | -118 | 12 | -31 |
| TLU-1 | 0 | -3 | -3 | 1 | -1 |
| TLU-2/AFOLU-4/WM-4 Bundle | 0 | -157 | -333 | -412 | -166 |
| TLU-3 | 0 | 22 | 25 | 25 | 20 |
| TLU-5 | 32 | 55 | 71 | 83 | 58 |
| TLU-6 | -1 | 0 | 1 | 0 | 0 |
| **Subtotal – TLU** | 31 | -83 | -240 | -303 | -90 |
| **Summation Total** | **894** | **3,797** | **-1,812** | **1,611** | **1,726** |
| **Simultaneous Total** | **894** | **3,794** | **-1,881** | **1,470** | **1,680** |

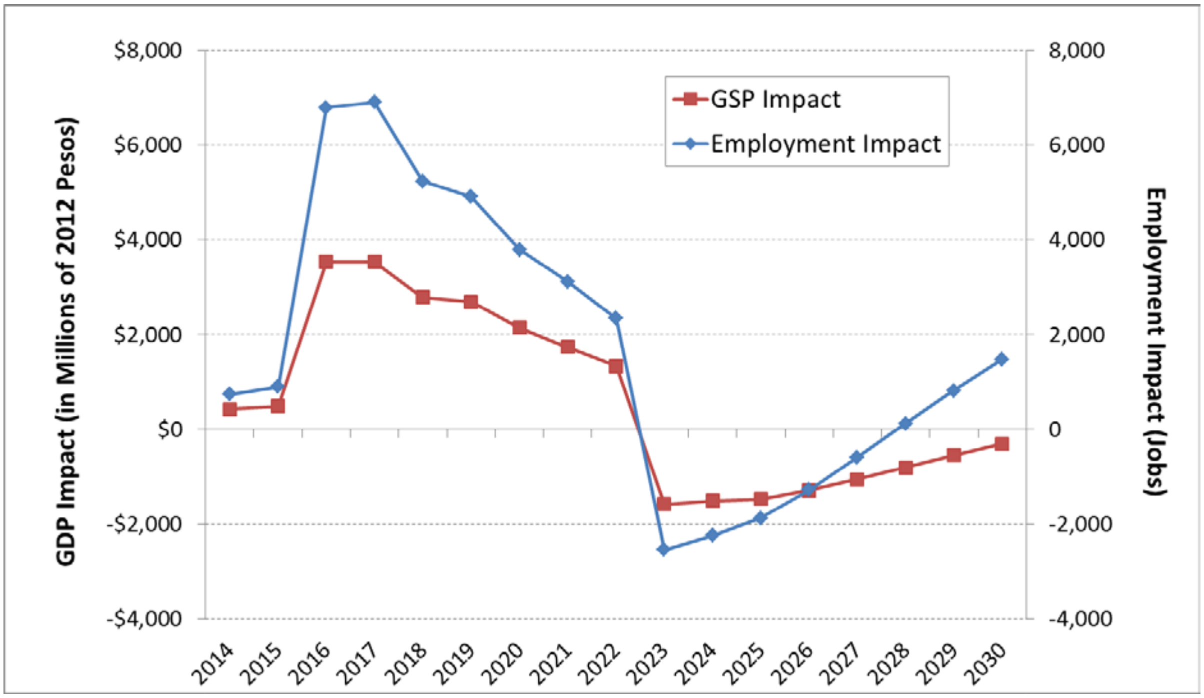
## B. Integrated Analysis of All Policy Options/Policy Bundles

The last row in Tables 9-3 and 9-4 present the integrated macro-economic impacts of the 22 policy options/policy bundles. Table 9-5 presents the more detailed results of this simultaneous simulation. Figure 9-2 presents the yearly GSP and employment impacts. This simulation is based on an integrated analysis of all the 22 policy options/policy bundles modeled in one simultaneous run in the REMI Model. The simultaneous run provides the macro impacts for the case that all of the policy options are implemented together. Any potential intra- or inter-sectoral double-counting of the costs and savings of the policy options have been eliminated at the micro level analysis. The results highlight the following impacts of the GHG mitigation options on the Baja California economy:

**Table 9-5. Integrated Macro-economic Impacts of All Policy Options/Policy Bundles**

| **Differences from Baseline Level** | | | | | | |
|---|---|---|---|---|---|---|
| **Variable** | **Units** | **2015** | **2020** | **2025** | **2030** | **Jobs/ Yr/NPV** |
| Total Employment | Jobs | 894 | 3,794 | -1,881 | 1,470 | 1,680 |
| Gross Domestic Product | Millions of Fixed (2012) Pesos | 486 | 2,141 | -1,475 | -311 | 9,853 |
| Output | Millions of Fixed (2012) Pesos | 930 | 4,262 | -2,613 | 46 | 21,004 |
| Disposable Personal Income | Millions of Fixed (2012) Pesos | 274 | 1,701 | 94 | 1,040 | 11,367 |
| PCE-Price Index | 2009=100 (Nation) | -8 | -73 | -209 | -266 | N/A |
| Population | Number of People | 30 | 514 | 351 | -81 | N/A |
| **Baseline Plus Addition of the Policy** | | | | | | |
| **Variable** | **Units** | **2015** | **2020** | **2025** | **2030** | |
| Total Employment | Jobs | 1,382,763 | 1,506,728 | 1,620,484 | 1,765,949 | |
| Gross Domestic Product | Millions of Fixed (2012) Pesos | 733,967 | 869,858 | 1,032,077 | 1,233,786 | |
| Output | Millions of Fixed (2012) Pesos | 1,493,397 | 1,791,123 | 2,152,880 | 2,605,516 | |
| Disposable Personal Income | Millions of Fixed (2012) Pesos | 414,410 | 498,166 | 602,587 | 736,114 | |
| PCE-Price Index | 2009=100 (Nation) | 125 | 144 | 162 | 183 | |
| Population | Number of People | 3,550,479 | 3,870,538 | 4,189,327 | 4,494,710 | |
| **Percent Change from Baseline Level** | | | | | | |
| **Variable** | **Units** | **2015** | **2020** | **2025** | **2030** | |
| Total Employment | Jobs | 0.0647% | 0.2525% | -0.1159% | 0.0833% | |
| Gross Domestic Product | Millions of Fixed (2012) Pesos | 0.0663% | 0.2467% | -0.1428% | -0.0252% | |
| Output | Millions of Fixed (2012) Pesos | 0.0623% | 0.2385% | -0.1212% | 0.0017% | |
| Disposable Personal Income | Millions of Fixed (2012) Pesos | 0.0661% | 0.3427% | 0.0156% | 0.1416% | |
| PCE-Price Index | 2009=100 (Nation) | -0.0056% | -0.0459% | -0.1163% | -0.1305% | |
| Population | Number of People | 0.0009% | 0.0133% | 0.0084% | -0.0018% | |

**Figure 9-2. Integrated Yearly GSP and Employment Impacts of the 22 Policy Options/Policy Bundles**

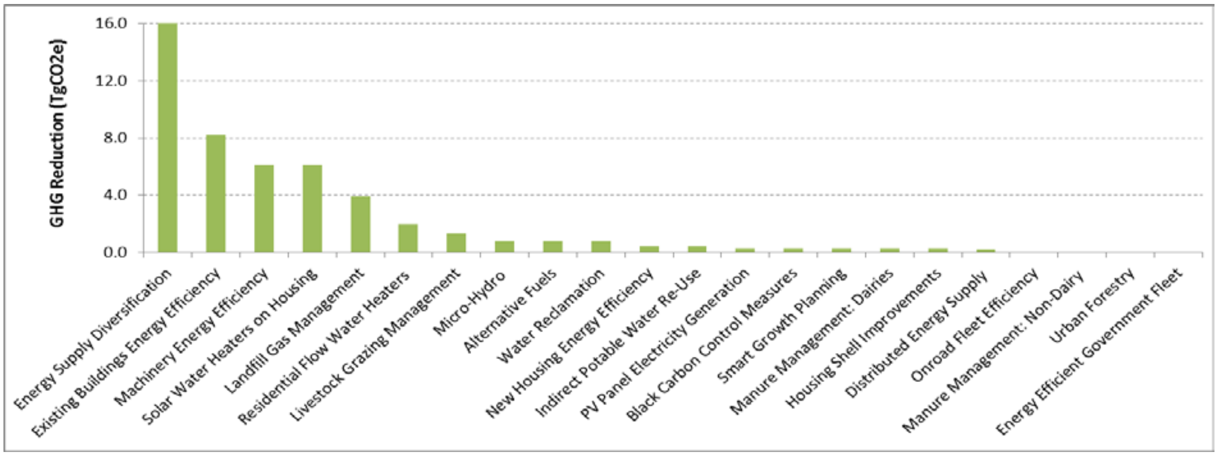



- The investment in GHG mitigation policies are estimated to generate significant positive impacts to the Baja California state economy during the upfront investment period of the various projects (primarily between 2015 and 2022, though different options have different starting years and initial investment periods);
- Both the GSP and employment impacts become negative starting from 2023 when the initial investment of the various options is completed and the production of capital equipment has peaked, and the increased annual capital cost (due to the payback of the initial investment) starts to dominate the overall impact;
- The savings resulting from the implementation of energy efficiency related options increase overtime, and, by 2028, the net employment impact is projected to become positive again, while the net GSP impact approaches zero by the target year 2030 (in general employment impacts are more positive than GSP impacts in percentage terms because of the relative labor intensity of the mitigation options);
- The employment gain is projected to be 1,680 jobs per year over the entire planning period;
- The net GSP gain is projected to be about $9.85 billion (2012 pesos) in NPV by 2030. Although the yearly GSP impacts are projected to be negative between 2023 and 2030, the substantial GSP gains in the earlier years more than offset the negative impacts in later years, and thus lead to the overall positive GSP impacts in NPV over the entire planning period;
- The net disposable personal income gain is projected to be about $11.37 billion (2012 pesos) in NPV over the planning period.

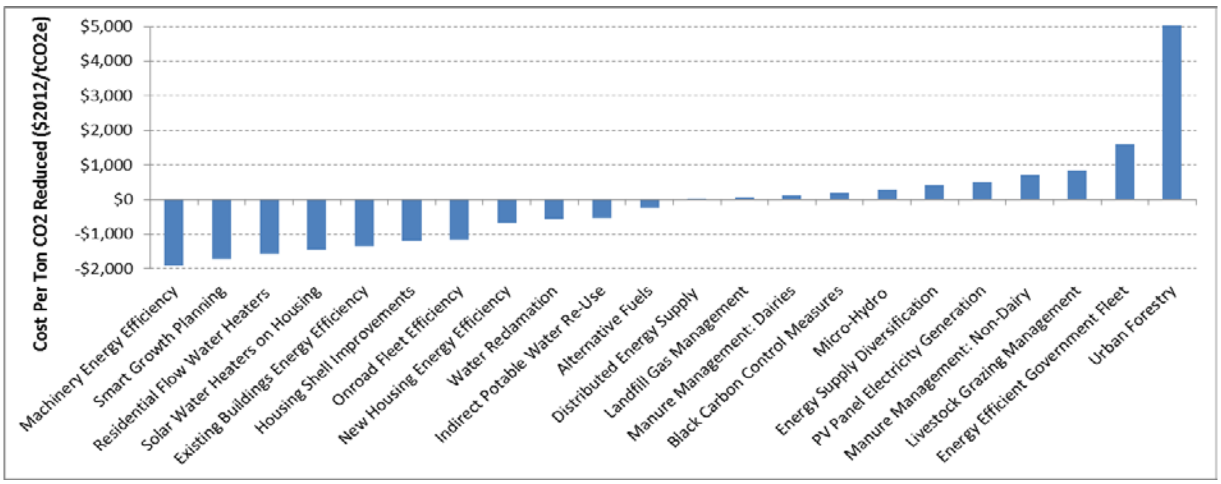
A comparison between the summation of simulations of individual policy options and the simultaneous simulation shows that the former yields higher positive employment and GSP impacts to the economy. However, the differences are only 3% and 1%, respectively. The overlaps between the options have been accounted for in the microeconomic analysis and have been eliminated before performing the macro-economic analysis. The difference between the simultaneous simulation and the ordinary sum can be explained by the non-linearity in the REMI model and synergies in economic actions it captures. Given that the impacts are not calculated through fixed multipliers in the REMI Model and the simulation results are magnitude-dependent, it is not surprising that when we model all the mitigation options together, we obtain different results than when we compute the sum of the results of each option modeled separately.

Figure 9-3 presents a comparison of the recommended policies in terms of their cumulative GHG reduction potentials (from highest to lowest), cost-effectiveness (from cheapest to most costly) and GSP impacts (from most positive to most negative). A comparison of these results indicates that in general the cost-effectiveness of a policy is closely correlated with the GSP impact. In other words, the cost-effective (cost-saving) policies tend to have the most influence on the positive GSP impact. ES-4 Machinery Energy Efficiency is estimated to be the most cost-effective policy option, and results in the highest GSP gains. Moreover, this policy option also has large GHG reduction potential (ranking 3$^{rd}$). Other options that result in high GHG reduction, low per ton cost of GHG reduction, and high GSP impact include Solar Water Heaters on Housing and Residential Flow Water Heaters. Energy Supply Diversification is projected to result in the highest GHG reduction. However, this policy is estimated to lead to the highest negative GSP impact, mainly due to the high capital costs of the renewable electricity generation (see further discussions of this policy option in the Sensitivity Tests Section below).

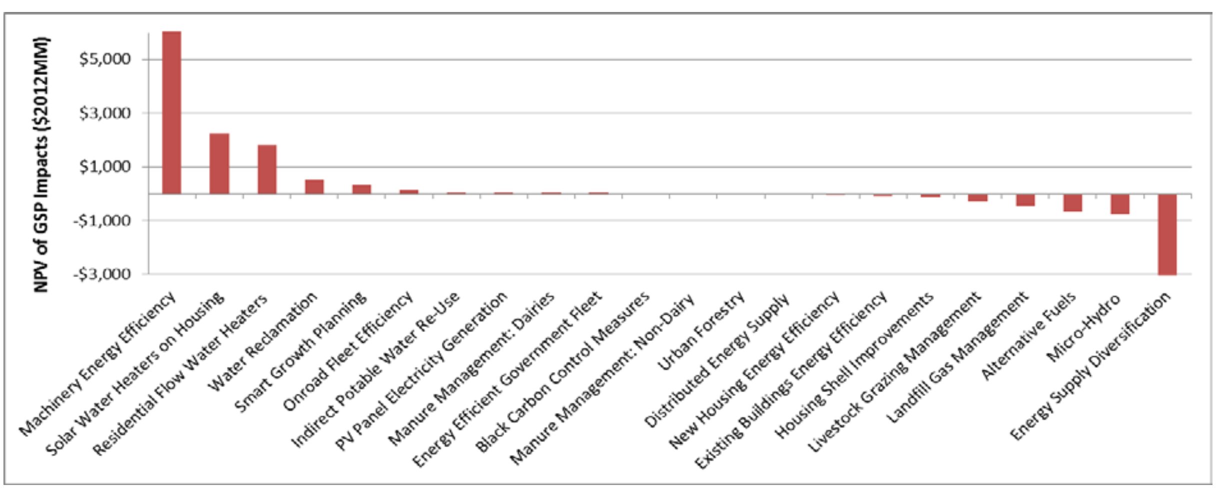
**Figure 9-3. GHG Reduction, Cost-Effectiveness, GSP Impacts**




**(a) Cumulative GHG Reduction Potential by Policy**




**(b) Cost-Effectiveness by Policy**




**(c) Net Changes to Baja California GSP by Policy (2016-2035 NPV)**

## Sectoral Impacts

Table 9-6 presents the NPVs of the Gross Output and GSP impacts and the average employment impact for each individual economic sector. Table 9-7 presents the results in relation to top sectors that are positively and negatively affected by the GHG mitigation and sequestration policy options. In terms of the NPV of the GSP impacts, the top positively stimulated sectors are those related to household spending (e.g., Real Estate Activities and Wholesale and Retail) and the manufacturing sector that produce energy efficiency equipment and appliances, as well as renewable generation equipment. The top negatively affected sector is the Electricity, Gas, and Water Supply sector. The vast majority of the negative impacts are for the Electricity Generation and Distribution due to the reduction of electricity consumption resulting from the energy saving and energy efficiency improvement. There are two major reasons that the Construction sector is projected to be the second most negatively affected sector in terms of GSP impact. First, the reduced demand for electricity from energy efficiency improvement in the RCII sectors would reduce the need to build new power plants, which will in turn reduce the demand for the Construction. Second, compared with conventional electricity generation, renewable electricity generation has a relatively lower percentage investment demand for Construction.

In terms of the employment impacts, the top positively affected sector is Coke, Refined Petroleum and Nuclear Fuel sector, followed by Manufacturing sector and Agriculture, Hunting, Forestry, and Fishing sector. The major reason for the high positive impacts to the Coke, Refined Petroleum and Nuclear Fuel sector is that this sector has an extremely high labor intensity. The NPV of the GSP gain of the Manufacturing sector is about 30 times that of the Coke, Refined Petroleum and Nuclear Fuel sector. However, the latter has a labor intensity of nearly 40 times of the former. The top three negatively affected sectors in terms of employment impacts are the same as those for the GSP impacts, except that the Construction sector ranks top this time. This is again because the Construction sector is much more labor intensive compared with the Electricity, Gas, and Water Supply sector.

### Table 9-6. Gross Output, GSP, and Employment Impacts by Sector

| REMI Sector | NPV of Gross Output (Millions 2012$) | NPV of GSP (Millions 2012$) | Employment Per Year (jobs) |
|---|---|---|---|
| Agriculture, Hunting, Forestry, and Fishing | $2,220.6 | $1,439.4 | 300 |
| Mining and Quarrying | $276.3 | $232.1 | 116 |
| Food, Beverages and Tobacco | $2,248.5 | $854.4 | 64 |
| Textile and Textile Products | $169.5 | $65.4 | 12 |
| Leather, Leather Products and Footwear | $44.9 | $17.9 | 4 |
| Wood and Products of Wood and Cork | $145.8 | $62.5 | 4 |
| Pulp, Paper, Paper Products, Printing, and Publishing | $512.6 | $225.9 | 6 |
| Coke, Refined Petroleum and Nuclear Fuel | $513.3 | $81.7 | 593 |
| Chemicals and Chemical Products | -$131.1 | -$39.5 | 5 |
| Rubber and Plastics | $485.5 | $155.2 | 20 |
| Other Non-Metallic Mineral | $501.5 | $261.1 | 15 |
| Basic Metals and Fabricated Metals | $3,507.6 | $1,253.5 | 59 |

| REMI Sector | NPV of Gross Output (Millions 2012$) | NPV of GSP (Millions 2012$) | Employment Per Year (jobs) |
|---|---|---|---|
| Machinery n.e.c. | $11,296.1 | $4,215.6 | 312 |
| Electrical and Optical Equipment | $8,683.3 | $1,740.1 | 72 |
| Transport Equipment | $1,100.6 | $379.9 | 11 |
| Manufacturing n.e.c., Recycling | $665.1 | $246.3 | 5 |
| Electricity, Gas, and Water Supply | -$24,754.2 | -$12,171.2 | -93 |
| Construction | -$2,598.2 | -$1,312.9 | -746 |
| Wholesale and Retail | $2,920.9 | $2,417.4 | 124 |
| Hotels and Restaurants | $1,170.1 | $797.8 | 146 |
| Inland Transport | $993.6 | $648.7 | 123 |
| Water Transport | $1.6 | $0.8 | 1 |
| Air Transport | $0.0 | $0.0 | 0 |
| Other Supporting and Auxiliary Transport Activities | $213.9 | $152.9 | 10 |
| Post and Telecommunications | $1,624.5 | $873.8 | 36 |
| Financial Intermediation | $429.0 | $354.7 | 24 |
| Real Estate Activities | $6,404.4 | $5,267.9 | 38 |
| Renting of Machinery and Equipment and Other Business Activities | $1,171.1 | $879.1 | 169 |
| Public Admin and Defense, Compulsory Soc Sec | -$423.2 | -$306.2 | -73 |
| Education | $233.1 | $209.5 | 24 |
| Health and Social Work | $158.4 | $120.0 | 0 |
| Other Community Social and Personal Services | $1,219.0 | $659.1 | 297 |
| **Total** | **$21,004.2** | **$9,783.1** | **1,680** |

**Table 9-7. Top Three Positively and Negatively Impacted Sectors**

| **Top 3 Positive and Negative Impacted Sectors in terms of Absolute GSP impacts in NPV (million 2012$)** | |
|---|---|
| ***Top 3 Positive Impact*** | ***Top 3 Negative Impact*** |
| Real Estate Activities | Electricity, Gas, and Water Supply |
| Manufacturing n.e.c. | Construction |
| Wholesale and Retail | Public Admin and Defense; Compulsory Social Security |
| **Top 3 Positive and Negative Impacted Sectors in terms of Absolute Per Year Employment Impact (Jobs)** | |
| ***Top 3 Positive Impact*** | ***Top 3 Negative Impact*** |
| Coke, Refined Petroleum and Nuclear Fuel | Construction |
| Manufacturing n.e.c. | Electricity, Gas, and Water Supply |
| Agriculture, Hunting, Forestry, and Fishing | Public Admin and Defense; Compulsory Social Security |

## Sensitivity Tests

Our modeling results indicate that the policy bundle ES-2/AFOLU-3 Energy Supply Diversification yields the largest negative macro-economic impact among the 22 GHG mitigation policy options/bundles analyzed. Several sensitivity tests were run to analyze how the changes in some key assumptions would affect the macro-economic impact analysis results for this policy bundle.

### A. Renewable Electricity Generation Equipment Produced within Baja California

Regional Purchase Coefficients (RPCs) in the REMI model determine what percent of the demand for each good or service is produced within the state of Baja California. Sensitivity analyses on this variable enable us to examine the impacts related to business decisions under new regulations, such as whether to purchase goods and services from in-state or out-of-state sources, or whether to locate manufacturing facilities within the state or move existing facilities outside of the state. For example, decreasing a baseline RPC can represent a situation in which businesses leave the state, due to increased uncertainties about the regulations. Conversely, increasing a baseline RPC can represent the attraction of new business into the state, due to aggressive industrial targeting efforts.

In the Base Case, the REMI Model utilizes projected RPCs, estimated using historical data for the Manufacturing sector.  Over the planning period, the default average RPC of the Manufacturing sector is about 57%, meaning that on average 57% of the equipment can be supplied by the companies located within the state. In the sensitivity tests, we assume that the RPCs of the Manufacturing sector are 50% higher or lower than the default values used in the Base Case simulations.

The second and third numerical columns in Table 9-8 show the sensitivity test results of RPC. The results indicate that a 50% increase in the in-state supply of renewable generation equipment would improve the macro-economic performance of the option for about 35% in terms of the employment impacts.

### B. Capital Cost of Renewable Electricity Generation

In this sensitivity test, we analyze the impacts of variations in the capital cost of renewable electricity generation in ES-2 on the macro impact of the policy bundle ES-2/AFOLU-3. Specifically, we assume that the capital cost of renewable generation is 50% higher or lower than the capital cost used in the Base Case analysis. The results are presented in fourth and fifth numerical columns of Table 9-8. They indicate that, if the capital cost of renewable electricity generation can be decreased by 50%, the macro-economic impacts of this policy bundle can be greatly improved to about $3.6 billion in positive GSP impacts and 328 average annual job gains over the entire planning period. However, if the capital cost of renewable generation is higher than in the Base Case by 50%, the negative impacts on employment and GSP of would be more than doubled.

### C. Projected Price of Natural Gas

In this sensitivity test, we assume that the natural gas fuel cost for the displaced NGCC generation in ES-2 is 50% higher or lower than the fuel cost used in the Base Case analysis. The lower the cost of natural gas, the less competitive are renewable electricity generation alternatives. As shown in the last two columns of Table 9-8, with a 50% lower projected NG cost, the negative employment impact of the policy bundle would be increased by about 87%. A 50% higher projected NG cost would improve the macro-economic performance of ES-2/AFOLU-3 by about 70% in terms of employment impact, and result in positive GSP impacts of $1.3 billion in NPV.

Overall, the macro impact results of policy bundle ES-2/AFOLU-3 are most sensitive to capital costs and least sensitive to changes in the RPCs.

**Table 9-8. Sensitivity Analysis Results for ES-2/AFOLU-3**

| Category | Units | Base Case | 50% Higher RPC | 50% Lower RPC | 50% Higher Capital Costs | 50% Lower Capital Costs | 50% Higher NG Fuel Cost | 50% Lower NG Fuel Cost |
|---|---|---|---|---|---|---|---|---|
| **Differences from Baseline Level (2014-2030)** | | | | | | | | |
| Average Annual Employment | Jobs per year | -773 | -515 | -1,042 | -1,806 | 328 | -232 | -1,446 |
| Gross State Product (NPV) | Millions of Fixed (2012) Pesos | -3,034 | -197 | -5,967 | -11,881 | 3,628 | 1,335 | -8,475 |
| Output (NPV) | Millions of Fixed (2012) Pesos | -6,381 | -498 | -12,453 | -24,212 | 7,292 | 2,468 | -17,407 |
| Disposable Personal Income (NPV) | Millions of Fixed (2012) Pesos | -536 | 1,030 | -2,121 | -5,719 | 3,392 | 2,496 | -4,320 |
| **Percent Change from Baseline Level (2030)** | | | | | | | | |
| Total Employment | Jobs | -0.183% | -0.188% | -0.177% | -0.339% | -0.025% | -0.133% | -0.245% |
| Gross State Product | Millions of Fixed (2012) Pesos | -0.198% | -0.200% | -0.195% | -0.389% | -0.006% | -0.128% | -0.286% |
| Output | Millions of Fixed (2012) Pesos | -0.186% | -0.188% | -0.184% | -0.368% | -0.003% | -0.118% | -0.272% |
| Disposable Personal Income | Millions of Fixed (2012) Pesos | -0.150% | -0.153% | -0.146% | -0.321% | 0.023% | -0.076% | -0.241% |

**D. Discount Rate**

When we evaluate the impacts on gross state product, it is important to consider the time value of money. People place a higher value on cash flows today than if they are delayed into the future. In the Base Case, we discount the cash flows between 2016 and 2030 to present values at a rate of 5%. Table 9-9 compares GSP impacts using alternative discount rates. The middle numerical column of Table 9-9 replicates the net present values shown in Table 9-7, while the first numerical column shows the net present value calculation based on a 2% discount rate, and the third numerical column shows the calculation using an 8% discount rate. In general, the absolute value of the total net present value decreases when the discount rate increases and vice versa. However, since about half of the policies result in positive impacts, while the other half result in negative impacts, the net GSP impacts of all the 22 policy options together are not sensitive to the discount rate. This sensitivity test shows that the net present value of GSP impacts ranges between around $9.7 billion to $10.6 billion in the simultaneous simulation when the discount rate varies between 2% and 8%.

**Table 9-9. GSP NPV Impacts with Alternative Discount Rates (Millions of 2012 Pesos)**

| Scenario | 2% | 5% | 8% |
|---|---|---|---|
| ES-1 | -$1,214 | -$783 | -$502 |
| ES-2/AFOLU-3 Bundle | -$7,203 | -$3,165 | -$720 |
| ES-3 | -$103 | -$26 | $19 |
| ES-4 | -$34 | $39 | $80 |
| **Subtotal – ES** | -$8,555 | -$3,935 | -$1,123 |
| RCII-1 | -$183 | -$127 | -$89 |
| RCII-2 | -$91 | -$62 | -$42 |
| RCII-3 | -$408 | -$96 | $94 |
| RCII-4 | $15,457 | $10,850 | $7,779 |
| RCII-5 | $2,856 | $2,334 | $1,946 |
| RCII-6 | $2,366 | $1,875 | $1,518 |
| **Subtotal – RCI** | $19,997 | $14,774 | $11,205 |
| AFOLU-1 | -$7 | -$5 | -$3 |
| AFOLU-2 | -$5 | $7 | $13 |
| AFOLU-5 | -$362 | -$311 | -$265 |
| AFOLU-6 | -$9 | -$6 | -$4 |
| **Subtotal – AFOLU** | -$382 | -$316 | -$260 |
| WM-1 | -$673 | -$476 | -$342 |
| WM-2 | $66 | $41 | $26 |
| WM-3 | $703 | $517 | $390 |
| **Subtotal – WM** | $95 | $83 | $74 |
| TLU-1 | -$5 | -$4 | -$3 |
| TLU-2/AFOLU-4/WM-4 Bundle | -$1,071 | -$690 | -$442 |
| TLU-3 | $189 | $139 | $105 |
| TLU-5 | $471 | $345 | $258 |
| TLU-6 | $1 | $0 | $0 |
| **Subtotal – TLU** | -$415 | -$210 | -$82 |

| | | | |
|---|---|---|---|
| **Summation Total** | **$10,740** | **$10,397** | **$9,814** |

| | | | |
|---|---|---|---|
| **Simultaneous Total** | **$10,557** | **$10,278** | **$9,737** |

## Conclusion

This Chapter summarizes the analysis of the macro-economic impacts of the 22 GHG mitigation/sequestration policy options/policy bundles on the Baja California state economy. We used a state of the art macro-econometric model, the Regional Economic Models, Inc. Policy Insight Plus (REMI PI+) Model to perform this analysis. The data used in this study are based on the microeconomic impact analysis of the cost and saving estimates associated with the mitigation options, and are supplemented by a set of macro-economic modeling assumptions.

The macro-economic analysis results indicate that, as a group, the recommended GHG mitigation policy options/policy bundles yield a positive impact on the Baja California economy. On net, the combination of the 22 policy options/bundles are expected to result in an increase in employment of about 1,680 new jobs per year during the planning period from 2014 to 2030 and yield an increase in GSP of about $9.85 billion pesos in NPV.

In addition, our results indicate a great disparity in the impacts across individual mitigation options. RCII-4 Finance Incentives for Machinery Energy Efficiency is estimated to contribute the highest economic gains. This stems primarily from their ability to improve energy efficiency and thus reduce production costs of the industrial sectors. The results also stem from the stimulus of increased investment in energy-efficient equipment and machinery. ES-2/AFOLU-3 Energy Supply Diversification is estimated to result in the highest negative impacts to the Baja economy. The negative impacts from this policy bundle mainly stem from the high capital cost of renewable electricity generation compared with the avoided fossil fuel electricity generation.

Note that the estimates of economic benefits to Baja California do not include the economic value of other benefits associated with implementing the GHG mitigation options, including the avoidance of negative environmental impacts from continued GHG emissions that have been mitigated, the savings from the associated decrease in ordinary pollutants that have important impacts upon human health, the reduction in the use of natural resources, and other factors.

# Acronyms and Abbreviations

| | |
|---|---|
| $/kWh | pesos per kilowatt-hour |
| $/MM | millions of pesos |
| $/MWh | pesos per megawatt-hour |
| $/t | pesos per metric ton |
| $/tCO2e | pesos per metric ton of carbon dioxide equivalent |
| % | per cent |
| AFOLU | Agriculture, Forestry, and Other Land Use |
| AG | Advisory Group |
| B-2 | fuel blend of 2% biodiesel and 98% diesel. |
| B-10 | fuel blend of 10% biodiesel and 98% diesel. |
| 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 |
| CAP | Climate Action Plan |
| CCC | Council on Climate Change |
| CCI | Cross-Cutting Issues |
| CCS | Center for Climate Strategies |
| cf | cubic feet |
| CGE | computable generated equilibrium |
| $CH_4$ | methane |
| CHP | combined heat and power |
| CI | custom industry |
| CICESE | Center for Scientific Research and Higher Education of Ensenada |
| CNG | compressed natural gas |
| $CO_2$ | carbon dioxide |
| $CO_2e$ | carbon dioxide equivalent |
| COLEF | El Colegio de la Frontera Norte |
| CRF | capital recovery factor |
| CSD | Council for Sustainable Development |
| CY | calendar year |
| DG | distributed generation |
| DOE | [United States] Department of Energy |
| DOT | [United States] Department of Transportation |
| DSM | demand-side management |
| E-10 | fuel blend of 10% ethanol and 90% gasoline |
| E-85 | fuel blend of 85% ethanol and 15% gasoline |
| 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 |
| INECC | National Institute of Ecology and Climate Change |
| 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 |
| LPM | Local Project Manager |
| LPMACC | Law on Prevention, Mitigation and Adaptation of Climate Change |
| $m^2$ | square meter |
| ME | macro-economic |
| metric ton | 1,000 kilograms or 22,051 pounds |
| MJ | megajoule |
| MM | million |
| MMBtu | millions of British thermal units |
| MMt | million metric tons |
| $MMtCO_2e$ | million metric tons [teragrams] of carbon dioxide equivalent |
| 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 |
| $N_2O$ | 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 |
| PEACC | State Climate Action Plan |
| PFC | perfluororocarbon |
| PHEV | plug-in hybrid electric vehicle |
| PM | particulate matter |
| PM10 | particulate matter of 10 microns |
| POD | policy option document |
| PS | power supply |
| PV | photovoltaic |
| R&D | research and development |
| RCII | Residential, Commercial, Institutional and Industrial |
| REMI PI+ | Regional Economic Models, Inc. Policy Input Plus |
| RFS | renewable fuel standard |

| | |
|---|---|
| RPC | regional purchase coefficient |
| RPS | renewable portfolio standard |
| SBC | systems benefit charge |
| SEMARNAT | Ministry of Environment and Natural Resources |
| $SF_6$ | sulfur hexafluoride |
| SPA | Secetaria de Proteccion al Ambiente |
| $SO_2$ | 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 |
| USC | University of Southern California |
| 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 |
| WVO | Waste Vegetable Oil |
| WWF | World Wildlife Fund |
| yr | year |
| ZMT | Metropolitan Area of Tijuana |