Janet Napolitano
Governor

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

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Stephen A. Owens
Director

August 30, 2006

The Honorable Janet Napolitano
Governor of the State of Arizona
1700 W. Washington St.
Phoenix, Arizona 85007

Re: Climate Change Action Plan

Dear Governor Napolitano:

On behalf of the Climate Change Advisory Group (CCAG), I am pleased to submit the Climate Change Action Plan, prepared pursuant to Executive Order 2005-02.

The Action Plan is the product of more than a year's effort by the 35-member CCAG and its five Technical Working Groups (TWGs). The full CCAG met six times between July 2005 and June 2006, and the TWGs met a total of 40 times via teleconference during this time.

The Action Plan contains a comprehensive set of 49 recommendations for addressing and reducing greenhouse gas (GHG) emissions in Arizona. Of the 49 policy recommendations adopted by the CCAG, 45 received unanimous consent, two received a supermajority of support and two received a majority of support.

Pursuant to Executive Order 2005-02, the CCAG prepared an inventory and forecast of GHG emissions in Arizona, which found that between 1990 and 2005 Arizona's net GHG emissions increased by nearly 56%. Arizona's GHG emissions are projected to increase by 148% from 1990 to 2020.

As the Action Plan states, "While Arizona's high emissions growth rate presents challenges, it also provides major opportunities. Because more than three-fourths of Arizona's GHG emissions are directly related to energy and transportation, the opportunity exists for Arizona to reduce its GHG emissions while continuing its strong economic growth by being more energy efficient, using more renewable energy sources, building new infrastructure "right" in the first place to produce lower emissions and increasing the use of cleaner transportation modes, technologies and fuels."

On behalf of the CCAG, thank you for the opportunity to participate in this important effort.

Sincerely,

Stephen A. Owens
Director

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ARIZONA
Climate Change Advisory Group

CLIMATE CHANGE ACTION PLAN
AUGUST 2006

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G. RCI, and Waste - detailed policy description/analysis
H. Energy Supply - detailed policy description/analysis
I. Transportation and Land Use - detailed policy description/analysis
J. Agriculture and Forestry - detailed policy description/analysis

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Thomas D. Peterson and The Center for Climate Strategies, whose dedicated team of professionals contributed extraordinary amounts of time, energy and expertise in facilitation of the CCAG process and preparation of the CCAG's documents and recommendations:

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Michael Lazarus
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Stephen Roe
Adam Rose
Will Schroeer
David von Hippel
Eric Williams

Kurt Maurer, of the Arizona Department of Environmental Quality, who coordinated and supervised all activities associated with the CCAG process on behalf of ADEQ, including overseeing the writing and production of this *Climate Change Action Plan*.

Special thanks goes as well to the following ADEQ employees, whose excellent service and commitment helped ensure an open, public process that supported the CCAG's work and its recommendations:

Nancy Wrona
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Philip Amorosi
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Randy Sedlacek

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A very special "thank you" goes to Cinda Briggs, George Copeland, Ray Palmer, Kate Widland and other staff at the Salt River Project who graciously allowed the use of their conference room facilities for CCAG meetings and provided other support for the CCAG's public meetings.

Finally, the CCAG recognizes the many individuals who participated in the CCAG's sector-based Technical Work Groups. For a complete listing of these individuals by work group, see Appendix C.

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Executive Order 2005-02

On February 2, 2005, Governor Janet Napolitano signed Executive Order 2005-02 establishing the Climate Change Advisory Group (CCAG). Appointed by the Governor, the 35-member CCAG comprised a diverse group of stakeholders who brought broad perspective and expertise to the topic of climate change in Arizona. The Governor's Executive Order directed the CCAG, under the coordination of the Arizona Department of Environmental Quality (ADEQ), to:

1) prepare an inventory and forecast of Arizona greenhouse gas (GHG) emissions; and
2) develop a Climate Change Action Plan with recommendations for reducing GHG emissions in Arizona.

The Executive Order emphasized that "Arizona and other Western States have particular concerns about the impacts of climate change and climate variability on the environment, including the potential for prolonged drought, severe forest fires, warmer temperatures, increased snowmelt, reduced snow pack and other effects."

The Executive Order also recognized that "actions to reduce GHG emissions, including increasing energy efficiency, conserving natural resources and developing renewable energy sources, may have multiple benefits including economic development, job creation, cost savings, and improved air quality."

The CCAG Process

The CCAG held its first meeting on July 14, 2005, followed by a year of intensive fact-finding and consensus building, facilitated by the Center for Climate Strategies (CCS). The CCAG met six times during this period, and five sector-based technical work groups (TWGs) of the CCAG — Energy Supply (ES); Residential, Commercial, Industrial and Waste Management (RCI); Transportation and Land Use (TLU); Agriculture and Forestry (AF); and Cross-Cutting Issues (CC) – met a total of 40 times via teleconference.

The recommendations adopted by the CCAG underwent two levels of screening. First, a potential policy option being considered by a TWG was accepted as a "priority for analysis" and developed for full analysis only if it had a supermajority of support from CCAG members (with a "supermajority" defined as five or fewer "no" votes or objections). Second, after the analyses were conducted, only policy options that received at least majority support from CCAG members were adopted as recommendations by the CCAG and included in this report.

Of the 49 policy recommendations adopted by the CCAG, 45 received unanimous consent, two (2) received a supermajority of support, and two (2) received a majority of support.

Emissions Inventory and Forecast

Prior to the first meeting of the CCAG, a preliminary inventory and forecast of GHG emissions for Arizona for years 1990 through 2020 was produced pursuant to Executive Order 2005-02.

The inventory provided several critical findings, including:

- Between 1990 and 2005 Arizona's net GHG emissions increased by nearly 56%, from an estimated 59.3 million metric tons carbon dioxide equivalent ($MMtCO_2e$) to an estimated 92.6 $MMtCO_2e$.
- Arizona's GHG emissions are forecasted to increase by 148% from 1990 to 2020, taking into account the effects of recent energy efficiency actions adopted by the State. Without these actions emissions growth in 2020 would be forecasted to increase by 159% over 1990 levels.
- The transportation and electricity sectors account for more than three-fourths – roughly 77% -- of Arizona's total GHG emissions.

Figure E-1 below shows the relative amount of GHG emissions contributed by each sector in 2000.

Figure E-1 Arizona Greenhouse Gas (GHG) Emissions in 2000

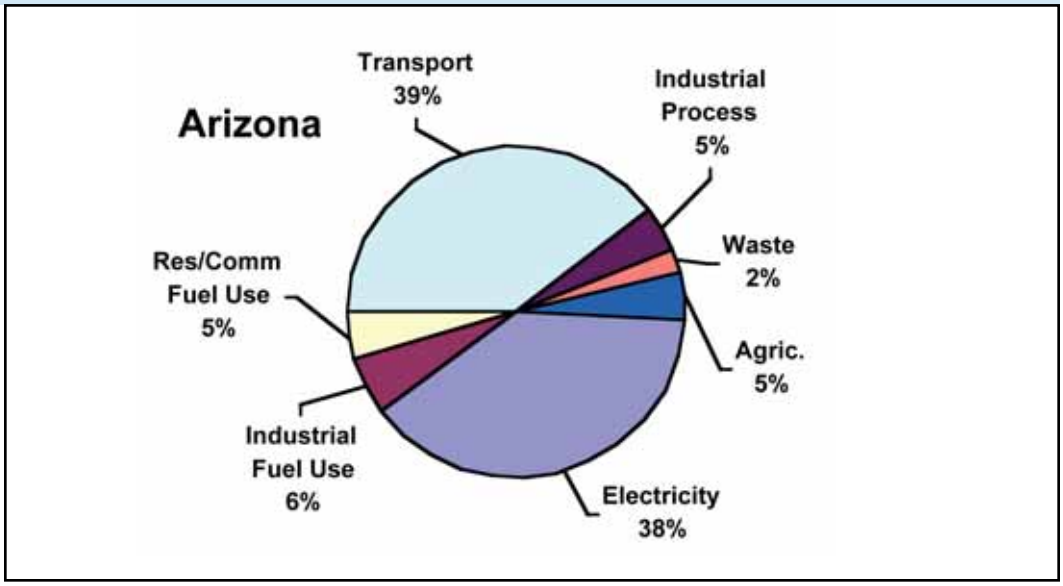
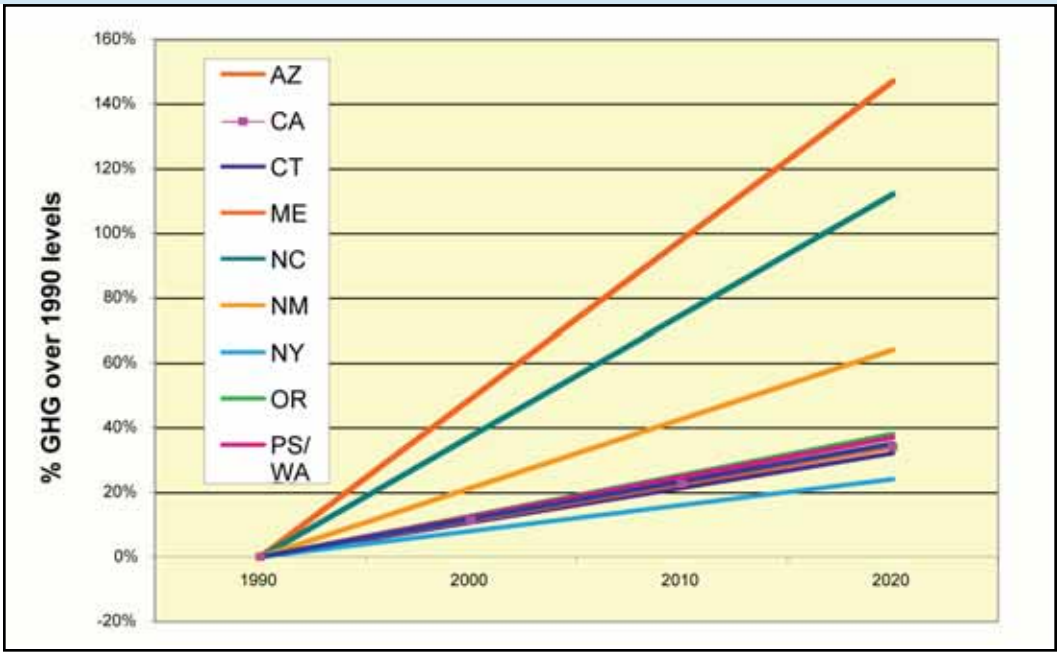


Figure E-2 below shows how Arizona's projected growth in GHG emissions compares to the growth rates in other states with climate action plans.

Figure E-2 Comparison of 1990-2020 GHG Emissions Growth for States with Climate Plans



While Arizona's high emissions growth rate presents challenges, it also provides major opportunities. Because more than three-fourths of Arizona's GHG emissions are directly related to energy and transportation, the opportunity exists for Arizona to reduce its GHG emissions while continuing its strong economic growth by being more energy efficient, using more renewable energy sources, building new infrastructure "right" in the first place to produce lower GHG emissions and increasing the use of cleaner transportation modes, technologies and fuels.

The CCAG's Recommended Policy Options

The CCAG is recommending a comprehensive set of 49 policy options to reduce GHG emissions in Arizona. The CCAG strongly recommends early and aggressive implementation of the recommendations and a corresponding set of incentives to promote their early adoption. The CCAG believes that early action and implementation of its policy recommendations are critical to put Arizona quickly on the path toward significant emissions reductions. The CCAG also urges that the policy options be implemented as a set, to the greatest extent practicable, to achieve the maximum GHG emissions reductions possible.

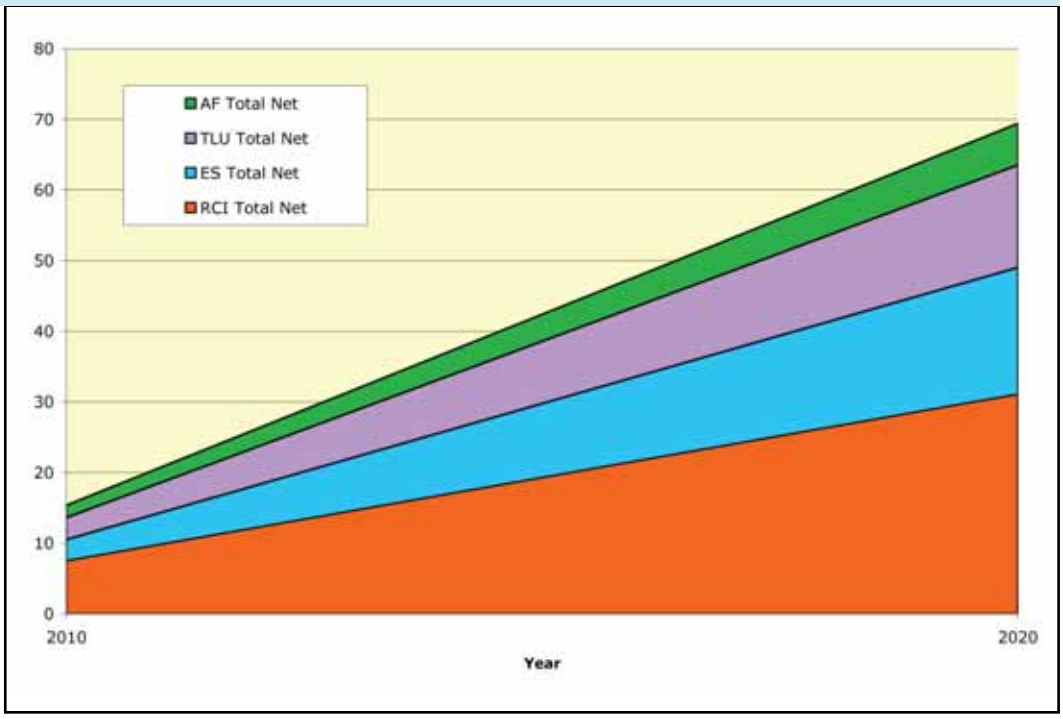
Overarching Recommendation: Set a State Goal to Reduce Arizona's GHG Emissions to 2000 Levels by 2020 and to 50% below 2000 Levels by 2040.

As an overarching policy matter, the CCAG recommends that Arizona establish a statewide goal of reducing future GHG emissions to a level equal to 2000 emissions by the year 2020 and to 50% below the 2000 emissions level by the year 2040.

The recommended goal for reductions in Arizona's GHG emissions reflects the CCAG's policy options recommendations. In fact, the CCAG's recommended policy options, if fully implemented, could reduce GHG emissions in Arizona by several million metric tons more than the amounts called for in the recommended goal. The CCAG's policy options could cut Arizona's GHG emissions by more than 69 $MMtCO_2e$ in 2020, reducing GHG emissions to more than five percent (5%) below the 2000 level. Cumulative GHG emissions reductions from 2007-2020 for all the policy options combined could total more than 485 $MMtCO_2e$ (adjusted for overlap to avoid double-counting of reductions).

Figure E-3 below shows the annual GHG reductions that could be achieved by sector through the CCAG's recommended policy options from 2010 to 2020. As Figure E-3 illustrates, a significant portion of the achievable reductions are associated with energy efficiency and renewable energy policy options in the residential, commercial, and industrial sectors.

Figure E-3 2010 through 2020 GHG Reductions, by Sector



AF – Agriculture and Forestry
TLU – Transportation and Land Use
ES – Energy Supply
RCI – Residential Commercial Industrial (fuel use)

The recommended goal for Arizona is consistent with the goals set by other states, including those in the West, that are implementing GHG reduction strategies:

AZ	2000 levels by 2020; 50 percent below 2000 levels by 2040
CA	2000 levels by 2010; 1990 levels by 2020; 80 percent below 1990 levels by 2050
CT	1990 levels by 2010; 10 percent below by 2020; 75 percent below by 2100
MA	1990 levels by 2010; 10 percent below by 2020; 75 percent below by 2100
ME	1990 levels by 2010; 10 percent below by 2020; 75 percent below by 2100
NJ	3.5 percent below 1990 levels by 2005
NM	2000 levels by 2012; 10 percent below by 2020; 75 percent below 2050
NY	5 percent below 1990 by 2010; 10 percent below 1990 levels by 2020
OR	1990 levels by 2010; 10 percent below by 2020; 75 percent by 2050
RI	1990 levels by 2010; 10 percent below by 2020; 75 percent by 2100
WA (Puget Sound)	1990 levels by 2020; 70-80 percent below 1990 levels by 2050

Reducing Arizona's GHG emissions to the recommended levels through full implementation of all of the CCAG's recommendations also would result in significant economic benefits for the state, including substantial economic cost savings, new job creation and enhanced economic development. The Center for Climate Strategies (CCS) has calculated overall net economic cost savings from the CCAG's recommendations of more than $5.5 billion between 2007-2020, with additional significant cost savings also expected between 2020-2040 (although not calculated by CCS). The CCS also has calculated an average net economic cost savings of nearly $13 per ton of GHG emisssions reduced under the CCAG's recommended policy options (if fully implemented).

The Policy Options

The CCAG is recommending a comprehensive set of forty-nine (49) policy options:

Cross-Cutting (CC) Issues

The CCAG is recommending five (5) policy options to facilitate reductions in Arizona's GHG emissions across economic sectors and address issues associated with climate change. These policy options include:

- Set a State GHG Reduction Goal (as stated above) (CC-1)
- Establish a GHG Emissions Reporting Mechanism (CC-2)
- Establish a GHG Emissions Registry (CC-3)
- Undertake Climate Action Education and Outreach (CC-4)
- Develop a State Climate Change Adaptation Strategy (CC-5)

Residential, Commercial, Industrial and Waste Management (RCI) Sectors

The CCAG is recommending a set of twelve (12) policy options to reduce emissions from the RCI sector, including improving energy efficiency, substituting lower-emissions energy resources, and strategies to reduce emissions from the production of electricity consumed by the RCI sector. The state's rapid growth and limited pursuit of energy efficiency to date offers particularly strong opportunities to reduce emissions through improving the efficiency of buildings, appliances and industrial practices. The RCI policy options include:

- Set Demand-Side Efficiency Goals and Establish Funds, Incentives, and Programs to Achieve Them (RCI-1)
- Establish State Leadership Programs to Achieve Energy Savings and Promote Clean Energy (RCI-2)
- Implement Enhanced Appliance Efficiency Standards (RCI-3)
- Adopt Building Standards/Codes/Design Incentives for Energy Efficiency and Smart Growth (RCI-4 & RCI 5)
- Encourage Distributed Generation of Renewable Energy and Combined Heat and Power (RCI-6 & RCI 7)
- Implement Electricity Pricing Strategies that Support Energy Conservation (RCI-8)
- Promote Low-Global-Warming-Potential Refrigerants in Commercial Operations (RCI-9)
- Provide Incentives for Consumers to Switch to Low GHG Energy Sources (RCI-10)
- Increase Recycling and Solid Waste Management and Reduction (RCI-12)
- Increase Water Use Efficiency and Promote Energy Efficiency and Renewable Energy Production from Water and Wastewater Management (RCI-13)

Energy Supply (ES) Sector

The CCAG is recommending a set of eight (8) policy options to significantly reduce GHG emissions from the ES sector. The principal challenge in addressing GHG emissions from Arizona's electricity sector is the state's extraordinary growth rate and the accompanying projected increase in energy demand. New policies are needed to increase utilization of Arizona's renewable energy resources, like solar, wind, biomass and geothermal, and reduce reliance on pulverized coal technology. The ES policy options include:

- Increase the Environmental Portfolio Standard by 1% each year through 2025 (ES-1)
- Provide Incentives for and Encourage Investment in Renewable Energy (ES-3)
- Explore Development of a National or Regional GHG Cap and Trade Program (ES-4)
- Implement Carbon Intensity Targets (ES-6)
- Reduce Barriers to Renewables and Distributed Generation of Clean Energy (ES-9)
- Implement Net Metering and Advanced Metering for Energy Consumption (ES-10)
- Implement Pricing Strategies to Promote Energy Conservation and Use of Renewable Energy (ES-11)
- Implement Integrated Resource Planning (ES-12)

Transportation and Land Use (TLU) Sector

The CCAG is recommending a set of thirteen (13) policy options to reduce GHG emissions reductions from the TLU sector, including improved vehicle fuel efficiency, increased usage of lower-emissions fuels, greater use of lower-emissions means of travel and land use and other strategies to decrease the growth in fuel use and vehicle miles traveled (VMT). GHG emissions from the TLU sector, which are expected to more than double by 2020 (over 1990 levels), are influenced by transportation technologies and fuels, along with population, economic growth and land use policies that affect the demand for transportation services. The TLU policy options include:

- Adopt the Clean Car Program (TLU-1)
- Implement Policies to Promote Smart Growth Planning, Infill, Increased Density and Transit-Oriented/Pedestrian Friendly Development (TLU-2)
- Promote Multi-Modal Transit (TLU-3)
- Reduce Vehicle Idling (TLU-4)
- Set Standards for Alternative Fuels (TLU-5)
- Provide Incentives for Hybrid Vehicles (TLU-7)
- Explore Feebates (TLU-8)
- Implement a Pilot Program for Pay-As-You-Drive Insurance (TLU-9)

- Encourage Low Rolling Resistance Tires and Promote Proper Tire Inflation (TLU-10)
- Provide Incentives for Accelerated Replacement/Retirement of High-Emitting Diesel Vehicles (TLU-11)
- Increase the Use of Biodiesel (TLU-12)
- Implement Practices and Procurement Policies to Achieve a Lower-GHG-Emitting State Vehicle Fleet (TLU-13)
- Reduce the Speed Limit to 60 mph for Commercial Trucks on Highways/Freeways (TLU-14)

Agriculture and Forestry (AF) Sectors

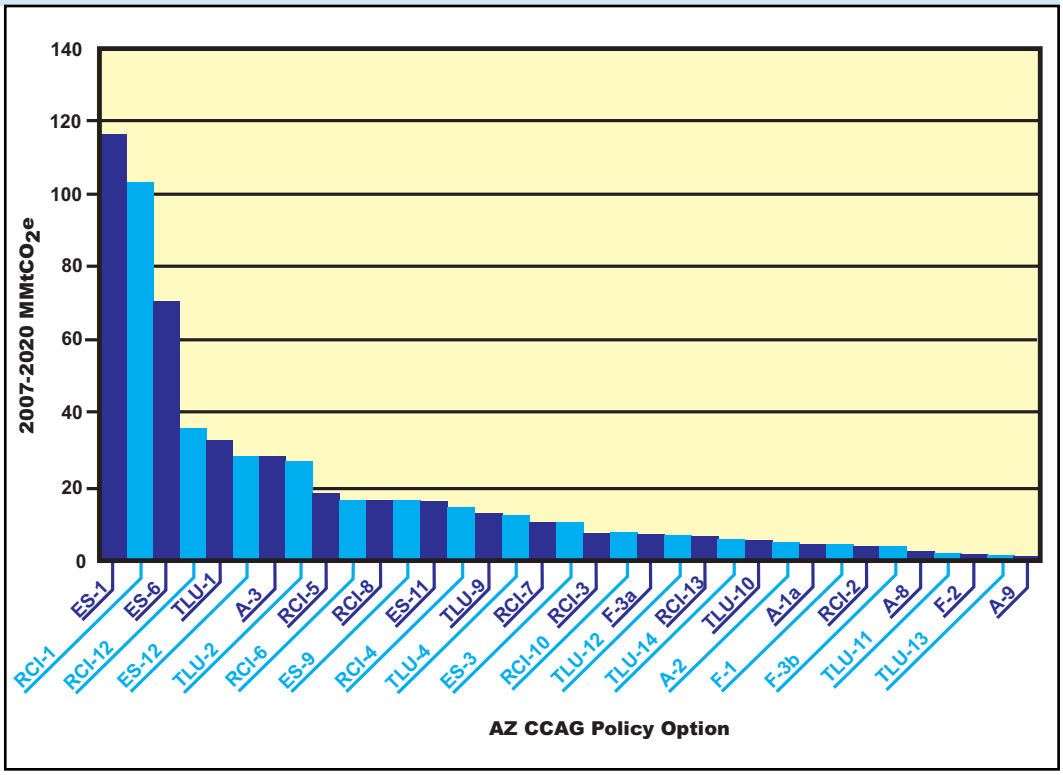
The CCAG is recommending eleven (11) policy options for the AF sectors. While the AF sectors are directly responsible for only a small amount of Arizona's current GHG emissions, there are opportunities for GHG reductions in the sectors, as well as reductions in overall GHG emissions in the state by increased carbon sequestration through new policies and practices in the AF sectors. The AF policy options include:

- Use Manure Digesters to Reduce Methane Emissions from Livestock Operations and Promote Energy Use of the Captured Methane (A-1)
- Use Biomass Feedstocks for Electricity or Steam Production (A-2)
- Increase Ethanol Production and Use (A-3)
- Convert Agricultural Land to Grassland or Forest to Increase Carbon Sequestration (A-7)
- Reduce Conversion of Farm and Rangelands to Developed Uses (A-8)
- Promote Consumption of Locally Produced Agricultural Commodities to Reduce Transportation Emissions (A-9)
- Decrease the Conversion of Forestland to Developed Uses (F-1)
- Increase Reforestation and Restoration of Forestland (F-2)
- Improve Forest Ecosystem Management (F-3a & 3b)
- Improve Commercialization of Biomass Gasification and Combined Cycle Technologies (F-4)

GHG Reductions from the Recommended Policy Options

Figure E-4 below shows the amount of GHG emissions reductions achievable under each individual, quantified policy option cumulatively from 2007-2020, ranked by its GHG reduction potential. The CCS was able to quantify the GHG emissions reduction potential for 35 of the 49 total recommended policy options.

Figure E-4 CCAG Recommended Policy Options, by Quantified Indvidual GHG Reduction 2007-2020



Policy Option	$MMtCO_2e$
Environmental Portfolio Standard/Renewable Energy Standard and Tariff (ES-1)	116.00
Demand-Side Efficiency Goals, Funds, Incentives, and Programs (RCI-1)	103.00
Carbon Intensity Targets (ES-6)	70.40
Solid Waste Management (RCI-12)	36.00
State Clean Car Program (TLU-1)	32.50
Integrated Resource Planning (ES-12)	28.00
Ethanol Production and Use (A-3)	28.00
Smart Growth Bundle of Options (TLU-2)	26.70
"Beyond Code" Building Design Incentives and Programs for Smart Growth (RCI-5)	18.00
Distributed Generation/Combined Heat and Power (RCI-6)	16.00
Electricity Pricing Strategies (RCI-8)	16.00
Reduce Barriers to Renewables and Clean Distributed Generation (ES-9)	16.00
Pricing Strategies (ES-11)	16.00
Building Standards/Codes for Smart Growth (RCI-4)	14.00
Pay-As-You-Drive Insurance (TLU-9)	12.30
Reduction of Vehicle Idling (TLU-4)	11.80
Distributed Generation/Renewable Energy Applications (RCI-7)	10.00
Direct Renewable Energy Support (ES-3) (including Tax Credits and Incentives, R&D, and siting/zoning)	10.00
Appliance Standards (RCI-3)	7.00
Demand-Side Fuel Switching (RCI-10)	7.00
Forest Ecosystem Management – Residential Lands (F-3a)	6.40

Policy Option	$MMtCO_2e$
Biodiesel Implementation (TLU-12)	6.20
Water Use and Wastewater Management (RCI-13)	6.00
60 mph Speed Limit for Commercial Trucks (TLU-14)	5.20
Low Rolling Resistance Tires and Tire Inflation (TLU-10)	4.80
Biomass Feedstocks for Electricity or Steam Production (A-2)	4.54
Manure Management – Manure Digesters (A-1)	3.82
Forestland Protection from Developed Uses (F-1)	3.73
State Leadership Programs (RCI-2)	3.00
Forest Ecosystem Management – Other Lands (F-3b)	2.90
Reduce Conversion of Farm and Rangelands to Developed Uses (A-8)	1.59
Accelerated Replacement/ Retirement of High-Emitting Diesel Fleet (TLU-11)	1.20
Reforestation/Restoration of Forestland (F-2)	0.65
State Lead-By-Example (via Procurement and SmartWay) (TLU-13)	0.40
Programs to Support Local Farming/Buy Local (A-9)	0.15

The data presented illustrate the potential "stand alone" GHG emissions reductions achievable separately under each individual policy option if the option was implemented solely by itself and not in conjunction with other policy options. The potential GHG emissions reduction figures do not account for overlaps that could occur between reductions achievable under individual policy options if the options were implemented together.

For example, while Figure E-4 shows cumulative GHG emissions reductions of 116 $MMtCO_2e$ for policy option ES-1 as a "stand alone" option, the total would become 70.3 $MMtCO_2e$ if the option were implemented in conjunction with all of the other recommended policy options, due to overlaps (especially with the RCI sector). See pages H-3 to H-4 in Appendix H. The same principle applies for ES-6, which changes from 70.4 $MMtCO_2e$ to 50.3 $MMtCO_2e$. See page H-18 in Appendix H. When adjusted for overlaps to avoid double counting, the cumulative GHG emissions reductions potentially achievable from 2007-2020 through full implementation of all of the CCAG's recommended policy options is 485.4 $MMtCO_2e$. See Table 1-3 on page 24 and footnote 15.

CHAPTER 1: OVERVIEW

Executive Order 2005-02

On February 2, 2005, Governor Janet Napolitano signed Executive Order 2005-02 establishing the Climate Change Advisory Group (CCAG). Appointed by the Governor, the 35-member CCAG comprised a diverse group of stakeholders who brought broad perspective and expertise to the topic of climate change in Arizona. The Governor's Executive Order directed the CCAG, under the coordination of the Arizona Department of Environmental Quality (ADEQ), to:

1) prepare an inventory and forecast of Arizona greenhouse gas (GHG) emissions; and
2) develop a Climate Change Action Plan with recommendations for reducing GHG emissions in Arizona.

The Executive Order declared that "scientific consensus has developed that increasing emissions of carbon dioxide (CO_2), methane and other greenhouse gases released to the atmosphere are affecting the Earth's climate" and emphasized that "Arizona and other Western States have particular concerns about the impacts of climate change and climate variability on the environment, including the potential for prolonged drought, severe forest fires, warmer temperatures, increased snowmelt, reduced snow pack and other effects."

The Executive Order also recognized that "a number of states are addressing climate change and greenhouse gas emissions on an individual and/or regional basis" and declared that "actions to reduce GHG emissions, including increasing energy efficiency, conserving natural resources and developing renewable energy sources, may have multiple benefits including economic development, job creation, cost savings, and improved air quality."

The CCAG Process

The CCAG held its first meeting on July 14, 2005, followed by a year of intensive fact-finding and consensus building. The CCAG met six times, with its last formal meeting on June 22, 2006. During this period, five sector-based technical work groups (TWGs) of the CCAG met a total of 40 times via teleconference, beginning in August 2005 and concluding in May 2006.

The TWGs consisted of CCAG members as well as other individuals with interest and expertise in the issues being addressed by each TWG. The five TWGs were: Energy Supply (ES); Residential, Commercial, Industrial and Waste Management (RCI); Transportation and Land Use (TLU); Agriculture and Forestry (AF); and Cross-Cutting Issues (CC).

The CCAG process involved a model of informed self-determination through a facilitated stepwise consensus building approach. Under the oversight of ADEQ, the process was conducted by The Center for Climate Strategies (CCS), an independent, expert facilitation and technical analysis

team, based on procedures that CCS consultants have used in a number of other state climate change planning initiatives since 2000, adapted specifically for Arizona.

During the course of the process, the CCAG reached technical consensus on specific mitigation options and evaluative findings related to benefits, costs, and ancillary and feasibility issues associated with options, followed by development of policy consensus on individual recommendations. The CCAG process sought but did not mandate consensus, and it explicitly documented the level of CCAG support for individual policy recommendations and key findings established through a voting process, including barriers to consensus where they existed.

The recommendations adopted by the CCAG and presented in this report underwent two levels of screening by the CCAG. First, a potential policy option being considered by a TWG was accepted as a "priority for analysis" and developed for full analysis only if it had a supermajority of support from CCAG members (with a "supermajority" defined as five or fewer "no" votes or objections). Second, after the analyses were conducted, only policy options that received at least majority support from CCAG members were adopted as recommendations by the CCAG and included in this report.

In total, of the 49 policy recommendations adopted by the CCAG, 45 received unanimous consent, two (2) received a supermajority of support, and two (2) received a majority of support (see later chapters in this report and the Appendices for details).

Arizona GHG Emissions Inventory and Forecast

Prior to the first meeting of the CCAG, a preliminary inventory and forecast of GHG emissions for Arizona for years 1990 through 2020 was produced pursuant to Executive Order 2005-02. This document, entitled "Arizona GHG Emissions Inventory and Reference Case Projections, 1990–2020," was completed in June 2005, and then approved by unanimous consent at the CCAG's December 2005 meeting following technical review and revision by the CCAG. This assessment included detailed coverage of all economic sectors and GHGs in Arizona, including future emissions trends and assessment issues related to energy, economic and population growth. Figure 1-1 depicts the level of emissions from each sector in Arizona in year 2000. For comparison, Figure 1-2 shows GHG emissions in the United States as a whole by economic sector.

Figure 1-1 Arizona Greenhouse Gas (GHG) Emissions in 2000

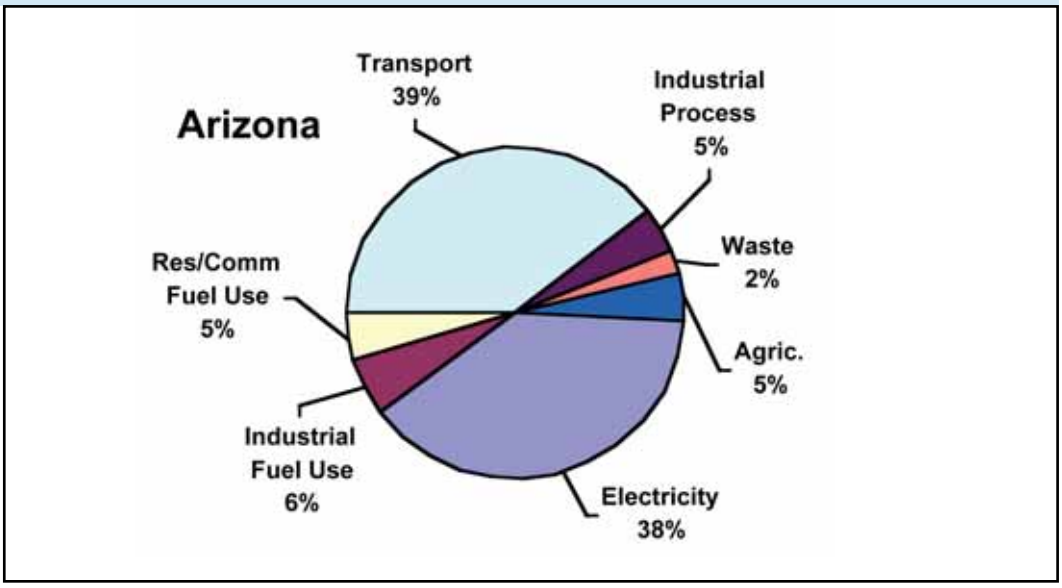
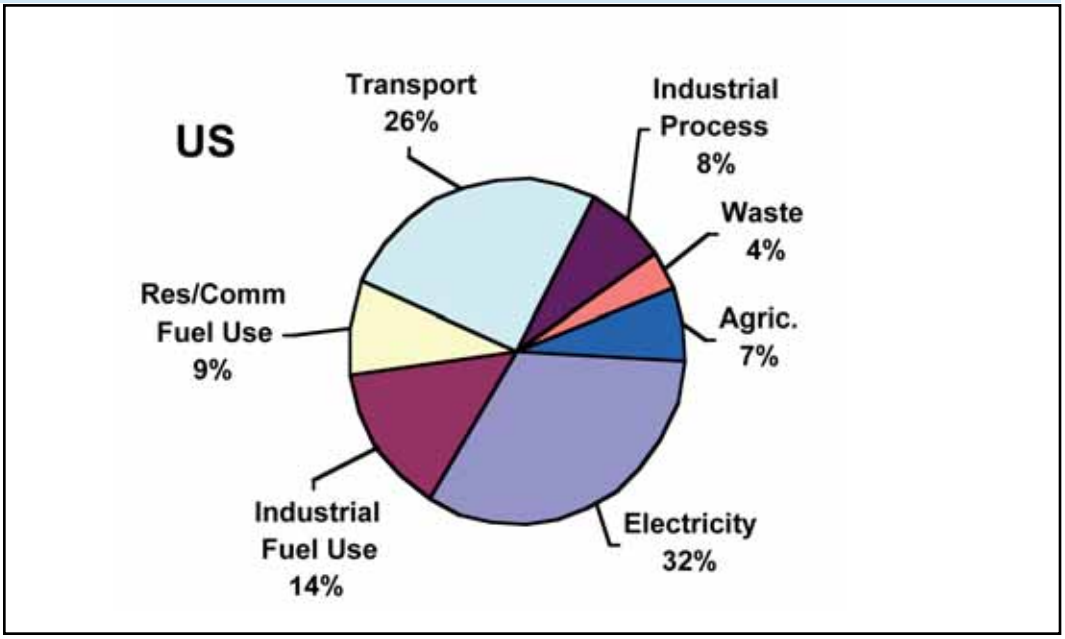


Figure 1-2 US Greenhouse Gas (GHG) Emissions in 2000



The inventory of Arizona's GHG emissions provided several critical findings, including:

- Between 1990 and 2005 Arizona's net GHG emissions increased by nearly 56%, from an estimated 59.3 million metric tons carbon dioxide equivalent ($MMtCO_2e$) to an estimated 92.6 $MMtCO_2e$.[1]
- Arizona's GHG emissions have increased more than the nation as a whole, driven by Arizona's high population and economic growth combined with relatively high levels of energy use and carbon intensive energy sources, particularly coal and petroleum. The State's GHG emissions are forecasted to increase by 148% from 1990 to 2020[2], while national emissions are forecasted to rise by about 42% over this same period.[3]
- Arizona's per capita GHG emissions (the total level of statewide emissions divided by state population) of 14 metric tons carbon dioxide equivalent (tCO_2e) are less than the national average of 22 tCO_2e because of the relative absence of heavy industry in the State and other factors, such as lower than average heating needs for buildings and facilities.
- The transportation and electricity sectors account for more than three-fourths – roughly 77% -- of Arizona's total GHG emissions, and are higher than the national average. Both sectors are growing at relatively high rates as well.
- Other fossil fuels usage – such as natural gas, oil products, and coal – in the residential, commercial, and industrial sectors contributes another 11% of the state total, while other industrial processes, agriculture and waste account for about 12% combined.
- The storage of forest carbon was found to have a significant offsetting effect to emissions from other sources.

The emissions forecast revealed substantial emissions growth rates and related policy challenges. Arizona's projected GHG increase of 148% over 1990 levels by the year 2020 (without further mitigation actions) is the highest known projected emissions growth rate in the country.[4]

Arizona's rate is almost five times the average growth rate for the West Coast and Northeastern states that have completed climate action plans. (The average projected GHG emissions growth rate for these states during the 1990-2020 period is 33%.) Figure 1-3 compares Arizona's projected GHG emissions growth with the growth in other states that are addressing their GHG emissions (expressing the increase from 1990-2020 as a percentage of 1990 levels for each state). Figure 1-4 provides a detailed breakdown of forecasted GHG emissions in Arizona by sector.[5]

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[1] Arizona's GHG emissions in 2000 were an estimated 82.3 $MMtCO_2e$, a 40% increase over 1990 levels.

[2] These growth figures take into account the projected effects of recent energy efficiency related actions for the RCI sectors adopted by the State. Taking these actions into account, Arizona's GHG emissions are projected to be roughly 147 $MMtCO_2e$ in 2020. Without these actions emissions growth in 2020 would be forecasted to increase by 159% over 1990 levels for a total of nearly 154 $MMtCO_2e$ in 2020.

[3] U.S. Energy Information Administration CO_2 inventory and forecast data from 1990 to 2030, available at www.eia.doe.gov/environment.html.

[4] These emissions estimates do not include black carbon and organic carbon contributions, such as soot, smoke and fine particulate matter from diesel emissions. These contributions are difficult to convert into CO_2 equivalents, but application of available methods indicates that black carbon and organic carbon emissions may have accounted for 3 to 6 $MMtCO_2e$ in Arizona in 2002.

[5] The figures used for projected GHG emission increases do not take into account impacts on energy demand resulting from higher temperatures due to climate change; rather, the figures assumed current, business-as-usual scenarios.

Figure 1-3 Comparison of 1990-2020 GHG Emissions Growth for States with Climate Plans

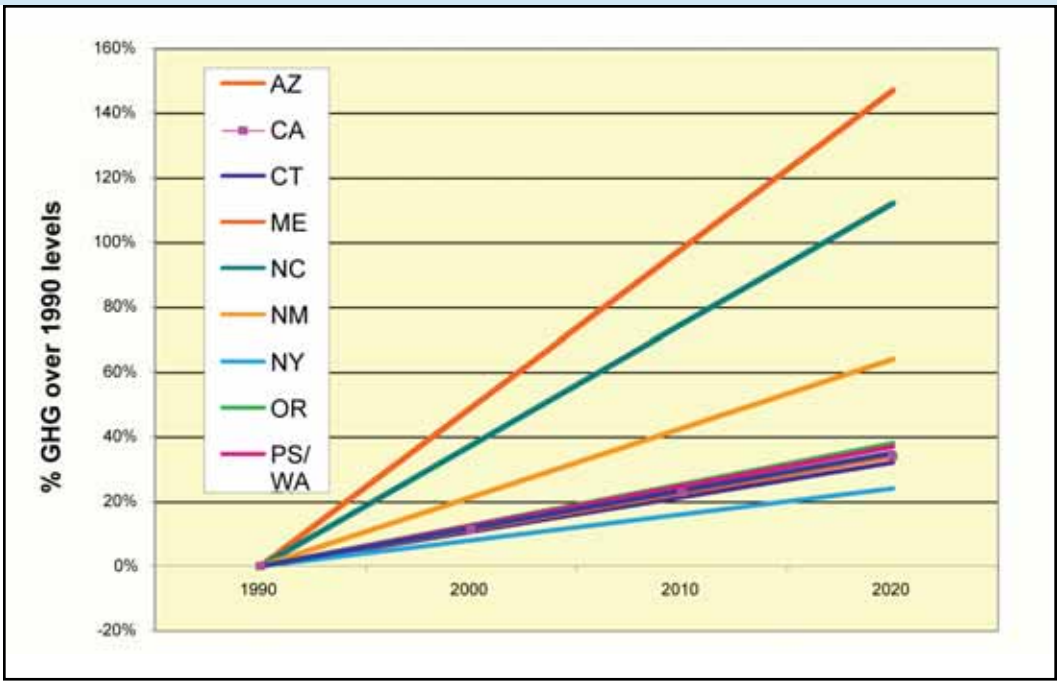
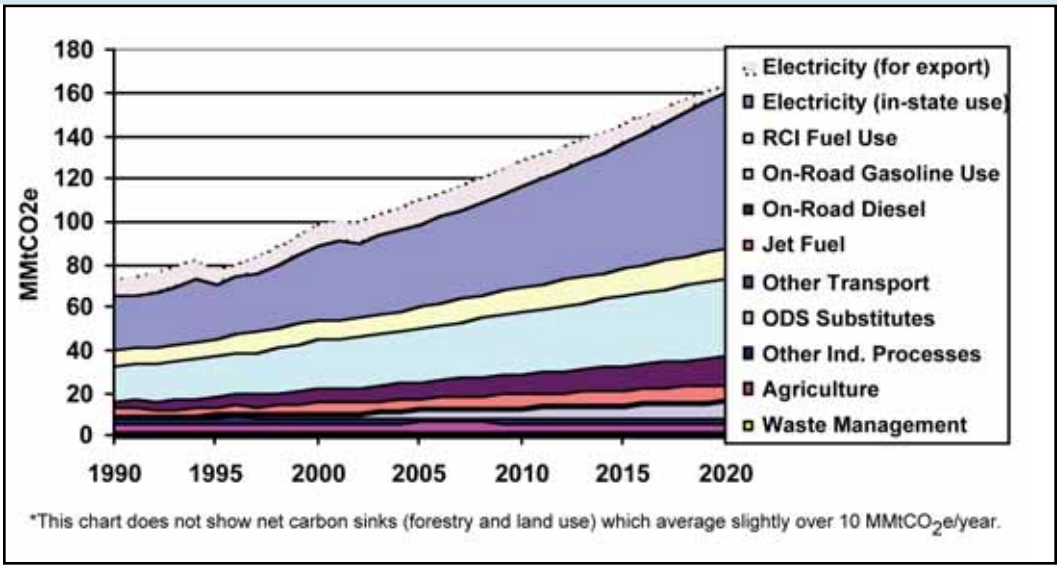


Figure 1-4 Chart of Projected Arizona GHG Emissions from 1990-2020



MMtCO$_2$e - Million Metric Tons Carbon Dioxide Equivalent
RCI - Residential Commercial Industrial
ODS – Ozone Depleting Substances

While Arizona's high emissions growth rate presents challenges, it also provides major opportunities. Because more than three-fourths of Arizona's GHG emissions are directly related to energy and transportation, the opportunity exists for Arizona to reduce its GHG emissions while continuing its strong economic growth by being more energy efficient, using more renewable energy sources, building new infrastructure "right" in the first place to produce lower GHG emissions and increasing the use of cleaner transportation modes, technologies and fuels.

The CCAG's Policy Options

A. The Overarching Recommendation:

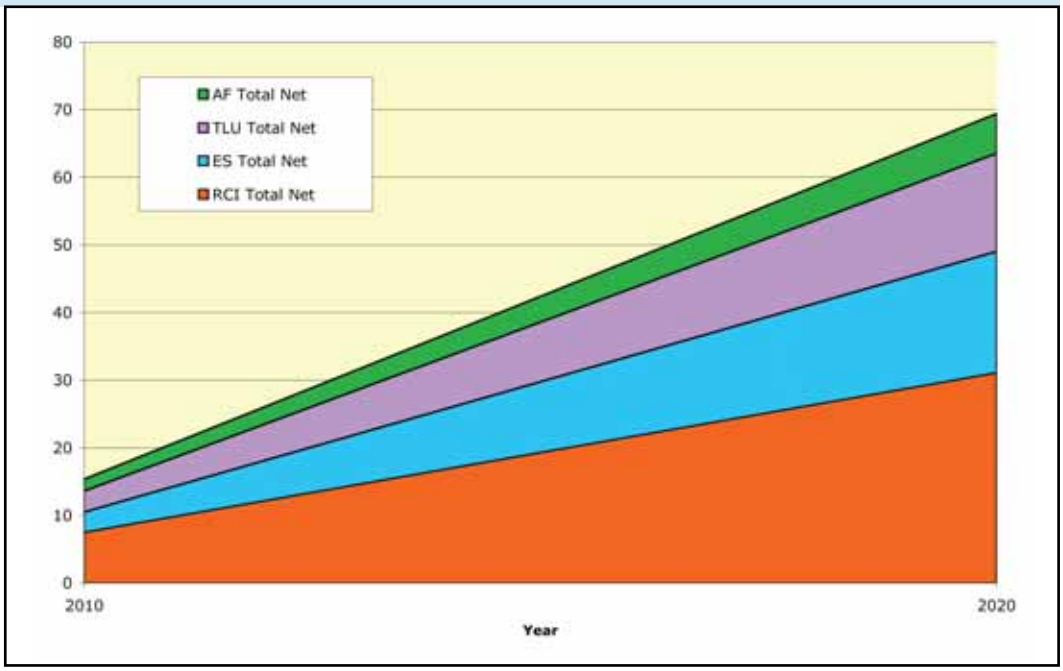
Set a State Goal to Reduce Arizona's GHG Emissions to 2000 Levels by 2020 and to 50% below 2000 Levels by 2040

As an overarching policy matter, the CCAG recommends that Arizona establish a statewide goal of reducing future GHG emissions to a level equal to 2000 emissions by the year 2020, and to 50% below the 2000 emissions level by the year 2040.

The recommended goals for significant reductions in Arizona's GHG emissions reflect the CCAG's recommendations for 49 specific policy recommendations and extensive consideration of benefits, costs, and feasibility issues. In fact, the CCAG's recommended policy options, if fully implemented, could reduce GHG emissions in Arizona by several million metric tons more than the amounts called for in the recommended goal. The CCAG's policy optons could cut Arizona's GHG emissions by more than 69 $MMtCO_2e$ in 2020, reducing GHG emissions to more than five percent (5%) below the 2000 level. Cumulative GHG emissions reductions from 2007-2020 for all the policy options combined could total more than 485 $MMtCO_2e$ (adjusted for overlaps to avoid double-counting of reductions).

The GHG reductions between 2010 and 2020 achievable by sector under the CCAG's recommendations are shown in Figure 1-6, which illustrates that a significant portion of the achievable reductions are associated with energy efficiency and renewable energy policy options in the residential, commercial, and industrial sectors.

Figure 1-5 2010 through 2020 GHG Reductions, by Sector



AF – Agriculture and Forestry
TLU – Transportation and Land Use
ES – Energy Supply
RCI – Residential Commercial Industrial (fuel use)

The recommended goal for Arizona is consistent with the goals set by other states, including those in the West, that are implementing GHG reduction strategies. Table 1-1 below shows how the CCAG's recommendation compares to the goals set by other states:

Table 1-1 Greenhouse Gas (GHG) Reduction Goals & Timelines by State

STATE	GHG REDUCTION GOALS & TIMELINES BY STATE
AZ	2000 levels by 2020; 50 percent below 2000 levels by 2040
CA	2000 levels by 2010; 1990 levels by 2020; 80 percent below 1990 levels by 2050
CT	1990 levels by 2010; 10 percent below by 2020; 75 percent below by 2100
MA	1990 levels by 2010; 10 percent below by 2020; 75 percent below by 2100
ME	1990 levels by 2010; 10 percent below by 2020; 75 percent below by 2100
NJ	3.5 percent below 1990 levels by 2005
NM	2000 levels by 2012; 10 percent below by 2020; 75 percent below 2050
NY	5 percent below 1990 levels by 2010; 10 percent below by 2020
OR	1990 levels by 2010; 10 percent below by 2020; 75 percent by 2050
RI	1990 levels by 2010; 10 percent below by 2020; 75 percent by 2100
WA (Puget Sound)	1990 levels by 2020; 70-80 percent below 1990 levels by 2050

While the CCAG's recommended goal calls for a somewhat lower percentage reduction in GHG emissions against a base year of 1990 than in other states, the goal is aggressive in light of Arizona's record projected baseline growth rate. Moreover, the CCAG's recommended goal also is consistent with the scale of reductions estimated by the IPCC and the National Academies of Science (NAS) needed to stabilize future GHG emissions.[6]

The CCAG strongly recommends the early and aggressive implementation of the recommendations in this Action Plan, and a corresponding set of incentives to promote such early adoption. The CCAG believes that early action and implementation of its policy recommendations are critical to put Arizona quickly on the path toward significant emissions reductions. The CCAG also urges that the policy options be implemented as a set, to the greatest extent practicable, to achieve the maximum GHG emissions reductions possible.

[6] IPCC, Third Assessment Report, Summary for Policymakers, 2001, p. 20. http://www.ipcc.ch/pub/un/syreng/spm.pdf

B. Overview of the Policy Options

The CCAG is recommending a comprehensive set of 49 policy options to reduce GHG emissions in Arizona. These recommendations are summarized in Table 1-2 at the end of this chapter and include: 12 actions in the Residential, Commercial, Industrial and Waste Management (RCI) sectors; 8 actions in the Energy Supply (ES) sector; 13 actions in the Transportation and Land Use (TLU) sector; 11 actions in the (AF) Agriculture and Forestry sectors[7]; and 5 Cross Cutting (CC) issues across all sectors. The detailed descriptions of these recommendations presented in this report and its appendices also include a wide variety of potential implementation approaches considered by the CCAG.

Although not prepared in coordination with other state and regional actions, the recommendations adopted by the CCAG are consistent with and supportive of resolutions adopted by the Western Governors Association (WGA), including those adopted at its June 2006 annual meeting in Sedona, Arizona, pertaining to "Regional and National Policies Regarding Global Climate Change,"[8] "Clean and Diversified Energy for the West,"[9] and "Transportation Fuels for the Future,"[10] as well as the recommendations of the WGA's Clean and Diversified Energy Advisory Committee (CDEAC).[11]

In addition to substantially reducing Arizona's GHG emissions, implementation of the CCAG's recommendations would produce significant economic benefits for the state. The Center for Climate Strategies (CCS) has calculated overall net economic cost savings from the CCAG's recommendations of more than $5.5 billion between 2007-2020, with additional significant cost savings also expected between 2020-2040 (although not calculated by the CCS). The CCS also has calculated an average net economic cost savings of nearly $13 per ton of GHGs removed under the CCAG's recommended policy options (if fully implemented).

The CCAG's recommendations also complement other efforts underway, including those by the Growing Smarter Oversight Council, which is addressing issues associated with current and projected growth in Arizona. This underscores the potential co-benefits of the CCAG's recommended policy options.

Finally, the CCAG has recommended that, while taking action to reduce GHG emissions in Arizona, the Governor also should develop a State climate change adaptation strategy that identifies – and outlines steps for responding to – the potential impacts of climate change on the State. Because of the current build-up in the atmosphere of GHGs and the length of time (100 years or longer) that GHGs like CO_2 will remain in the atmosphere, Arizona will experience the effects of climate change for years to come, even if immediate action is taken to reduce future GHG emissions. As such, it is essential that Arizona develop a strategy to manage the projected impacts of ongoing climate

[7] Policy options F-3a and F-3b address Forest Ecosystem Management, on residential lands and other lands, respectively. While they are summarized collectively in the narrative of this Action Plan, they are counted separately for the total number of policy options.
[8] Resolution 06-3 http://www.westgov.org/wga/policy/06/climate-change.pdf
[9] Resolution 06-10 http://www.westgov.org/wga/policy/06/clean-energy.pdf
[10] Resolution 06-20 http://www.westgov.org/wga/policy/06/futurefuels.pdf
[11] http://www.westgov.org/wga/meetings/am2006/CDEAC06.pdf

change, and to that end, the CCAG recommends, among other actions, that the Governor consider appointing a task force or advisory group to develop recommendations for the State adaptation strategy.

C. Summary of the Recommended Individual Policy Options

Short summaries of the 49 policy options recommended by the CCAG are listed below.[12] More detailed descriptions of individual policy options can be found in the sector chapters which follow. Fully detailed descriptions of the individual policy options that were presented to and approved by the CCAG can be found in the Technical Appendices.

Cross-Cutting (CC) All Sectors

State Greenhouse Gas Reduction Goal (CC-1)

Arizona should establish a statewide GHG reduction target to lower GHG emissions to 2000 levels by 2020 and to 50% below 2000 GHG levels by 2040. The emissions reductions achievable through the specific recommendations adopted by the CCAG can exceed these goals in 2020.

State Greenhouse Gas Reporting (CC-2)

Arizona should implement a GHG reporting mechanism to support tracking and management of GHG emissions. A reporting mechanism will assist in future emissions inventories, promote awareness and action to reduce GHG emissions, and is an essential precursor enabling a GHG registry and possible future trading opportunities. To the greatest extent possible, GHG reporting should be structured collaboratively with other interested states.

State Greenhouse Gas Registry (CC-3)

Arizona should implement a GHG registry mechanism – preferably on a regional basis in concert with other interested states – to enable tracking, management, crediting, and "baseline protection" for entities that reduce GHG emissions.

State Climate Action Education and Outreach (CC-4)

Arizona should undertake extensive climate change education and outreach activities to create a foundation of public awareness to ensure the long-term success of the State's mitigation and adaptation actions.

State Climate Change Adaptation Strategy (CC-5)

Arizona should develop and implement a comprehensive state climate change adaptation strategy to manage the projected impacts of climate change while simultaneously taking action to reduce its GHG emissions. The Governor may wish to appoint a CCAG-like task force or advisory group to develop this strategy.

[12] More detailed descriptions and discussion of the policy options are presented in chapters 4-8 of this Action Plan and in the Appendices to the Action Plan (see http://www.azclimatechange.us/template.cfm?FrontID=4670).
Gaps in the numbers sequence of policy options reflect options that the CCAG did not approve for recommendation in this Action Plan.

Residential, Commercial, Industrial (RCI) and Waste Management Sectors

Demand-Side Efficiency Goals, Funds, Incentives, and Programs (RCI-1)

Arizona should set energy savings goals for electricity and natural gas, as well as programs and funding mechanisms to achieve these goals:

1) Electricity (energy savings target): 5% savings by 2010, 15% savings by 2020;
2) Natural Gas (utility spending target): ramp up to spending 1.5% of gas utility revenues by 2015.

State Leadership Programs (RCI-2)

Arizona should establish "Lead by Example" initiatives to achieve energy cost savings and promote clean energy technologies by the public and private sectors. Initiatives include a further 15% reduction in energy use per square foot in State buildings from 2011 to 2020; standards for new State buildings; green procurement strategies; and promotion of new combined heat and power (CHP) facilities in State buildings.

Appliance Standards (RCI-3)

Arizona should implement State appliance efficiency standards for appliances not covered by federal standards or where higher-than-federal standard efficiency requirements are appropriate.

Building Standards/Codes for Smart Growth (RCI-4)

Arizona should adopt and implement improved energy efficiency building codes, including potentially establishing a statewide code or strongly encouraging local jurisdictions to adopt and maintain state-of-the-art codes.

"Beyond Code" Building Design Incentives and Programs for Smart Growth (RCI-5)

Arizona should ensure that new and existing buildings achieve high levels of energy efficiency by implementing energy performance standards for State-funded and other government buildings, and by providing incentives for private and other buildings.

Distributed Generation/Combined Heat and Power (RCI-6)

Arizona should encourage distributed generation/combined heat and power (DG/CHP) systems through a combination of regulatory changes and incentive programs.

Distributed Generation/Renewable Energy Applications (RCI-7)

Arizona should promote increasing use of renewable distributed generation through direct incentives for system purchase, market-based incentives for system operation (including "net metering"), State goals or directives, and favorable rules for interconnecting renewable generation systems with the electricity grid.

Electricity Pricing Strategies (RCI-8)

Arizona should implement changes in Arizona electricity pricing and tariffs to provide improved incentives for end-users to conserve energy (through inverted block rates) and to adjust the timing of energy use to the extent this reduces GHG emissions.

Mitigating High Global Warming Potential Gas Emissions (RCI-9)

Arizona should consider promoting the use of low "global warming potential" refrigerants in retail food stores, restaurants, and refrigerated transport vehicles (trucks and railcars) through voluntary agreements, specifications, and incentives.

Demand-Side Fuel Switching (RCI-10)

Arizona should encourage consumers to switch from high-carbon fuels (coal and oil) to lower-carbon fuels (natural gas) or "low or zero carbon" energy sources (solar water heating or biofuels) through a combination of incentives and targeted research.

Solid Waste Management (RCI-12)

Arizona should ensure that curbside recycling programs are provided in all communities over 50,000 in population; increase the penetration of recycling in multi-family dwellings; create new recycling programs for the commercial sector (including construction materials); develop markets for recycled materials; increase participation/recovery rates for existing recycling programs; develop a statewide recycling goal; and reduce waste generation.

Water Use and Wastewater Management (RCI-13)

Arizona should accelerate investment in water use efficiency, increase the energy efficiency of all water and wastewater treatment operations, increase renewable energy production by water and wastewater agencies; encourage and create incentives for technologies with the capability to reduce water use associated with power generation; and ensure that power plants use the best management practices and economically feasible technology available to conserve water.

Energy Supply (ES) Sector

Environmental Portfolio Standard /Renewable Energy Standard and Tariff (ES-1)

Arizona should adopt a more aggressive renewable energy mandate than the current Environmental Portfolio Standard. It would start with the 2005 requirement for 1% renewables and increase it 1% each year to 26% in 2025, allowing out-of-state renewables and renewable energy credits (RECs) trading. Further, the CCAG recommends applying this requirement to generation statewide, not only to Arizona Corporation Commission (ACC) jurisdictional utilities.

Direct Renewable Energy Support (ES-3)

Arizona should encourage investment in renewables by providing direct financial incentives and by removing siting and zoning barriers to renewable energy facilities. *(Note: This recommendation is brought forward by the CCAG jointly with recommendation RCI-7 concerning Distributed Generation/Renewable Energy Applications.)*

GHG Cap and Trade Program (ES-4)

Arizona should explore the development of a regional or national, economy-wide cap and trade program for GHG emissions. (*Note: While this recommendation originated in the Energy Supply workgroup and focused initially on utilities, the CCAG "economy-wide" reference explicitly recommends that a multi-sector cap and trade program be investigated.*)

Carbon Intensity Targets (ES-6)

Arizona should implement a mandatory carbon intensity target that begins in 2010 (i.e., equal to carbon intensity in 2010) and declines by 3 percent annually through 2025. The carbon intensity target would be translated annually into a cap, and trading would be allowed under that cap.

Reduce Barriers to Renewables and Clean Distributed Generation (ES-9)

Arizona should remove barriers to renewable energy and clean distributed generation (DG) to enable more clean generation to enter Arizona's energy supply mix. This would have the effect of displacing fossil fuel generation, thereby reducing CO_2 emissions. (*Note: This recommendation is brought forward by the CCAG jointly with recommendation RCI-6 concerning Distributed Generation/Combined Heat and Power.*)

Metering Strategies (ES-10)

Arizona should implement two effective metering strategies:

Net metering allows owners of grid-connected distributed generation (generating units on the customer side of the meter) to generate excess electricity and sell it back to the grid, effectively "turning the meter backward."

Advanced metering allows electricity customers much greater opportunity to manage their electricity consumption, such as setting a meter to turn off or turn down air conditioning while away.

Pricing Strategies (ES-11)

Arizona should implement pricing strategies such as "*real-time pricing*" in which utility customer rates are not fixed, but reflect the varying costs that utilities actually pay for power; *"time-of-use"* rates, which differ for different times of the day and/or different seasons; *"increasing block"* rates whereby prices increase with higher consumption; and *green pricing* whereby customers are given the opportunity to purchase electricity with a renewable or cleaner mix than the standard supply mix offered by the utility.

Integrated Resource Planning (ES-12)

Arizona should implement an Integrated Resource Planning (IRP) process, which integrates technology and policy options on the demand side with supply side options to satisfy anticipated future demand for energy. (Traditional approaches simply focus on supply-side options to meet forecasted load growth.) Demand-side measures include energy efficiency, distributed generation, waste energy recycling, and peak-shaving measures.

Transportation and Land Use (TLU) Sector

State Clean Car Program (TLU-1)

Arizona should adopt the State Clean Car Program emissions standards adopted by 11 states in order to reduce the net emissions of GHGs from passenger vehicle operation. The standards, which must still be approved by the U.S. Environmental Protection Agency (EPA), would take effect in Model Year 2011 (calendar year 2010).

Smart Growth Bundle of Options (TLU-2)

Arizona should implement a bundle of options to reduce GHG emissions through land use practices and policies. The options include:

1) infill and brownfield redevelopment;
2) transit-oriented development;
3) pedestrian and bicycle friendly development;
4) smart growth planning, modeling and tools;
5) promoting use of multi-modal transit options;
6) increased density.

Multi-Modal Transit Options (TLU-3)

Arizona should implement a bundle of options to reduce GHG emissions through land use practices and policies that specifically promote the use of multi-modal transit options.

Reduction of Vehicle Idling (TLU-4)

Arizona should implement policies to reduce idling from diesel and gasoline heavy-duty vehicles, buses, and other vehicles through the combination of a statewide anti-idling rule and by promoting and expanding the use of technologies that reduce heavy-duty vehicle idling. These technologies include:

1) automatic engine shut down/start up system controls;
2) direct fired heaters (for providing heat only);
3) auxiliary power units;
4) truck stop electrification.

Standards for Alternative Fuels (TLU-5)

Arizona should develop and enforce a State standard for neat biodiesel (B100), biodiesel blends, and ethanol blends to ensure fuel quality and reduce emissions and performance problems with these fuels, and to enable more widespread acceptance of these fuels.

Hybrid Promotion and Incentives (TLU-7)

Arizona should encourage government programs to promote and incentivize the purchase of hybrid vehicles, including reduction in fees and taxes (such as the State's Vehicle License Tax) and giving preferential infrastructure access to hybrids on carpool lanes or metered parking spaces.

Feebates (TLU-8)

Arizona should study the desirability/feasibility of a "feebate" program to incentivize greater consumer choices and purchase of vehicles that produce lower emissions of GHGs while conserving fuel, including:

1) a fee on relatively high emissions/lower fuel economy vehicles and
2) a rebate or tax credit on low emissions/higher fuel economy vehicles.

Pay-As-You-Drive Insurance (TLU-9)

Arizona should implement a pilot program to test the feasibility of allowing *"pay as you drive"* (PAYD) insurance under which insurance rates would be based on the miles driven.

Low Rolling Resistance Tires and Tire Inflation (TLU-10)

Arizona should establish a tire replacement program for low-rolling resistance tires, which manufacturers currently use on new vehicles but are not easily available to consumers as replacement tires. Arizona also should promote proper tire inflation to improve mileage and reduce emissions.

Accelerated Replacement/Retirement of High-Emitting Diesel Fleet (TLU-11)

Arizona should reduce GHG black carbon emissions from heavy-duty diesel vehicles by developing and implementing an incentives program in Arizona to accelerate the replacement and/or retirement of the highest-emitting diesel vehicles.

Biodiesel (TLU-12)

Arizona should implement a series of proposals to increase the use of biodiesel in Arizona.

State Lead-By-Example via Vehicle Procurement and SmartWay (TLU-13)

Arizona state agencies should "lead by example" by adopting procurement policies and practices and/or joining the EPA SmartWay program to achieve a lower-emitting vehicle fleet for the State.

60 MPH Speed Limit for Commercial Trucks (TLU-14)

Arizona should reduce the speed limit for commercial trucks to 60 mph on Arizona highways and freeways.

Agriculture (A) and Forestry (F) Sectors

Manure Management - Manure Digesters (A-1)

Arizona should reduce methane emissions from livestock manure through the use of manure digesters installed at dairies and promote energy utilization of the methane captured (e.g., electricity production).

Biomass Feedstocks for Electricity or Steam Production (A-2)

Arizona should implement programs to displace fossil fuel use through the use of agricultural waste (e.g., orchard trimmings, and other crop residue) as a feedstock for electricity or steam production.

Ethanol Production and Use (A-3)

Arizona should provide incentives for the production of ethanol from crops, agricultural waste, or other materials to offset fossil fuel (gasoline) use.

Convert Agricultural Land to Grassland or Forest (A-7)

Arizona should increase carbon sequestration in agricultural land by converting marginal land used for annual crops to permanent cover (grassland or forests).

Reduce Conversion of Farm and Rangelands to Developed Uses (A-8)

Arizona should reduce the rate at which existing crop and rangelands are converted to developed uses.

Programs to Support Local Farming/Buy Local (A-9)

Arizona should promote consumption of locally-produced agricultural commodities, which would offset consumption of commodities transported from other states or countries.

Forestland Protection from Developed Uses (F-1)

Arizona should implement policy initiatives to decrease the conversion of forest and woodlands to urban and other developed uses.

Reforestation/Restoration of Forestland (F-2)

Arizona should expand forest cover (and associated carbon stocks) by regenerating or establishing forests in areas with little or no present forest cover.

Forest Ecosystem Management (F--3a & 3b)

Arizona should use 50% or more of biomass extracted from residential and non-residential lands for wood products and/or energy production; accelerate current and planned fuels treatments in Arizona; and have the Governor's Forest Health Oversight Council and Forest Health Advisory Council review forest management practices and policies aimed at GHG reduction and carbon sequestration.

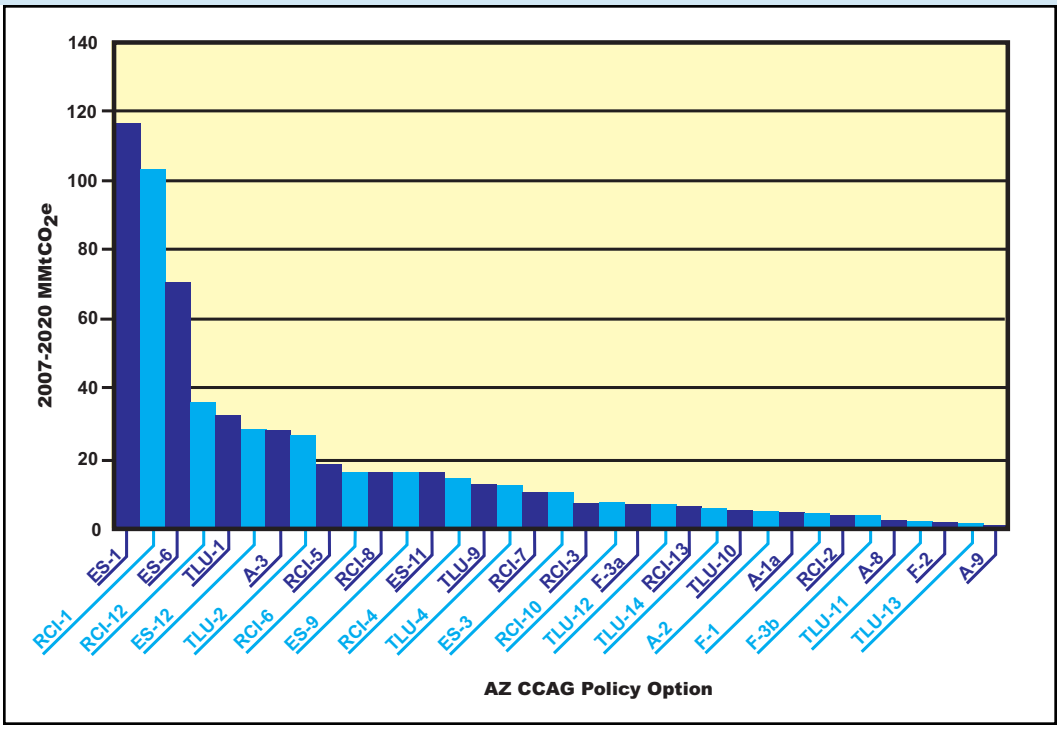
Improved Commercialization of Biomass Gasification and Combined Cycle (F-4)

Arizona should accelerate the rate of technology development and market deployment of biomass gasification and combined cycle (BGCC) technologies.

Policy Option Rankings by Reductions and Savings/Costs

Figures 1-7 and 1-8 and Table 1-2 below show the amount of GHG emissions reductions achievable from 2007-2020 under each individual, quantified policy option.[13] The CCS was able to quantify the GHG emissions reduction potential for 35 of the 49 total recommended policy options. Figure 1-8 ranks the CCAG's recommended policy options by total savings/cost per ton GHG removed over this same period.

Figure 1-7 CCAG Recommended Policy Options, by Quantified Indvidual GHG Reduction 2007-2020



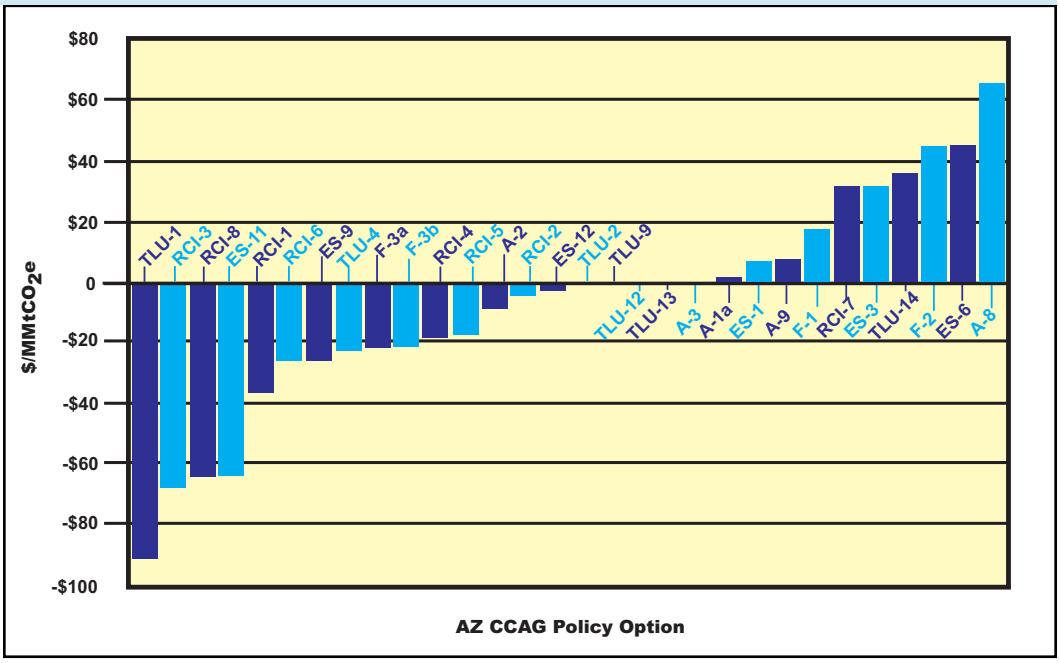
Policy Option	$MMtCO_2e$
Environmental Portfolio Standard/Renewable Energy Standard and Tariff (ES-1)	116.00
Demand-Side Efficiency Goals, Funds, Incentives, and Programs (RCI-1)	103.00
Carbon Intensity Targets (ES-6)	70.40
Solid Waste Management (RCI-12)	36.00
State Clean Car Program (TLU-1)	32.50
Integrated Resource Planning (ES-12)	28.00
Ethanol Production and Use (A-3)	28.00
Smart Growth Bundle of Options (TLU-2)	26.70
"Beyond Code" Building Design Incentives and Programs for Smart Growth (RCI-5)	18.00
Distributed Generation/Combined Heat and Power (RCI-6)	16.00
Electricity Pricing Strategies (RCI-8)	16.00
Reduce Barriers to Renewables and Clean Distributed Generation (ES-9)	16.00
Pricing Strategies (ES-11)	16.00

[13] Quantification reflects potential GHG reduction if each option is implemented alone, rather than as part of a comprehensive package of CCAG-recommended options. Results would appear lower when overlaps and duplication are taken into account.

Policy Option	$MMtCO_2e$
Building Standards/Codes for Smart Growth (RCI-4)	14.00
Pay-As-You-Drive Insurance (TLU-9)	12.30
Reduction of Vehicle Idling (TLU-4)	11.80
Distributed Generation/Renewable Energy Applications (RCI-7)	10.00
Direct Renewable Energy Support (ES-3) (including Tax Credits and Incentives, R&D, and siting/zoning)	10.00
Appliance Standards (RCI-3)	7.00
Demand-Side Fuel Switching (RCI-10)	7.00
Forest Ecosystem Management – Residential Lands (F-3a)	6.40
Biodiesel Implementation (TLU-12)	6.20
Water Use and Wastewater Management (RCI-13)	6.00
60 mph Speed Limit for Commercial Trucks (TLU-14)	5.20
Low Rolling Resistance Tires and Tire Inflation (TLU-10)	4.80
Biomass Feedstocks for Electricity or Steam Production (A-2)	4.54
Manure Management – Manure Digesters (A-1)	3.82
Forestland Protection from Developed Uses (F-1)	3.73
State Leadership Programs (RCI-2)	3.00
Forest Ecosystem Management – Other Lands (F-3b)	2.90
Reduce Conversion of Farm and Rangelands to Developed Uses (A-8)	1.59
Accelerated Replacement/ Retirement of High-Emitting Diesel Fleet (TLU-11)	1.20
Reforestation/Restoration of Forestland (F-2)	0.65
State Lead-By-Example (via Procurement and SmartWay) (TLU-13)	0.40
Programs to Support Local Farming/Buy Local (A-9)	0.15

Figure 1-8 CCAG Recommended Policy Options, by Quantified Cost Per Ton GHG Removed

Cost savings are shown below the axis. Net costs are shown above the axis.



Policy Option	Cost/Cost Savings per Ton GHG Removed
State Clean Car Program (TLU-1)	-$90
Appliance Standards (RCI-3)	-$66
Electricity Pricing Strategies (RCI-8)	-$63
Pricing Strategies (ES-11)	-$63
Demand-Side Efficiency Goals, Funds, Incentives, and Programs (RCI-1)	-$36
Distributed Generation/Combined Heat and Power (RCI-6)	-$25
Reduce Barriers to Renewables and Clean Distributed Generation (ES-9)	-$25
Reduction of Vehicle Idling (TLU-4)	-$22
Forest Ecosystem Management – Residential Lands (F-3a)	-$21
Forest Ecosystem Management – Other Lands (F-3b)	-$21
Building Standards/Codes for Smart Growth (RCI-4)	-$18
"Beyond Code" Building Design Incentives and Programs for Smart Growth (RCI-5)	-$17
Biomass Feedstocks for Electricity or Steam/Production (A-2)	-$8
State Leadership Programs (RCI-2)	-$4
Integrated Resource Planning (ES-12)	-$2
Smart Growth Bundle of Options (TLU-2)	$0
Pay-As-You-Drive Insurance (TLU-9)	$0
Biodiesel Implementation (TLU-12)	$0
State Lead-By-Example (via Procurement and SmartWay) (TLU-13)	$0
Ethanol Production and Use (A-3)	$0
Environmental Portfolio Standard/Renewable Energy Standard and Tariff (ES-1)	$6
Programs to Support Local Farming/Buy Local (A-9)	$6
Manure Management – Manure Digesters (A-1)	$7
Forestland Protection from Developed Uses (F-1)	$17
Distributed Generation/Renewable Energy Applications (RCI-7)	$31
Direct Renewable Energy Support (ES-3) (including Tax Credits and Incentives, R&D, and siting/zoning)	$31
60 mph Speed Limit for Commercial Trucks (TLU- 14)	$35
Reforestation/Restoration of Forestland (F-2)	$44
Carbon Intensity Targets (ES-6)	$44
Reduce Conversion of Farm and Rangelands to Developed Uses (A-8)	$65

Table 1-2 CCAG Recommended Policy Options, By Sector

RESIDENTIAL, COMMERCIAL, INDUSTRIAL (RCI) AND WASTE MANAGEMENT					
	CCAG Policy Option	2010 Annual GHG Reduction ($MMtCO_2e$)	2020 Annual GHG Reduction ($MMtCO_2e$)	2007-2020 Cumulative Reduction ($MMtCO_2e$)	Cost/Cost Savings Per Ton GHG Removed ($\$/tCO_2e$)
RCI-1	Demand-Side Efficiency Goals, Funds, Incentives, and Programs	3.1	15.1	103	-$36
RCI-2	State Leadership Programs	0.04	0.4	3	-$4
RCI-3	Appliance Standards	0.2	1.0	7	-$66
RCI-4	Building Standards/Codes for Smart Growth	0.3	2.2	14	-$18
RCI-5	"Beyond Code" Building Design Incentives and Programs for Smart Growth	0.2	3.1	18	-$17
RCI-6	Distributed Generation Combined Heat and Power	0.4	2.7	16	-$25
RCI-7	Distributed Generation Renewable Energy Applications	0.1	2.1	10	$31
RCI-8	Electricity Pricing Strategies	1.1	1.5	16	-$63
RCI-9	Mitigating High Global Warming Potential (GWP) Gas Emissions (HFCs, SFCs, PFCs)	Not available			
RCI-10	Demand-Side Fuel Switching	0.1	1.2	7	Not available
RCI-12	Solid Waste Management	2.2	3.7	36	Not available
RCI-13	Water Use and Wastewater Management	0.2	0.8	6	Not available

Notes

Numbers are rounded to the nearest one-tenth.

Cost savings are shown as negative costs. All costs are estimated using a real discount rate of 5% (see Appendix G for details).

RCI-9: Lack of specific policy design and lack of data prevented estimation of tons and costs.

RCI-10: Lack of data prevented estimation of costs.

RCI-12: Lack of data prevented estimation of costs.

RCI-13: Lack of data prevented estimation of costs.

Table 1-2 CCAG Recommended Policy Options, By Sector

ENERGY SUPPLY (ES)					
	CCAG Policy Option	2010 Annual GHG Reduction ($MMtCO_2e$)	2020 Annual GHG Reduction ($MMtCO_2e$)	2007-2020 Cumulative Reduction ($MMtCO_2e$)	Cost/Cost Savings Per Ton GHG Removed ($\$/tCO_2e$)
ES-1	Environmental Portfolio Standard/Renewable Energy Standard and Tariff	4.2	16.4	116.0	$6
ES-3	Direct Renewable Energy Support (including Tax Credits and Incentives, R&D, and siting/zoning)	0.1	2.1	10.0	$31
ES-4	National or Regional GHG Cap and Trade	- 0.28—0.18	2.0—18.5	7 - 88	$7 - $19
ES-6	Carbon Intensity Targets	0.0	14.0	70.4	$44
ES-9	Reduce Barriers to Renewables and Clean Distributed Generation	0.4	2.7	16.0	-$25
ES-10	Metering Strategies	Not available			
ES-11	Pricing Strategies	1.1	1.5	16.0	-$63
ES-12	Integrated Resource Planning	0.1	5.4	28.0	-$2

Notes

Cost savings are shown as negative costs. All costs are estimated using a real discount rate of 5% (see Appendix H for details).

ES-3: This option is quantified under RCI-7, Distributed Generation/Renewable Energy Applications. Values are shown above for completeness, but not included in cumulative totals to prevent double-counting.

ES-4: These estimates are based on U.S. Energy Information Administration (EIA) modeling of a national cap-and-trade policy and the likely impact on Arizona's power sector based on simple apportionment. The above values reflect the range of results for GHG reductions and costs from four scenarios modeled by EIA. These values are not included in the cumulative totals because Arizona cannot implement a national or regional cap-and-trade policy unilaterally and to avoid duplicative counting of reductions based on overlaps with other policy option recommendations.

ES-9: This option is quantified under RCI-6, Distributed Generation/Combined Heat and Power. Values are shown above for completeness, but not included in cumulative totals to prevent double-counting.

ES-10: This option is an enabling policy for RCI-6 and RCI-7; its quantification is incorporated as part of those options.

ES-11: This option is quantified under RCI-8, Electricity Pricing Strategies. Values are shown above for completeness, but not included in cumulative totals to prevent double-counting.

ES-12: This option overlaps substantially with ES-1, Environmental Portfolio Standard, and ES-6, Carbon Intensity Targets Values are shown above for completeness, but not included in cumulative totals to prevent double-counting.

Table 1-2 CCAG Recommended Policy Options, By Sector

TRANSPORTATION AND LAND USE (TLU)					
	CCAG Policy Option	2010 Annual GHG Reduction ($MMtCO_2e$)	2020 Annual GHG Reduction ($MMtCO_2e$)	2007-2020 Cumulative Reduction ($MMtCO_2e$)	Cost/Cost Savings Per Ton GHG Removed ($\$/tCO_2e$)
TLU-1	State Clean Car Program	0.3	5.6	32.5	-$90
TLU-2	Smart Growth Bundle of Options	1.5	4.0	26.7	$0
TLU-3	Promoting Multimodal Transit	Not available			
TLU-4	Reduction of Vehicle Idling	0.7	1.3	11.8	-$22
TLU-5	Standards for Alternative Fuels	Not available			
TLU-7	Hybrid Promotion and Incentives	Not available			
TLU-8	Feebates	Not available			
TLU-9	Pay-As-You-Drive Insurance	0.0	2.8	12.3	$0
TLU-10	Low Rolling Resistance Tires and Tire Inflation	0.0	0.8	4.8	Not available
TLU-11	Accelerated Replacement/ Retirement of High-Emitting Diesel Fleet	0.2	0.03	1.2	Not available
TLU-12	Biodiesel Implementation	0.1	1.1	6.2	$0
TLU-13	State Lead-By-Example (via Procurement and Smart Way)	0.03	0.04	0.4	$0
TLU-14	60 mph Speed Limit for Commercial Trucks	0.3	0.5	5.2	$35

Notes

Cost savings are shown as negative costs. All costs are estimated using a real discount rate of 5% (see Appendix I for details).

TLU-3: This option was analyzed in tandem with TLU-2; its quantification is incorporated as part of that option.

TLU-5: This option is an enabling policy for TLU-12 and A-3; its quantification is incorporated as part of those options.

TLU-7: This option overlaps substantially with TLU-1; its quantification is incorporated as part of that option.

TLU-8: This option overlaps substantially with TLU-1. Insufficient data prevented estimation of cumulative GHG reductions and costs.

TLU-10: Insufficient data prevented estimation of costs.

TLU-11: Insufficient data prevented estimation of costs.

Table 1-2 CCAG Recommended Policy Options, By Sector

AGRICULTURE (A) AND FORESTRY (F)					
	CCAG Policy Option	2010 Annual GHG Reduction ($MMtCO_2e$)	2020 Annual GHG Reduction ($MMtCO_2e$)	2007-2020 Cumulative Reduction ($MMtCO_2e$)	Cost/Cost Savings Per Ton GHG Removed ($\$/tCO_2e$)
A-1	Manure Management – Manure Digesters	0.2	0.5	3.8	$1
A-2	Biomass Feedstocks for Electricity or Steam Production	0.05	0.1	4.5	-$8
A-3	Ethanol Production and Use	0.5	4.0	28.0	$0
A-7	Convert Agricultural Land to Forest or Grassland	Not available			
A-8	Reduce Conversion of Farm & Rangelands to Developed Uses	0.1	0.2	1.6	$65
A-9	Programs to Support Local Farming/Buy Local	0.01	0.02	0.1	$6
F-1	Forestland Protection from Developed Uses	0.3	0.3	3.7	$17
F-2	Reforestation/Restoration of Forestland	0.02	0.1	0.6	$44
F-3a	Forest Ecosystem Management – Residential Lands	0.5	0.5	6.4	-$21
F-3b	Forest Ecosystem Management – Other Lands	0.2	0.2	2.9	-$21
F-4	Improved Commercialization of Biomass Gasification and Combined Cycle	Not available			

Notes

Cost savings are shown as negative costs. All costs are estimated using a real discount rate of 5% (see Appendix J for details).

A-7: Lack of specific policy design and lack of data prevented estimation of tons and cost.

F-4: This option overlaps substantially with F-3a and 3b, thus it was not estimated to prevent double-counting.

The GHG emissions reductions estimate for each policy option in Table 1-2 is presented as a "stand alone" figure, indicating the potential GHG emissions reductions achievable if the particular policy option was implemented solely by itself and not in conjunction with other policy options. To estimate the total quantity of GHG emissions reductions achievable if all of the CCAG's recommended policy options were implemented together, the potential cumulative GHG emissions reduction figure for the combined policy options must be adjusted to account for overlaps between individual policy options to avoid double-counting of potential reductions.

For example, there would be overlaps between and among policy options in the RCI and ES sections, as reductions in electricity demand could also result in lower electricity production. As such, again for example, while ES-1 has a "stand alone" reduction estimate of 116 $MMtCO_2e$ cumulatively from 2007-2020, the potential reductions from this policy option are an estimated 70.3 $MMtCO_2e$ if all of the CCAG's policy options were implemented together as a comprehensive package. See page H3 in Appendix H. The same principle would apply to ES-6, which would change from a "stand alone" GHG emissions reduction estimate of 70.4 $MMtCO_2e$ to 50.3 $MMtCO_2e$ cumulatively from 2007 to 2020 if it were implemented as part of a comprehensive package. See page H3 in Appendix H.

Table 1-3 below shows the total estimated GHG emissions reductions achievable if all of the CCAG's recommended policy options were implemented together, with the appropriate adjustments made to account for overlaps and avoid double-counting of emissions reductions.

Table 1-3 Totals

Total of all CCAG Options with Adjustments for Overlap (Detailed data may be found in the Tables presented in Chapters 4-8 and the Appendices.)	**2010 Annual GHG Reduction ($MMtCO_2e$)**	**2020 Annual GHG Reduction ($MMtCO_2e$)**	**2007-2020 Cumulative Reduction ($MMtCO_2e$)**
	15.4	69.4	485.4[14]

The Center for Climate Strategies (CCS) has calculated overall net economic cost savings from the CCAG's policy option recommendations of more than $5.5 billion from 2007-2020. The CCS also has calculated that the average cost for each ton of GHGs removed would be -$12.74, meaning that there would be a net econmic cost *savings* of $12.74 for each ton of GHGs removed.[15]

[14] As noted, the potential cumulative GHG reduction figures have been adjusted to account for overlaps between reductions achievable under individual policy options to avoid double-counting of potential GHG emissions reductions. The CCAG notes that the cumulative figure represents the total potential GHG emissions reductions achievable if all of the recommended policy options are implemented and acknowledges that there may be challenges to full implementation of all the recommended policy options. The CCAG also notes that the cumulative figures do not include any potential emissions reductions from ES-4 Cap and Trade because only a range of estimates is presented in Table 1-2. The cumulative figures would be higher if reductions from a cap and trade program were included.

[15] The overall net economic cost savings figure of more than $5.5 billion and the average $12.74 per ton net savings figure are based on the savings/costs for the cumulative GHG emissions reductions for which CCS was able to estimate savings/cost data, as indicated in Table 1-2, adjusted for overlaps to prevent double-counting of reductions.

While some CCAG members may hold differing opinions about the science of climate change, the CCAG agreed at the outset of its deliberations not to debate climate change science in order to achieve the directive of Executive Order 2005-02 and move the CCAG process forward.[16]

As Governor Napolitano's Executive Order stated, a growing scientific consensus has emerged that increasing emissions of carbon dioxide, methane, nitrous oxides, and other GHGs are affecting the Earth's climate. The work of the Intergovernmental Panel on Climate Change (IPCC) represents this consensus.[17] According to the IPCC, human activities, particularly the burning of fossil fuels such as coal and petroleum, have added measurably to the natural background levels of GHGs in the atmosphere, which in turn has contributed to rising global temperatures.[18]

The IPCC estimates that the Earth's surface temperature increased by about 1 degree Fahrenheit during the past century, with much of that warming occurring during the past two decades. The hottest 22 years on record have occurred since 1980; the hottest 10 years on record have all occurred since 1990; and 2005 was the hottest year ever recorded. According to the IPCC, most of the observed warming over the last 50 years is likely due to increased GHG concentrations attributable to human activities (see Figure 2-1 below).[19]

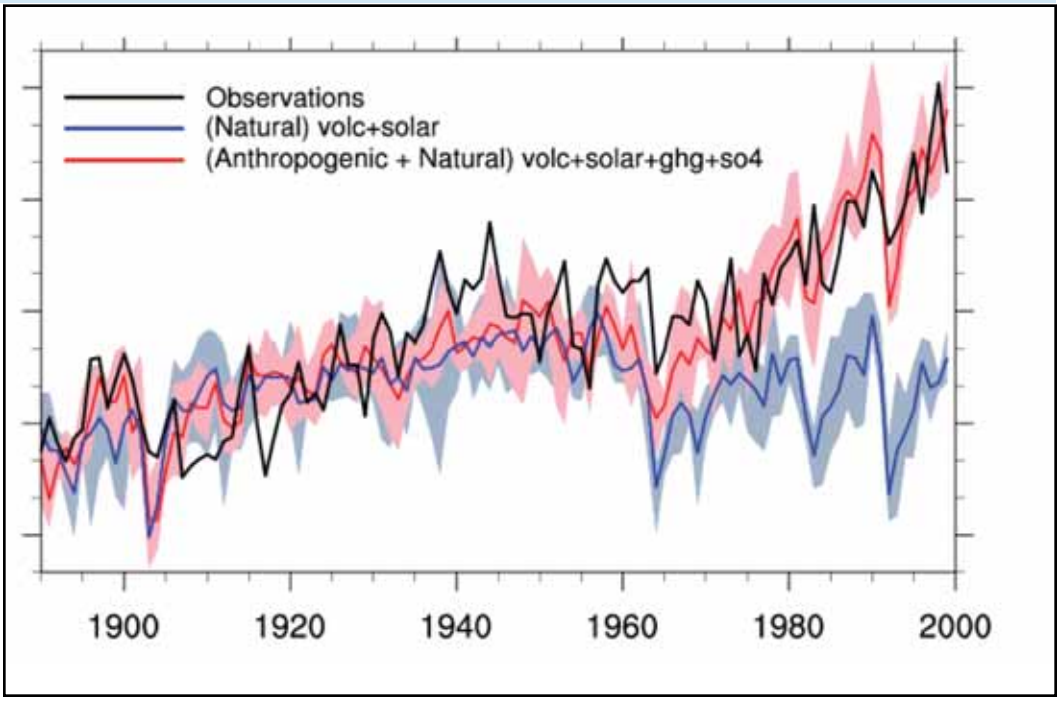
[16] On September 29, 2005, many CCAG members participated in an informal background briefing on the causes and impacts of climate change presented by Dr. Andrew Comrie, Professor of Atmospheric Sciences, University of Arizona.
See http://www.azclimatechange.us/ewebeditpro/items/O40F7043.pdf

[17] The IPCC is composed of thousands of scientists (including several from Arizona, such as Dr. Jonathan Overpeck, Professor of Geosciences, University of Arizona, and director of the University's Institute for the Study of Planet Earth) representing the parties to the United Nations Framework Convention on Climate Change (UNFCCC), and was formed to provide assessments of climate science, impacts, and mitigation policy to the parties to the UNFCCC every five years.
See http://www.ipcc.ch.

[18] IPCC, Third Assessment Report (2001) www.ipcc.ch.

[19] IPCC, Third Assessment Report (2001) The IPCC's Fourth Assessment Report is due in 2007. The National Academy of Sciences affirmed the IPCC conclusions in its 2001 report titled "Climate Change Science: An Analysis of Some Key Questions," http://newton.nap.edu/catalog/10139.html.

Figure 2-1 Observed Temperatures and Two Simulations: Natural vs. Anthropogenic Plus Natural[20]



(Figure courtesy of Dr. Gerald Meehl, National Center for Atmospheric Research.)

Future increases in global temperature are projected to occur with increased atmospheric GHG concentrations unless action is taken to reduce total annual GHG emissions. According to the IPCC, worldwide consequences of increased temperatures due to the build-up of GHGs in the atmosphere are likely to include increased warming of the earth, and enhanced heat stress, natural and human water system needs, melting glaciers and ice caps, sea level rise, increased severe weather events, flooded coastal and lowland communities, more frequent and intense tropical storms and hurricanes, expanded drought, expansion of tropical disease risk, and other serious occurrences.[21]

[20] IPCC scientists use climate models to simulate the observed temperature changes over the last century attributable to atmospheric "forcings," both natural and anthropogenic (a forcing can be a warming or cooling effect).
Figure 2-1 compares the results for two simulations:

(1) The blue line shows a simulation of natural forcing (solar variation and volcanic activity).

(2) The red line shows the simulation of natural forcing plus anthropogenic forcing, i.e., GHG gases and sulfate aerosols (which have a cooling effect).

Actual temperature observations are shown in a black line representing deviations from the average of temperatures from 1890-1999.

[21] IPCC, Third Assessment Report (2001)

Impacts in Arizona and the West

Over the past 50 years, the climate in the western United States has warmed on average by 1.4 degrees Fahrenheit. IPCC climate models predict that further June to August temperature increases of 3.6 to 9.0 degrees Fahrenheit are possible by 2040 to 2069 for western North America,[22] while the most extreme warming scenario currently considered possible suggests that annual mean temperatures in the southwestern United States could increase potentially by up to 14 degrees Fahrenheit before the end of the century.[23] A warmer climate could mean less winter snowfall, more winter rain and a faster, earlier snowmelt in Arizona's mountains.

Higher temperatures and increased evaporation also could lower reservoir levels, lake levels, and stream flows in the summer. Lower stream flows could concentrate pollutant levels and increase salinity, a critical water quality problem in Arizona. Less water would be available to support irrigation, hydropower production, public and industrial supply, fish and wildlife habitat, and recreation. More winter rain, coupled with more rapid snowmelt, could contribute to winter and spring flooding. Meanwhile, less spring and summer aquifer recharge could exacerbate already-declining water levels in parts of the state that depend on groundwater withdrawals for irrigation and municipal supply. With continued population growth, water demand could outpace water supply in areas of the State.

Even conservative estimates of climate change predict significant potential impacts on the Colorado River system by the end of this century due to decreased snowfall and snow pack and increased evaporation, including a 15% reduction in annual runoff; a 40% decrease in basin storage; and a decline in hydroelectric power production to 45 to 56% of the historical average. The date of peak spring runoff could continue to advance, coming more than a month earlier in many Western rivers by the century's end.[24]

Further, climate change could reduce Arizona's forested areas by 15 to 30%, with hotter, drier weather conditions increasing the already-high potential for more frequent, intense wildfires that threaten both forests and property.[25] Milder, drier winters could also increase the likelihood of insect outbreaks and wildfires that result from the accumulation of dead wood on the forest floor.

Arizona is already experiencing the effects of a hotter, drier climate. Due in part to a decade-long drought and warmer temperatures, Arizona's fire season began earlier (in February) this year (2006) than ever before. Moreover, the two worst wildfires in Arizona history have occurred in just the last few years:

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[22] Professor Steven Running, Numerical Terradynamic Simulation Group, University of Montana; published July 6, 2006 in ScienceXpress, the online version of the journal Science; 10.1126/science.1130370.

[23] Stainforth et al., Nature, Vol 433, 27 January 2005; www.nature.com/nature.

[24] From presentation of Dr. Andrew Comrie, Professor of Atmospheric Sciences, University of Arizona, to the CCAG. See http://www.azclimatechange.us/ewebeditpro/items/O40F7043.pdf

[25] U.S. Environmental Protection Agency Fact Sheet 236-F-98-007c, "Climate Change and Arizona" http://yosemite.epa.gov/OAR/globalwarming.nsf/UniqueKeyLookup/SHSU5BNJMV/$File/az_impct.pdf

the Rodeo-Chediski fire in 2002, which consumed nearly 500,000 acres; and the Cave Creek Complex fire in 2005, which burned nearly 250,000 acres.[26] The drought and warmer winter temperatures also have contributed to bark beetle infestations in the State's forests, killing thousands of pine trees and adding to the already-severe fire risk. The State's two driest years in more than a century occurred in 2002 and 2006, respectively, and coincided with the two lowest levels of run-off ever recorded due to decreased snowfall. The 2006 spring runoff season, which measures snowmelt from January through May, provided just 121,000 acre-feet of water this year (2006), as compared to 665,000 acre-feet normally.[27]

Climate change could likewise significantly alter Arizona's agricultural crop production, which is heavily dependent on irrigation.[28] Cotton yields could decline by 5 to 11% and wheat yields by as much as 70% as temperatures rise beyond the tolerance levels for the crop, particularly with reduced water availability. Livestock production, which accounts for about half of the State's annual agriculture industry, could also suffer, as livestock tend to gain less weight in hotter, drier conditions and when pasture yields decline, limiting forage.[29] The potential increased susceptibility of crops and livestock caused by these stressors, combined with reduced die-back of pests and diseases resulting from milder winters, could exacerbate these impacts.

A changing climate also could exacerbate Arizona's air pollution problems. During the winter of 2005-06, the Phoenix metropolitan area suffered a record-breaking 143 consecutive days without measurable precipitation, which contributed to unprecedented levels of particulate matter pollution (referred to as PM10) in the area. Between November 1, 2005 and March 15, 2006, the Phoenix metropolitan area exceeded the federal standard for PM10 on 30 days, and the Arizona Department of Environmental Quality (ADEQ) issued 25 High Pollution Advisories, more than in the previous decade combined. Increased temperatures also could contribute to increased ozone concentrations in the Phoenix metropolitan area during summer months.

[26] A July 6, 2006 study published in ScienceXpress, the online version of the journal Science, linked climate change to larger, longer-lasting wildfires in the Western United States and found that the worst fires (1,000 acres or more) occurred in years with warmer springs and earlier snowmelts. More acreage and larger fires burned in the West between 1987 and 2003 than in the previous 16-year span. See "Warming and Earlier Spring Increases Western U.S. Forest Wildfire Activity" http://www.sciencemag.org/cgi/rapidpdf/1128834.pdf. Dr. Thomas Swetnam of the University of Arizona's Tree Ring Research Laboratory, a CCAG member, was a co-author of the study.

[27] Arizona Republic, June 16, 2006.

[28] U.S. Environmental Protection Agency Fact Sheet 236-F-98-007c, "Climate Change and Arizona" http://yosemite.epa.gov/OAR/globalwarming.nsf/UniqueKeyLookup/SHSU5BNJMV/$File/az_impct.pdf

[29] Ibid.

Chapter 3
Greenhouse Gas Emissions Inventory and Reference Case Projections 1990-2020

Executive Order 2005-02 directed the Climate Change Advisory Group (CCAG) to prepare an inventory of Arizona's greenhouse gas (GHG) emissions and a projection of future emissions. The Center for Climate Strategies (CCS) prepared a draft document for this purpose for the first CCAG meeting, and CCAG members reviewed the methodology, assumptions, and conclusions in subsequent meetings. The Technical Work Groups did the same for the portions of the document relevant to their sectors. At their December meeting the CCAG members unanimously approved the final document, *Arizona Greenhouse Gas Emissions Inventory and Reference Case Projections, 1990-2020* (hereafter, the *Inventory and Projections,* Appendix D to the Action Plan).

The *Inventory and Projections* provides historical GHG emissions estimates for the years 1990 through 2003[30] using a set of generally-accepted principles and guidelines for state GHG emissions and relying to the extent possible on Arizona-specific data and inputs.[31] The reference case projections to 2020 are based on a compilation of various existing Arizona and regional projections of electricity generation, fuel use, and other GHG emitting activities, along with a set of simple, transparent assumptions described later in this chapter.

The *Inventory and Projections* covers the six types of gases included in the U.S. Greenhouse Gas Inventory: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Emissions of these greenhouse gases are presented using a common metric, CO_2 equivalence (CO_2e), which indicates the relative contribution of each gas to global average radiative forcing[32] on a Global Warming Potential (GWP) weighted basis. In addition, black carbon (soot/smoke particles) and organic carbon aerosols (used in a variety of commercial and consumer products) could have a significant climate impact, with black carbon having a particularly powerful warming impact. However, because the science is less certain on the relative magnitude of this impact, and because there are as yet no widely-accepted GWP weights to enable comparison with greenhouse gases, these black and organic carbon emissions are not integrated in the CO_2 equivalent emissions estimates provided in the main GHG inventory and projection figures presented here.

[30] For some sectors and sources, historical data are only available through 2000-2002.

[31] The Arizona Department of Environmental Quality (ADEQ) prepared a preliminary GHG inventory assessment, which provided a starting point for this analysis.

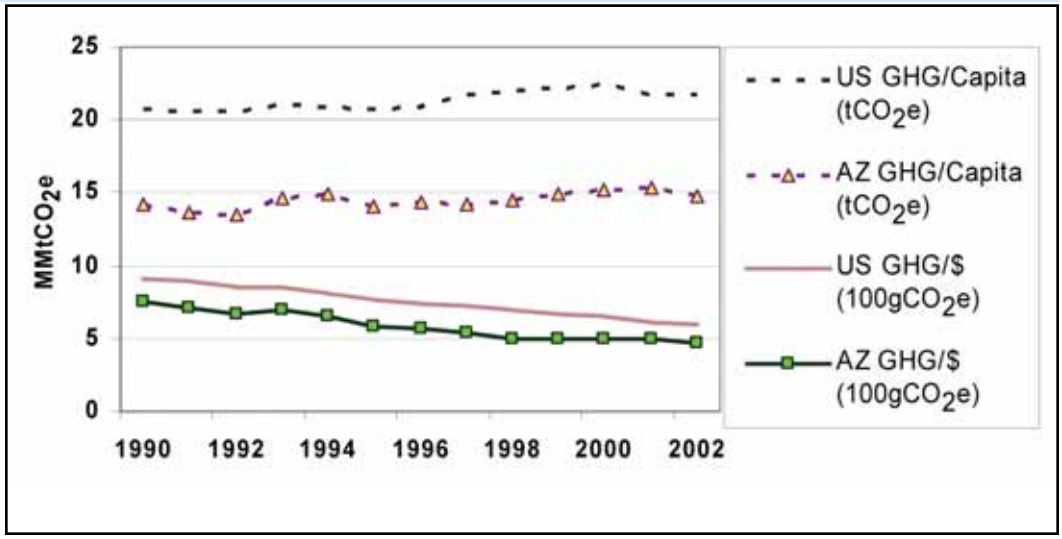
[32] A change in the net radiative energy (incoming solar radiation and outgoing infrared radiation) of the global Earth-atmosphere system is termed a radiative forcing. Positive radiative forcings warm the Earth's surface and lower atmosphere; negative radiative forcings cool them.

Arizona Greenhouse Gas (GHG) Emissions: Sources and Trends

In 2000, Arizona accounted for approximately 82.3 million metric tons[33] (MMt) of net carbon dioxide equivalent (CO_2e) emissions, an amount equal to 1.2% of total U.S. GHG emissions[34]. Arizona GHG emissions are rising rapidly compared with the nation as a whole, driven by the rapid pace of Arizona's population and economic growth. Arizona GHG emissions were up nearly 40% from 1990 to 2000, while national emissions rose by 23% during this period.[35]

On a per capita basis, Arizonans emit about 14 tCO_2e, 36% less than the national average of 22 tCO_2e per capita. Lower per capita emissions are due in part to Arizona's mild climate, and also to the State's less emissions-intensive economic base.[36] Figure 3-1 illustrates the State's lower emissions per capita and per unit of economic output. It also shows that like the nation as a whole, per capita emissions have remained fairly flat, while economic growth outpaced emissions growth throughout the 1990-2002 period. During the 1990s, emissions per unit of gross product dropped by 29% nationally, and by 33% in Arizona.

Figure 3-1 Arizona and U.S. GHG Emissions, Per Capita and Per Unit Gross Product (2000 Dollars)



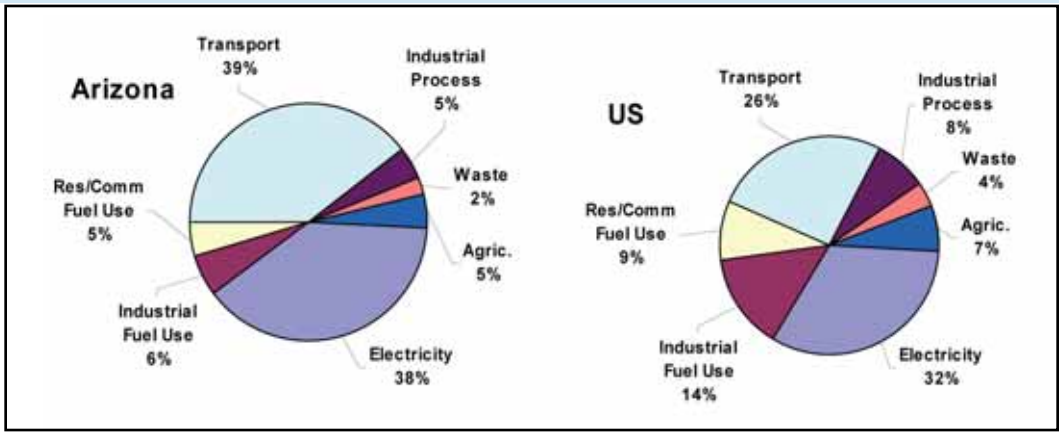
$MMtCO_2e$ – million metric tons carbon dioxide equivalent
tCO_2e – metric tons carbon dioxide equivalent
$100gCO_2e$ – 100 grams carbon dioxide equivalent

[33] All GHG emissions are reported here in metric tons.
[34] United States emissions estimates are drawn from Climate Analysis Indicators Tool (CAIT) version 1.5. (Washington, DC: World Resources Institute, 2003). Available at: http://cait.wri.org.
[35] During the 1990s, population grew by 39% in Arizona compared with 13% nationally. Furthermore, Arizona's economy grew faster on a per capita basis (up 63% vs. 52% nationally).
[36] Arizona's economy has a lower share of emissions-intensive industrial and agricultural activities, such as steel production, petroleum refining, or dairy farming. Furthermore, while cooling demands are significant, the emissions associated with air conditioning are lower on average than those for space heating in the rest of the country.

Electricity use and transportation are the State's principal GHG emissions sources. Together, the combustion of fossil fuels in these two sectors accounts for nearly 80% of Arizona's gross GHG emissions, as shown in Figure 3-2.[37] The remaining use of fossil fuels – natural gas, oil products, and coal – in the residential, commercial, and industrial (RCI) sectors constitutes another 11% of State emissions.

Agricultural activities such as manure management, fertilizer use, and livestock (enteric fermentation) result in methane and nitrous oxide emissions that account for another 5% of State GHG emissions. Industrial process emissions also comprise about 5% of State GHG emissions today, and these emissions are rising rapidly due to the increasing use of hydrofluorocarbons (HFC) as substitutes for ozone-depleting chlorofluorocarbons.[38] Other industrial processes emissions result from perfluorocarbon (PFC) use in semiconductor manufacturing, carbon dioxide released during cement and lime production, and methane released by natural gas systems and coal mines. Landfills and wastewater management facilities produce methane and nitrous oxide emissions accounting for the remaining 2% of current State emissions; these emissions have declined slightly in recent years as landfill gas is increasingly captured and flared or used for energy purposes.

Figure 3-2 Gross GHG Emissions by Sector, 2000, Arizona and U.S.



Gross emissions estimates do not include the effects of carbon sinks; i.e., the net carbon sequestered in, or released from, soils and vegetation. Recent U.S. Forest Service (USFS) estimates suggest that Arizona forests and the use of forest products sequestered on average about 7 $MMtCO_2e$ per year from 1985 to 2002. Much of this increase appears to have occurred during a period when the formal definition of forestland under Forest Inventory and Analysis (FIA) surveys was liberalized from a minimum 10% forest cover to 5% cover requirements. As a result, refined estimates regarding total statewide biomass sequestration may result in significant changes to current estimates as discussed below and should be the focus of further analysis. The *Inventory and Projections* reports *net* GHG emissions – which include the above sequestration estimates – separately from the *gross* GHG emissions.

[37] Gross emissions estimates only include those sources with positive emissions. Carbon sequestration in soils and vegetation is included in net emissions estimates.

[38] Chlorofluorocarbons (CFCs) are also potent greenhouse gases. However, they are not included in GHG estimates because of concerns related to implementation of the Montreal Protocol. See Appendix D.

A Closer Look at the Two Major Sources: Electricity and Transportation

As shown in Figure 3-2, electricity use accounts for nearly 40% of Arizona's gross GHG emissions, or about 35 $MMtCO_2e$, slightly higher than the national share of emissions from electricity production (32%).[39] On a per capita basis, in contrast, Arizona emits slightly less in terms of greenhouse gases (7 tCO_2e/capita vs. 8 tCO_2e/capita nationally) due to electricity. The average Arizonan uses about the same amount of electricity as the average US resident (12,000 kWh per person per year), but Arizona electricity has lower emissions than the national average.[40] Arizona gets slightly less electricity from coal (46% vs. 52% nationally in 2000) and more from low-emitting sources, such as nuclear, hydro, and renewables (44% vs. 29% nationally in 2000).

During the 1990s, Arizona electricity demand grew at a rate of 4% per year, while electricity emissions grew 3.3% annually, reflecting a decline in emissions per kWh. This decline was due largely to the rapid growth of new natural gas generation, and to a lesser extent, increases in nuclear generation.

It is important to note that these electricity emissions estimates reflect the *GHG emissions associated with the electricity sources used to meet Arizona demands*, corresponding to a consumption-based approach to emissions accounting. Another way to look at electricity emissions is to consider the *GHG emissions produced by electricity generation facilities in the State.* For many years, Arizona power plants have tended to produce considerably more electricity than is consumed in the State – in the year 2000, for example, Arizona produced 23% more electricity than it used, exporting on a net basis to consumers in nearby states. As a result, in 2000, emissions associated with electricity production (44.5 $MMtCO_2e$) were considerably higher than those associated with electricity use (34.5 $MMtCO_2e$).[41]

While the *Inventory and Projections* presents both the emissions from electricity production and use, unless otherwise indicated, tables, figures, and totals here reflect electricity use emissions. The consumption-based approach can better reflect the emissions (and emissions reductions) associated with activities occurring in the State, particularly with respect to electricity use (and efficiency improvements), and is thus particularly useful in a policy-making context. Under this approach, emissions associated with electricity exported to other states would need to be covered in those states' accounts in order to avoid double counting or exclusions. (Indeed, California, Oregon, and Washington are currently considering such an approach.)

Like electricity emissions, GHG emissions in Arizona from transportation fuel use have risen steadily since 1990 at an average rate of slightly over 3%

[39] Unlike for Arizona, for the U.S. as a whole, there is relatively little difference between the emissions from electricity use and emissions from electricity production, as the U.S. imports only about 1% of its electricity, and exports far less.

[40] In 2000, electricity generation in Arizona emitted 1107 lbCO2e (0.50tCO_2e) per MWh; the analysis assumes the same emission rate for electricity delivered to Arizona consumers. In 2000, electricity generation in the US averaged 1321 lbCO2e (0.60tCO_2e) per MWh.

[41] Estimating the emissions associated with electricity use requires an understanding of the electricity sources (both in-state and out-of-state) used by utilities to meet consumer loads. The current estimate reflects some simple assumptions described in the *Inventory and Projections* (Appendix D).

annually. Gasoline-powered vehicles account for about 65% of transportation GHG emissions. Diesel vehicles account for another 20%, air travel for roughly 10%, and the remainder of transportation emissions come from natural gas and liquefied petroleum gas (LPG) vehicles. As the result of Arizona's rapid expansion and an increase in vehicle miles traveled (VMT) during the 1990s (from 35 billion VMT in 1990 to 50 billion VMT in 2000), gasoline use has grown at a rate of 3.2% annually.[42] Meanwhile, diesel use has risen 6.5% annually, suggesting an even more rapid growth in freight movement within the State.

With respect to black carbon emissions, the transportation sector is the largest contributor. Transportation sources such as on-road diesel vehicles contributed 59% of Arizona's black carbon (BC) emissions in 2002. Other important BC emissions sectors include non-road diesel engines (18%; e.g., generators, construction equipment) and railroad engines (about 11%). Coal-fired electricity generating units contributed another 6%.

Reference Case Projections

Relying on U.S. Department of Energy (USDOE) and Arizona agency projections of electricity and fuel use, and other assumptions noted below, the *Inventory and Projections* makes a forecast of GHG emissions through 2020.[43] It assumes a continuation of current trends and reflects, to the extent possible, announced plans (e.g., power plant construction and retirement) and the implementation of recently enacted policies. One such policy is the Environmental Portfolio Standard, which currently requires investor-owned utilities to provide 1.1% of the electricity sales from renewable sources by 2012, and could result in emissions savings of slightly over 0.2 $MMtCO_2e$ by 2012.

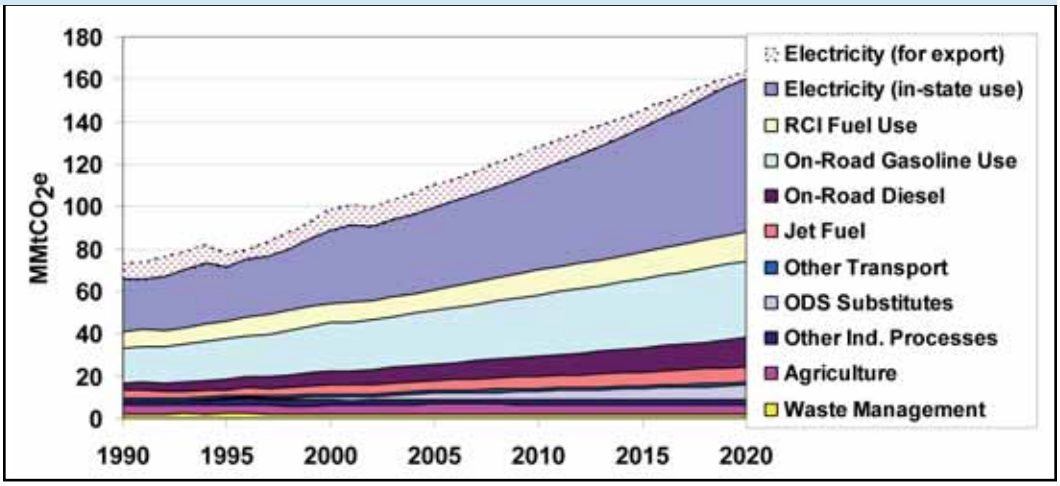
Figure 3-3 illustrates the results of the reference case projection in terms of gross GHG emissions. Corresponding numerical results are shown at the bottom of Table 3-1 under the four different emissions accounting approaches considered here: consumption basis, production basis, gross, and net. Under the gross, consumption-basis approach – i.e., excluding emissions associated with net electricity exports – Arizona GHG emissions climb to 160 $MMtCO_2e$ by 2020, 80% above 2000 levels and 143% above 1990 levels. Assuming current estimates for forest sequestration (6.7 $MMtCO_2e$) continue through 2020, net emissions are lower than gross emissions, but the relative increase is greater.

The percentage increases in emissions relative to historical levels are slightly lower under a production-based approach, i.e., one that includes all emissions associated with in-state electricity production. Under the gross emissions case, 2020 production-based emissions are 75% above 2000 levels and 123% above 1990 levels. This difference results from the assumption – based on estimates from the Arizona Corporation Commission and USDOE – that Arizona electricity sales will grow slightly faster than electricity generation from 2010 onwards.

[42] Based on U.S. Energy Information Agency data for the year 2000, Arizona gasoline use is also slightly below the national average (1.1 vs. 1.3 gallons per person per day). www.eia.doe.gov.
[43] Historical data run through 2001 to 2003 depending on the emissions source.

Electricity and gasoline use are projected to be the largest contributors to future emissions growth, as shown in Figure 3-4. Other major sources of emissions growth include freight transport (diesel), fuel use in buildings and industry (RCI), hydrofluorocarbons (HFCs) used in place of ozone-depleting substances (ODS), and air travel.

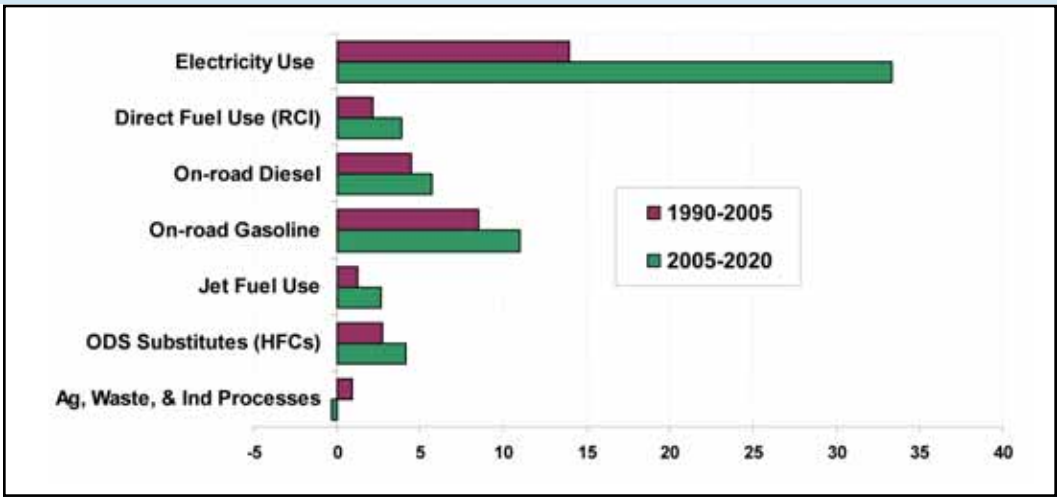
Figure 3-3 Gross GHG Emissions by Sector, 1990-2020: Historical and Projected



* This chart does not show net carbon sinks (forestry and land use) which average slightly over 10 $MMtCO_2e$/year.

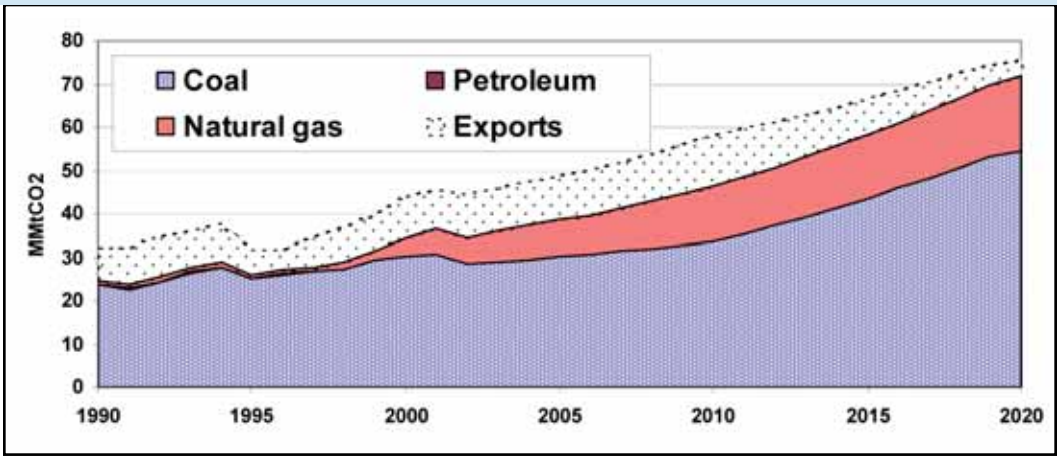
RCI – Residential, Industrial, and Commercial
ODS – Ozone-Depleting Substances

Figure 3-4 Contributions to Emissions Growth, 1990-2020: Reference Case Projections ($MMTCO_2e$)



The particularly steep increase in electricity use emissions is due not only to the assumption that electricity use will continue to grow rapidly, but also that natural gas prices will continue to rise, and the mix of new generation will shift heavily towards coal after 2010, as depicted in Figure 3-5.

Figure 3-5 CO_2 Emissions from Electricity Production in Arizona, by Fuel Source (Includes All In-State Emissions)



Overall, the projected rate of emissions growth is 3% per year from the year 2000 onward, well below anticipated levels of economic growth (4.9% per year), but nonetheless significant. As illustrated in Figure 3-6, emissions track population growth fairly closely until the latter half of this decade, after which they begin to rise more rapidly. The increase in per capita emissions after 2010 appears largely as the result of four factors:

1) electricity growth at a rate faster than population growth

2) increasing reliance on coal-based generation

3) on-road vehicle emissions, particularly freight traffic growing faster than population

4) increasing hydrofluorocarbon emissions in refrigeration, air conditioning, and other applications.

For nearly all other sources, with the exception of natural gas use in residential, commercial, and industrial sectors, emissions are projected to grow at a pace slower than State population.

Figure 3-6 Historical and Projected GHG Emissions, GSP, and Population (Indexed to 1990 Value)

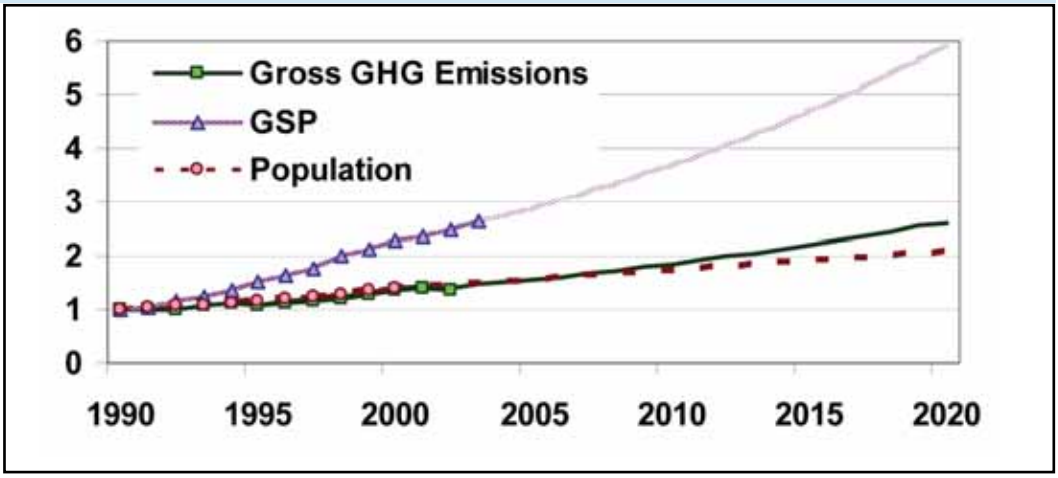


Table 3-1 Historical and Reference Case GHG Emissions, 1990-2020, by Source[44]

(Million Metric Tons CO_2e)	1990	2000	2010	2020	Explanatory Notes for Projections
Energy Use (CO2, CH4, N2O)	57.9	78.8	103.6	144.6	
Electricity Use	24.9	34.5	46.6	72.2	
Electricity Production (in-state)	32.3	44.5	58.4	75.8	Total emissions for in-state power plants
Coal	*30.9*	*39.2*	*42.4*	*57.5*	*See electric sector assumptions*
Natural Gas	*1.3*	*5.1*	*15.9*	*18.3*	*in Appendix H*
Oil	*0.1*	*0.2*	*0.0*	*0.0*	
Net Electricity Exports	-7.4	-10.0	-11.8	-3.6	
Res/Comm/Ind (RCI)	7.7	9.3	11.6	13.8	
Coal	*1.2*	*1.5*	*1.8*	*1.9*	*Based on USDOE regional projections*
Natural Gas	*4.2*	*4.7*	*5.7*	*7.2*	*Based on USDOE regional projections*
Oil	*2.2*	*3.0*	*4.1*	*4.6*	*Based on USDOE regional projections*
Wood (CH4 and N2O)	*0.1*	*0.1*	*0.1*	*0.1*	*Assumes no change after 2003*
Transportation	25.3	35.0	45.4	58.6	
On-road Gasoline	16.8	22.8	28.9	36.3	VMT from MoveAZ, constant energy/VMT
On-road Diesel	3.5	6.5	9.5	13.6	VMT from MoveAZ, constant energy/VMT
Jet Fuel and Aviation Gasoline	3.5	4.3	5.7	7.4	Based on USDOE regional projections
Natural Gas (pipeline use)	1.4	1.1	1.2	1.2	constant at 2002 levels
Other	0.2	0.2	0.1	0.1	Based on USDOE regional projections
Industrial Processes	1.9	4.1	6.3	9.1	
ODS Substitutes	0.0	1.4	4.0	6.9	Based on national projections (USEPA)
PFCs in Semi-conductor Ind.	0.4	1.0	0.5	0.3	Based on national projections (USEPA)
SF6 from Electric Utilities	0.5	0.3	0.2	0.1	Based on national projections (USEPA)
Cement & Other Industry	0.6	1.0	0.9	1.0	Increases with state population
Methane from Oil & Gas Systems	0.4	0.4	0.6	0.8	Increases with natural gas use
Methane from Coal Mining	0.1	0.1	0.1	0.1	Assumes no change after 2003
Agriculture, Land Use, Forestry	-2.6	-2.5	-2.1	-2.1	
Agriculture (CH4 & N2O)	4.1	4.2	4.7	4.7	Assumes (for now) no change after 2002
Soils and Forest Sinks	-6.7	-6.7	-6.7	-6.7	Subject to considerable uncertainty
Waste Management	2.1	1.9	2.0	1.9	
Solid Waste Management	1.7	1.3	1.4	1.1	Based on national projections (USEPA)
Wastewater Management	0.4	0.5	0.7	0.8	Increases with state population
Total Emissions - Consumption-Basis (Excluding Emissions from Net Electricity Exports)					
Gross (excluding sinks)	66.0	89.0	116.6	160.3	
increase relative to 1990		35%	77%	143%	
increase relative to 2000			31%	80%	
Net (including sinks)	59.3	82.3	109.9	153.5	
increase relative to 1990		39%	85%	159%	
increase relative to 2000			34%	87%	
Total Emissions - Production-Basis (Including All In-State Electricity Generation)					
Gross (excluding sinks)	73.5	99.0	128.4	163.9	
increase relative to 1990		35%	75%	123%	
increase relative to 2000			30%	66%	
Net (including sinks)	66.7	92.3	121.6	157.2	
increase relative to 1990		38%	82%	135%	
increase relative to 2000			32%	70%	

[44] These emissions estimates do not include black carbon and organic carbon contributions. These emissions are difficult to convert into CO_2 equivalents, given the lack of commonly accepted GWPs. Available research provides the basis for some initial GWP estimates, as discussed in Appendix D. Application of these GWPs suggests that Arizona black and organic carbon emissions may have accounted for 3 to 6 $MMtCO_2e$ emissions in 2002. These figures also do not take into account the projected effects of recent energy efficiency related actions for the RCI sectors adopted by the State. With these actions, Arizona's GHG emissions are projected to be roughly 147 $MMtCO_2e$ net, including sinks, in 2020, instead of 153.5 $MMtCO_2e$.

Key Uncertainties

The strong growth in GHG emissions forecast here is driven largely by economic, demographic, and land use trends (including growth patterns and transportation system impacts), all of which are subject to uncertainty. Table 3-2 presents some of the major assumptions used in this report. Population estimates are based on official projections from the Arizona Department of Economic Security (DES). These projections, however, are widely recognized as outdated (based on assumptions circa 1997). Population growth has been more rapid than these projections would indicate, and the DES projections are currently under revision and might lead to even higher GHG growth projections.[45]

Table 3-2 Key Annual Growth Rates, Historical and Projected

Parameter	Historical		Projected	Sources/Uses
	1980-1990	1990-2000	2000-2020	
Population*	3.1%	3.4%	72.0%	U.S. Census Bureau for historic, AZ Department of Economic Security for projection
GSP	4.1%	6.3%	4.9%	(not used for projections)
Employment*	3.9%	2.9%	2.5%	AZ DOT's MoveAZ report for historic, AZ Department of Economic Security for projection
Electricity sales	4.5%	4.0%	3.6%	EIA SEDS for historic, RCI TWG for projections
Personal Vehicle Miles Traveled*	n/a	n/a	2.4%	Bureau of Transport Statistics for historic, AZ DOT's MoveAZ for projections
Freight Vehicle Miles Traveled*	n/a	n/a	3.7%	Bureau of Transport Statistics for historic, AZ DOT's MoveAZ for projections

* Population, employment and vehicle miles traveled (VMT) projections for Arizona were used together with USDOE's Annual Energy Outlook 2005 projections of changes in fuel use on a per capita, per employee, and per VMT, as relevant for each sector. For instance, growth in Arizona residential natural gas use is calculated as the Arizona population growth times the change in per capita Arizona natural gas use for the Mountain region. Arizona population growth is also used as the driver of growth in cement production, soda ash consumption, solid waste generation, and wastewater generation.

In addition, the reference case does not include an analysis of future agriculture emissions, which might change significantly if water scarcity, commodity programs, and trade agreements, among other factors, induce major shifts among crops and livestock grown in the State.

[45] If the projected growth rates are higher than currently projected (2.0%), then some emissions projections could rise. However, it is important to note that several of the key drivers for this analysis, such as growth in electricity growth and passenger VMT, are already higher than the projected population, and may implicitly reflect population projections higher than the official forecast.

Two other areas may be subject to significant uncertainty, not simply because the future is hard to predict, but because of limited data availability and scientific understanding:

- **Terrestrial carbon emissions and sinks.** The net forest and land use sequestration estimates noted above are based on recent improvements to U.S. Forest Service (USFS) carbon stock inventory data that have changed data collection and interpretation during the period of analysis. For instance, during the Forest Inventory and Analysis (FIA) survey periods used for FORCARB2[46] estimates, the definition of Arizona forestland changed from a minimum forest cover requirement of 10%, to a minimum of 5%. As a result, grasslands may or may not be included in these estimates, depending on their level of tree stocking. Follow up work by CCS and the TWG with the USFS suggested that rangeland carbon fluxes are not likely to significantly affect the final results of the forest carbon inventory and forecast.[47]

  Second, what the USFS defines as forest area in Arizona has increased by 14% since 1985, when it totaled 4.25 million hectares. This addition appears to account for much of the net gain in carbon stock in the USFS estimates (offsetting a decrease in carbon stock per hectare from 1996 to 2002) and may or may not be attributable to the change in the definition of forestland and the addition of lands at between 5% and 10% forest cover. However, further analysis of data and conferrals with the USFS indicated that further quantification of these changes between inventory periods is unlikely to significantly change current inventory or forecast estimates.

- **Black carbon and other aerosol emissions.** Emissions of aerosols, particularly black carbon from fossil fuel and biomass combustion, could have potentially significant impacts in terms radiative forcing (i.e., climate impacts). Methodologies for conversion of black carbon mass estimates and projections to global warming potential involve significant uncertainty at present. Best available methods for estimating black carbon emissions and their carbon dioxide equivalent are provided in a supplement to Appendix D, along with a preliminary inventory for Arizona for the year 2002. These results are not integrated in either the CO_2 equivalent emissions estimates provided in the main GHG emissions inventory and forecast or the projections presented here.

[46] FORCARB is the original USFS model estimate of carbon in forests. FORCARB2 is the second version of this model.

[47] However, the carbon cycle for rangelands is not well understood, and has not been included in current surveys.

Chapter 4
Goals and Cross-Cutting Issues

Overview of Cross-Cutting Issues

Some issues considered by the CCAG apply broadly across multiple sectors and are therefore better addressed as "cross-cutting" issues across all sectors rather than assigned to any individual sector. This set includes GHG reduction goals, emissions reporting, GHG emission reduction registries, public education and outreach, and adaptation. The Cross Cutting Issues Technical Work Group (TWG) developed policy options for each of these issues.

Key Challenges and Opportunities

Cross cutting issues bring forth key challenges in addition to the CCAG's recommended goal. Notable among them, GHG reporting and registry programs will be far more effective if applied on a broad regional or national basis rather than through separate, state-by-state implementation. Beyond the usual differences in states' perspectives, a further challenge lies in the fact that states are at much different stages of the learning curve with respect to these and other climate actions.

Overview of Policy Recommendations

After carefully considering Arizona's extraordinary growth rate, overall emissions reduction feasibility, and goals established in other jurisdictions, the CCAG identified a GHG emission reduction goal that is aggressive, yet achievable. The CCAG recommends that a comprehensive effort be undertaken to develop policy options and recommendations for adapting to these conditions.

A thorough GHG emissions reporting program is essential for better understanding mitigation obstacles and opportunities, as well as for measuring future progress. A GHG registry will help recognize and share accomplishments and also protect entities by quantitatively recording early GHG reduction accomplishments. Public awareness of climate change is the cornerstone of public acceptance of the need for concerted climate action because climate impacts are already affecting Arizona dramatically.

All of the following recommendations received the unanimous support of the CCAG.

CCAG Cross-Cutting (CC) All Sectors Policy Descriptions

The Cross-Cutting sector includes policies and measures that apply across the board to all sectors and activities. Cross-cutting recommendations typically enable or support emissions mitigation activities and/or other opportunities. Fully detailed descriptions of the individual Cross-Cutting sector policy options as presented to and approved by the CCAG can be found in Appendix F.

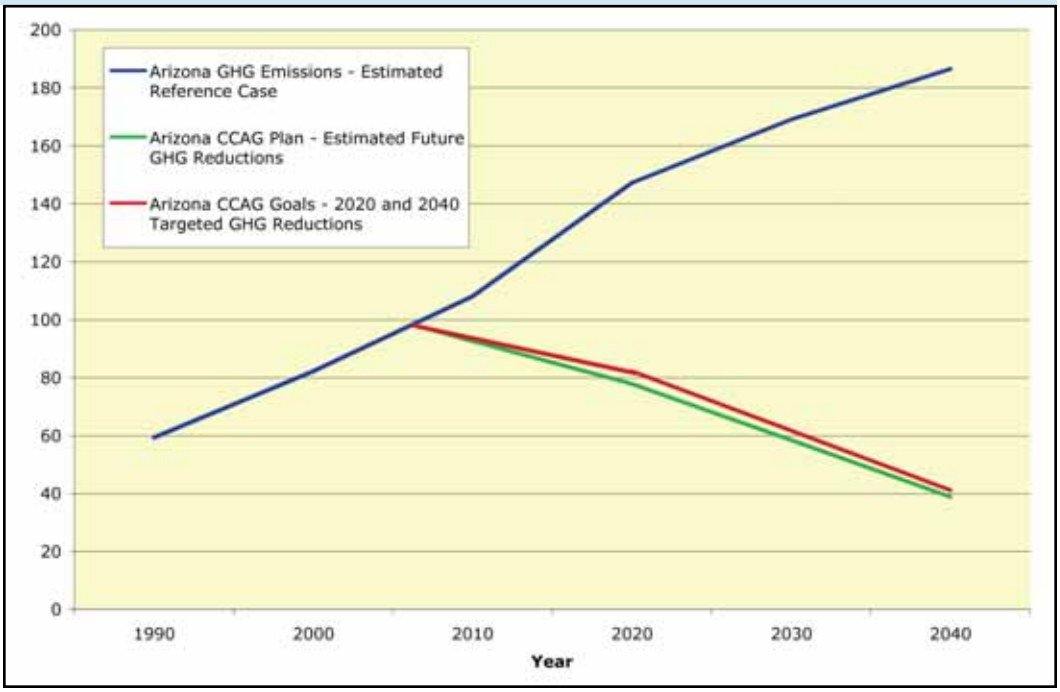
State GHG Reduction Goal (CC-1)

The CCAG recommends that Arizona establish a statewide GHG reduction target to lower GHG emissions to the 2000 level by 2020, with an additional 50% reduction below the 2000 level by 2040. In lieu of establishing a specific target for 2010, the CCAG also strongly recommends the early and aggressive implementation of the recommendations in this report, along with a corresponding set of incentives to promote early adoption.

As the reference case forecast in Figure 4-1 illustrates, Arizona's extraordinary growth in population and economic activity is expected to generate very high percentage growth in carbon emissions compared to other states. Early and aggressive action in Arizona is thus crucial to slowing – and ultimately reducing – carbon emissions.

The recommended goal for reductions in Arizona's GHG emissions reflects the CCAG's policy options recommendations. In fact, the CCAG's recommended policy options, if fully implemented, could reduce GHG emissions in Arizona by several million metric tons more than the amounts called for in the recommended goal.

Figure 4-1 1990-2040 GHG Emissions: Reference Case Forecast, CCAG Goal, and Estimated Cumulative Reductions with CCAG Options



State Greenhouse Gas Reporting (CC-2)

Measurement and public reporting of GHG emissions at a statewide, sector, or sub-sector level are important to support tracking and management of emissions. GHG reporting can help sources identify emission reduction opportunities and reduce potential risks associated with possible future GHG mandates by "starting up the learning curve." Tracking and reporting of GHG emissions will also help in the construction of periodic state GHG inventories.

GHG reporting is a key precursor for sources to participate in voluntary GHG reduction programs, opportunities for recognition, a GHG emission reduction registry, and to secure "baseline protection." Further, GHG reporting

is an opportunity for the state to influence reporting practices throughout the region and nation, and to build consistency with other reporting programs. Subject to consistently rigorous quantification, GHG reporting should not be constrained to particular sectors, sources, or approaches in order to encourage GHG mitigation activities from all quarters.

The CCAG recommends implementing a reporting mechanism that includes the following key elements:

- Phasing in mandatory GHG reporting by sectors as rigorous, standardized quantification protocols, base data, and tools become available and responsible parties become clear; allowing for voluntary reporting before mandatory reporting applies; and allowing the state itself to be a participant, reporting emissions associated with its own activities and the programs it implements.
- Applying to all source types (e.g., combustion, processes, vehicles, etc.) but using common sense regarding de minimis emissions.
- Having a goal of reporting "organization-wide emissions within Arizona" but doing so with greatest possible "granularity" to facilitate baseline protection (e.g., the "rolling up" of facility and field emissions reports in a reporting database would provide organization totals in Arizona).
- Reporting annually on a calendar year basis for all six traditional GHGs and, to the extent possible, black carbon.
- Requiring reporting of direct emissions, phasing in reporting of indirect emissions associated with purchased power and heat, and allowing voluntary reporting of other indirect emissions.
- Maximizing consistency with other state and federal reporting programs.
- Verifying emissions reports through self-certification and ADEQ spot-checks, adding third-party verification for registry purposes.
- Allowing for appropriate public transparency of reported emissions, and allowing voluntary project-based emissions reporting when properly quantified.

Suggestions for specific design elements of an effective GHG reporting program are included in Appendix F.

State Greenhouse Gas Registry (CC-3)

Measurement and recording of GHG emissions reductions at a macro- or micro-scale level in a central repository with a "transaction ledger" capacity to support tracking, management, and "ownership" of emission reductions as well as to encourage GHG reductions, to enable potential recognition, baseline protection, and/or the crediting of actions by implementing programs and parties in relation to possible emissions reduction goals, and to provide a mechanism for regional, multi-state, and cross-border cooperation. Subject to consistently rigorous quantification, registration of GHG reductions should not be constrained to particular sectors, sources, or approaches in order to encourage GHG mitigation activities from all quarters.

The CCAG recommends that the State implement a registry mechanism with the following key elements:

- Geographic applicability at least at the statewide level and as broadly (i.e., regionally or nationally) as possible.
- Allowing sources to start as far back chronologically as good data exists, as affirmed by third-party verification, and allowing registration of project-based reductions or "offsets" that are equally rigorously quantified.
- Incorporating adequate safeguards to ensure that reductions are not double-counted by multiple registry participants; providing appropriate transparency; and allowing the state itself to be a participant, registering GHG reductions associated with its programs, direct activities, or efforts.
- Striving for maximum consistency with other state, regional, and/or national efforts, greatest flexibility as GHG mitigation approaches evolve; and providing guidance to assist participants.

Suggestions for specific design elements of an appropriate GHG registry are included in Appendix F.

State Climate Action Education and Outreach (CC-4)

Public education and outreach are vitally important to foster a broad awareness of climate change issues and effects (including co-benefits, such as clean air and public health) among the state's citizens and to engage them in actions to reduce GHG emissions. Such efforts should seek to integrate with and build upon existing outreach efforts involving climate change and related issues in the state. Ultimately, public education and outreach will be the foundation for the long-term success of all the mitigation actions proposed by the CCAG as well as those which may evolve in the future.

The CCAG recommends that the state undertake climate change education and outreach activities directed toward, but not limited to, the following audiences:

- Policymakers (e.g., legislators, regulators, executive branch, agencies) – because implementation of climate actions hinges on policymakers' approval.
- Younger generations – by integrating climate change issues into educational curricula, post-secondary degree programs, and professional licensing programs.
- Community leaders and community-based organizations (e.g., businesses, institutions, municipalities, service clubs, social and affinity groups, non-governmental organizations, etc.) – in order to recognize leadership, share success stories and role models, and expand climate involvement and participation in climate change issues.
- The general public – to increase awareness and engage citizens in climate actions in their personal and professional lives.

One concept proposed by a CCAG member would be to create an "extension agent" position to assist in proliferating best practices among builders, homeowners, businesses, farmers and others. Further suggestions for specific activities are included in Appendix F.

State Climate Change Adaptation Strategy (CC-5)

Because of the build-up in the atmosphere of greenhouse gases that already has occurred, Arizona will experience the effects of climate change for years to come, even if immediate action is taken to reduce future GHG emissions. As such, it is essential that the state develop a strategy to identify and manage the projected impacts of ongoing climate change.

While taking action to reduce GHG emissions in Arizona, the CCAG recommends that a comprehensive state climate change adaptation strategy be developed and implemented. The strategy should include time- and program-based goals, characterization of the potential risks and costs of inaction, and the potential costs, benefits, and co-benefits associated with specific policy and program actions and time periods. Further, the strategy should outline actions to be taken to respond to existing climate change impacts and to coordinate these actions with response plans and efforts that are underway or may be contemplated at other agencies or organizations or through other initiatives. Such impacts include the concerns outlined Executive Order 2005-02 (i.e., prolonged drought, severe forest fires, warmer temperatures, increased snowmelt, and reduced snow pack) as well as other serious issues, including risks to public health.

The Governor may wish to consider appointing a task force or advisory group to develop recommendations for the state climate change adaptation strategy. Moreover, the Governor should direct state agencies and other appropriate institutions to identify and characterize potential current and future risks in Arizona to human, natural and economic systems, including potential risks to water resources, temperature sensitive populations and systems, energy systems, transportation systems, vital infrastructure and public facilities, and natural lands (e.g., forests, rangelands, and farmland).

Adaptation measures that also help mitigate GHG emissions should be given priority in the state climate change adaptation strategy, particularly water use conservation and efficiency, forest and agriculture conservation and management, energy production and use, facility siting and management (including residential), infrastructure development, and efficient transportation and land use systems. These actions should be linked to implementation of other specific recommendations of the CCAG to the greatest extent possible.

Chapter 5
RCI and Waste Management

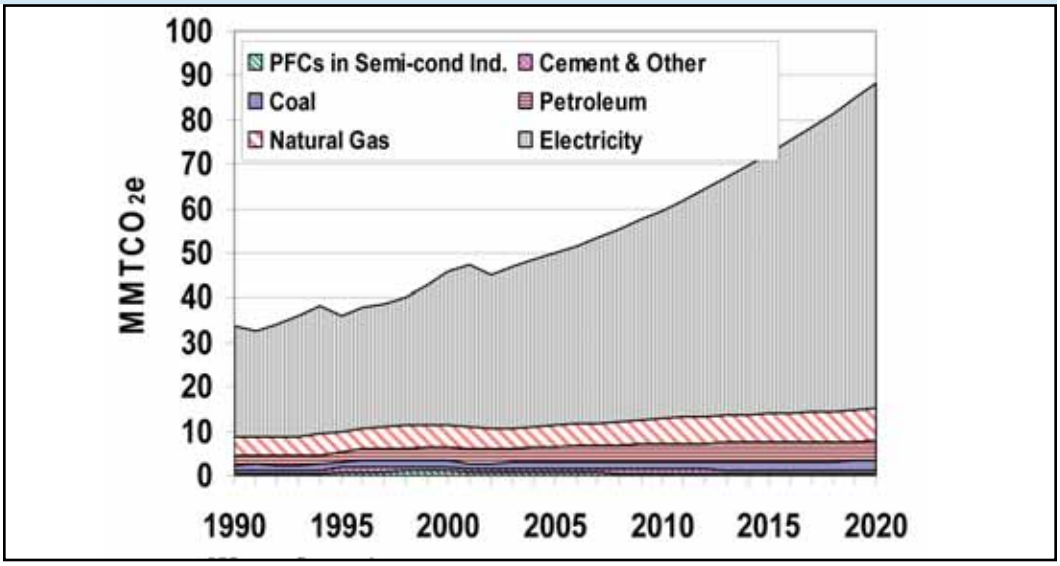
Overview of Greenhouse Gas Emissions

The residential, commercial, and industrial (RCI) sectors are directly responsible for only about one-tenth of Arizona's current GHG emissions (11.3 $MMtCO_2e$ in 2000). Direct emissions result principally from the on-site combustion of natural gas, oil, and coal, the release of CO_2 and fluorinated gases (HFCs, PFCs) during industrial processing (largely cement and semi-conductors), and the leakage of HFCs from refrigeration and related equipment.[48]

Considering only the direct emissions that occur within buildings and industries, however, ignores the fact that nearly all electricity sold in the state is consumed as the result of residential, commercial, and industrial activity. If the emissions associated with producing this electricity are considered, RCI activities are associated with about half of the state's GHG emissions. Arizona's future GHG emissions therefore will depend heavily on future trends in the consumption of electricity and other fuels in these sectors.

Figure 5-1 shows historical and projected RCI GHG emissions by fuel and source, and illustrates the large fraction of RCI emissions associated with electricity use. RCI emissions associated with electricity and natural gas use are expected to double from 2000 from 2020, and are likely to account for over half of the State's emissions growth during this period.[49]

Figure 5-1 Historical and Projected Residential Commercial and Industrial (RCI) Greenhouse Gas (GHG) Emissions, 1990 to 2020



[48] RCI fuel use accounted for 9.3 $MMtCO_2e$ in GHG emissions in 2000, while industrial process emissions, largely from cement production and the use of perfluorocarbons in the semi-conductor industry, accounted for 2.0 $MMtCO_2e$. Emissions due to leakage of HFC refrigerants from appliances and equipment in the RCI sector have not been estimated.

[49] The exception is process emissions from the semi-conductor industry, which are expected to decline significantly due to voluntary efforts.

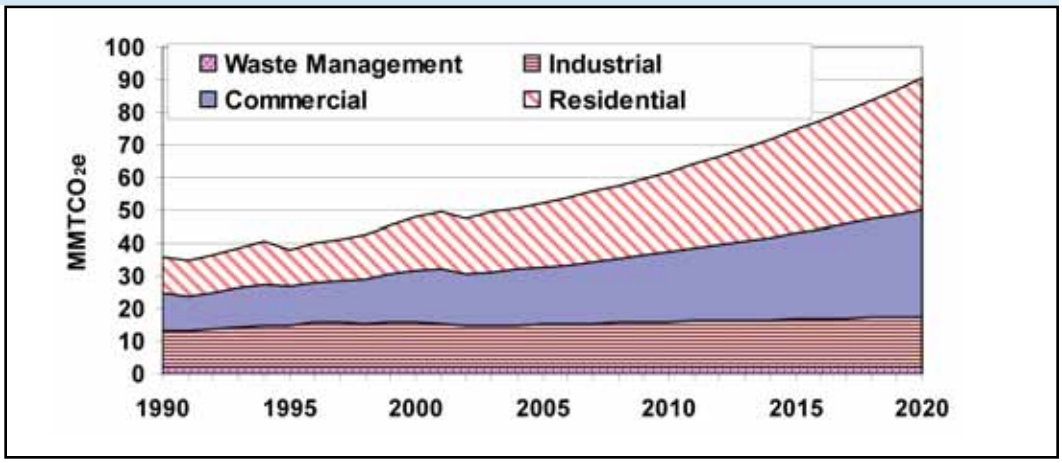
Table 5-1 shows estimated historical and projected emissions from solid waste management and wastewater treatment. Emissions from waste management consist largely of methane leaking from landfills, while emissions from wastewater treatment include both methane and nitrous oxide. These emissions, in terms of carbon equivalents, are relatively minor compared to overall RCI emissions, yielding 2010 and 2020 estimated emissions equal to 2 to 3% of RCI emissions.

Table 5-1 Summary of Estimated Historical and Projected Emissions from Waste and Wastewater Management in Arizona

(Million Metric Tons CO_2 equivalent)	1990	2000	2010	2020
Waste Management	2.1	1.9	2.0	1.9
Solid Waste Management	1.7	1.3	1.4	1.1
Wastewater Management	0.4	0.5	0.7	0.8

Until recently, overall emissions associated with residential, commercial, and industrial activity have been roughly equivalent across the three sectors. Rapid population growth and increasing emphasis on the commercial sector as the engine for the state's economy suggests, however, that over the coming decades the residential and commercial sectors will, under business as usual conditions, come to dominate in terms of emissions. Manufacturing activity is expected to continue to grow at a rate of about 1.8% per year, though this growth is likely to be offset by continuing declines in overall energy intensity due to energy efficiency gains and structural shifts to less energy-intensive industries.[50]

Figure 5-2 1990-2020 GHG Emissions by Sectors



[50] Projections of manufacturing activity (employment growth) are based on estimates from the Arizona Department of Economic Security. By contrast, non-manufacturing employment is projected to grow at an annual rate of 2.6%. Declines in energy intensity are based on projections by the U.S. Department of Energy (Annual Energy Outlook 2005).

Key Challenges and Opportunities

The principal means to reduce RCI emissions include improving energy efficiency, substituting electricity and natural gas with lower-emission energy resources (e.g., solar water heating), and various strategies to decrease the emissions associated with electricity production (see Energy Supply). The state's rapid growth and limited pursuit of energy efficiency to date offers particularly strong opportunities to reduce emissions through programs and initiatives to improve the efficiency of buildings, appliances, and industrial practices. At the same time, fast growth places pressure on communities and businesses to make swift decisions, and can shorten their time horizons for recouping investments. A key challenge lies in the design and implementation of strategies that overcome these barriers and thus ensure new buildings and industries take full advantage of opportunities to reduce energy use and emissions.

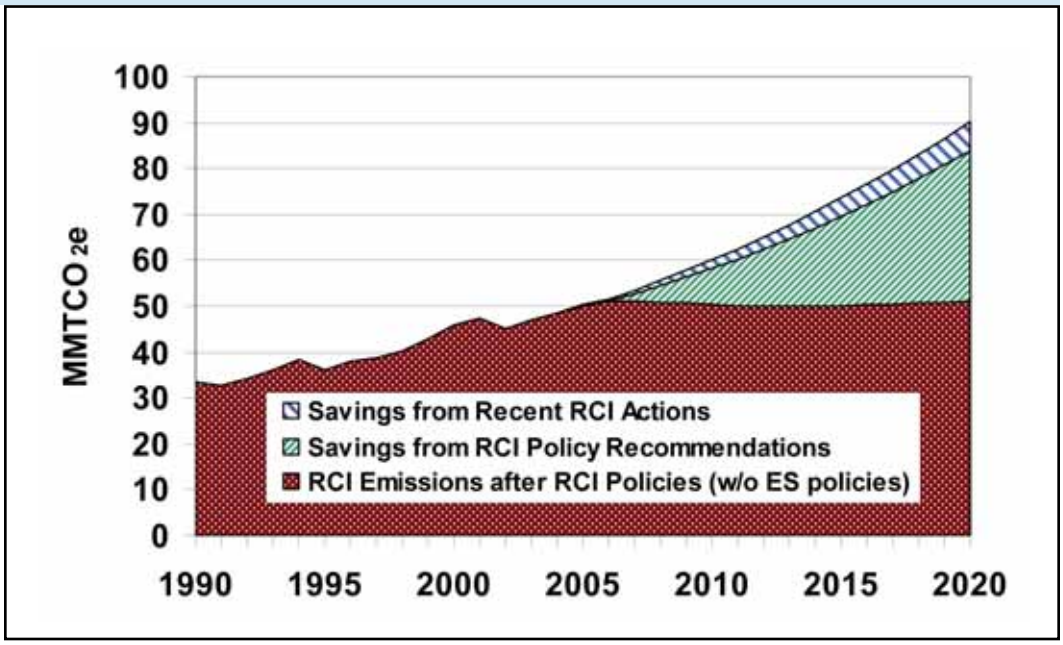
Arizona's business, tribal, government, and citizen representatives have recently taken major steps in this direction. Adopted in 2003, the state's government building energy goals are a nationally-recognized example of leadership-by-example. The state universities have recently installed state-of-the-art combined-heat-and-power facilities, and have completed extensive Energy Saving Performance Contracts. Together with several other states, Arizona adopted state appliance efficiency standards in 2005, which in part provided the impetus for federal adoption in the 2005 Federal Energy Bill. In the past year, the state's electric and gas utilities have made significant new commitments to increase their energy efficiency programs. And the state's semiconductor industry has committed to major reductions of PFC emissions; Intel Corporation, for example, has reduced its PFC emissions in Arizona by a factor of 4 over the past 3-4 years. While an indication of the growing momentum for improving efficiency and reducing emissions, these actions only begin to tap the overall potential of the state to slow its growth of energy use and GHG emissions.

Emissions from solid waste management practices can be addressed through the implementation of more aggressive recycling and waste reduction programs. Programs to reduce water use in the municipal, agricultural, and industrial sectors can yield further savings by reducing the energy required to pump water from place to place.

Overview of Policy Recommendations and Estimated Impacts

The CCAG recommends a set of ten (10) policy options for the residential, commercial, and industrial sectors, plus two (2) options focused on waste and water management, that offer the potential for major economic benefits and emissions savings. As summarized in Figure 5-3, these 12 policy recommendations could lead to emissions savings from reference case projections of 31 $MMtCO_2e$ per year by 2020 and cumulative savings of over 220 $MMtCO_2e$ from 2006 through 2020. The weighted average cost of saved carbon from the policy options for which quantitative estimates of both costs and savings were prepared was minus $30 per metric ton of CO_2 equivalent, meaning

Figure 5-3 Impact of Policy Recommendations on RCI Emissions



that there is a net savings to the Arizona economy in implementing these options. Most emissions savings from the RCI options are in the form of reduced carbon dioxide emissions, with relatively minor reductions of emissions of other greenhouse gases (principally methane and nitrous oxide) produced via leakage and/or combustion of fuels.

The estimated impacts of the RCI and solid waste/water management policies recommended by the CCAG are shown in Table 5-2. Also shown in Table 5-2 are the results of several policies that have either been recently implemented or will be implemented as a result of earlier State policies. These "Savings from Recent RCI Actions" are not accounted for in the reference inventory and forecast, but contribute to overall emissions reduction along with savings from the CCAG-recommended measures. The combination of savings from recent actions and CCAG policies are, in the RCI sectors, estimated to approximately equal projected reference case growth in emissions from 2006 through 2020.

The CCAG policy recommendations described below result not only in significant emissions and costs savings, but offer a host of additional benefits as well. These benefits include (but are by no means limited to) reduction in spending on energy by homeowners and businesses, contributing to local economic development, reduced local air pollution, reduced need for electricity supply facilities, and, for example, for building improvement measures, improvements in comfort and convenience.

In order for the RCI policy options recommended by the CCAG to yield the levels of savings described here, the options 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 options effective. Improved building codes will not be optimally effective, for example, without training of contractors, builders, architects, financial institutions,

Table 5-2 Summary of Results

RESIDENTIAL, COMMERCIAL, INDUSTRIAL (RCI) AND WASTE MANAGEMENT						
	CCAG Policy Option	2010 Annual GHG Reduction ($MMtCO_2e$)	2020 Annual GHG Reduction ($MMtCO_2e$)	2007-2020 Cumulative Reduction ($MMtCO_2e$)	Cost or Cost Savings Per Ton GHG Removed ($\$/tCO_2e$)	Level of CCAG Support
RCI-1	Demand-Side Efficiency Goals, Funds, Incentives, and Programs	3.1	15.1	103	-$36	Unanimous
RCI-2	State Leadership Programs	0.04	0.4	3	-$4	Unanimous
RCI-3	Appliance Standards	0.2	1.0	7	-$66	Unanimous
RCI-4	Building Standards/Codes for Smart Growth	0.3	2.2	14	-$18	Unanimous
RCI-5	"Beyond Code" Building Design Incentives and Programs for Smart Growth	0.2	3.1	18	-$17	Unanimous
RCI-6	Distributed Generation Combined Heat and Power	0.4	2.7	16	-$25	Unanimous
RCI-7	Distributed Generation Renewable Energy Applications	0.1	2.1	10	$31	Unanimous
RCI-8	Electricity Pricing Strategies	1.1	1.5	16	-$63	Unanimous
RCI-9	Mitigating High Global Warming Potential (GWP) Gas Emissions (HFCs, SFCs, PFCs)	Not available				Unanimous
RCI-10	Demand-Side Fuel Switching	0.1	1.2	7	Not available	Unanimous
RCI-12	Solid Waste Management	2.2	3.7	36	Not available	Unanimous
RCI-13	Water Use and Wastewater Management	0.2	0.8	6	Not available	Unanimous
Total all options, adjusted for overlap and interaction		7.5	31.1	222		

and building inspectors, among others, in the methods and benefits of efficient building design. Regulatory policies that provide incentives and lower disincentives for the adoption of consumer-sited combined heat and power and renewable electricity generation are also among the supporting policies crucial to the success of the RCI options recommended by the CCAG. The CCAG's work indicates that there are considerable benefits to both the environment and to consumers from adoption of the policy options offered, but 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.

CCAG RCI and Waste Management (RCI) Sector Policy Descriptions

The Residential, Commercial, Industrial and Waste Management Sectors include emissions reduction opportunities related to improving energy (and water) use efficiency, using lower GHG energy sources, and enhancing waste management practices. Fully detailed descriptions of the individual RCI policy options as presented to and approved by the CCAG can be found in the Appendix G.

Demand-Side Efficiency Goals, Funds, Incentives, and Programs (RCI-1)

The CCAG recommends the setting of energy savings goals for electricity and natural gas, and the implementation of the policy, program, and funding mechanisms that are needed to achieve these goals. These goals, incentives, and programs are intended to work in tandem with other strategies under consideration by the RCI and ES sectors. Suggested energy savings goals are as follows:

- Electricity (energy savings target): 5% savings by 2010, 15% savings by 2020.[51]
- Natural gas (utility spending target): ramp up to spending 1.5% of gas utility revenues on energy efficiency programs by 2015 pursuant to Arizona Corporation Commission (ACC) decoupling of gas sales and revenue. Further decisions by the ACC to decouple gas sales and revenues are viewed as central to achieving this target.

Possible implementation options include public benefit charges, tariff riders, enabling legislation, and/or regulatory directives. These and other options can be augmented, where applicable by state and national tax incentives for energy efficient equipment. Indeed, an evolving and flexible mix of these policy mechanisms may be needed to achieve the efficiency goals described here.

Supporting activities may be important elements in the success of energy efficiency strategies, and could include consumer education and outreach programs (including, for example, enhanced State Energy Office and university-based energy-efficiency extension services), and market transformation programs and organizations. Activities in support of energy efficiency could also include decoupling utility sales and revenues and creating performance incentives that reward utilities for implementing effective demand-side

[51] These savings targets would be for electricity sales (MWh), and would reflect cumulative (from today), verified savings as a percentage of those years' (projected) loads, starting from the time of policy adoption.

management (DSM) programs. Furthermore, the CCAG recommends the inclusion of energy efficiency resource in an integrated resource planning (IRP) process, which can enable the overall most efficient and cost-effective delivery of energy services.

State Leadership Programs (RCI-2)

The CCAG recommends that state and local governments undertake "Lead by Example" activities to achieve energy cost savings and promote clean energy technologies by the public and private sectors.

Specific recommendations include:

- Extending state building energy savings goal (A.R.S. §34-451) to include a further 15% reduction in energy use per square foot in state buildings from 2011 to 2020, along with purchasing of EnergyStar equipment.
- Standards for new state buildings, with possible design parameters including recommendations for new buildings to be better than code or LEED[52] (or similar) energy efficiency requirements, such as those recommended by the Arizona Working Group on Renewable Energy and Energy Efficiency and by the Energy Efficiency Task Force of the Western Governors Association Clean and Diversified Energy Advisory Committee (WGA CDEAC) (see also Option RCI-5), as well as mechanisms to support the state in achieving its building energy efficiency goals.
- Green procurement strategies, such as installation of renewable energy systems as additional backup services in emergency services buildings, and efforts to promote or require the purchase by state buildings of 5% of their building energy needs from renewable sources (over a phased-in period) by 2012, increasing to 10% by 2020.
- The promotion of new combined heat and power (CHP) facilities in State buildings, recent examples of which are the facilities in place and under construction at Arizona State University and the University of Arizona (approximately 35 MW total), and the expansion of existing performance contracting law to require life cycle analysis for CHP in State lease-purchase construction.

The full policy option description provided in Appendix G acknowledges numerous programs and policies currently in place in Arizona and includes additional specific recommendations.

Appliance Standards (RCI-3)

Appliance efficiency standards reduce the market cost of energy efficiency improvements by incorporating technological advances into base appliance models, thereby creating economies of scale. Appliance efficiency standards can be implemented at the state level for appliances not covered by federal standards. Arizona and other states recently adopted state level appliance efficiency standards covering several appliances.

[52] The Leadership in Energy and Environmental Design (LEED) certification process includes, but is not limited to, energy-efficiency specifications for buildings. Other building energy-efficiency guidelines may also be applicable.

The CCAG recommends implementation of state appliance efficiency standards for appliances not covered by federal standards or where higher-than-federal standard efficiency requirements are appropriate.

More specifically, the CCAG calls for the State to:

- Advocate for stronger federal appliance efficiency standards where such standards are technically feasible and economically justified.
- For those appliances not likely to be covered by federal efforts, pursue efficiency standards already adopted by California and/or other states.
- Where possible, consider encouraging local manufacturing of high-efficiency appliances and equipment when adopting state standards.

Building Standards/Codes for Smart Growth (RCI-4)

The CCAG recommends that improved and increasingly stringent energy efficiency codes for Arizona be adopted and implemented.

Building energy codes specify minimum energy efficiency requirements for new buildings or for existing buildings undergoing major renovations. Given Arizona's growth and the long lifetime of buildings, the current and future building codes will have a considerable impact on future energy use in buildings, and on related greenhouse gas emissions. Specifically, the CCAG recommends that:

- Arizona should either establish a statewide code or strongly encourage local jurisdictions to adopt and maintain state-of-the-art codes. Adoption is targeted for 2007, with codes in force in early 2008, but with the recognition that some municipalities in Arizona may implement energy efficiency codes later than others.
- Arizona and/or local jurisdictions should adopt the 2004 International Energy Conservation Code (IECC), to the extent that adoption has not already occurred. Also, Arizona and/or local jurisdictions should consider adopting innovative features of California's latest Title 24 building energy codes, such as lighting efficiency requirements in new homes.
- Arizona and local jurisdictions should update energy codes regularly. A three-year cycle could be timed to coincide with release of the national model codes.
- Revised building codes for Arizona as a whole and for local jurisdictions should be prepared with the involvement of local chapters of code organizations to assist in obtaining support for and compliance with the new policies. All buildings should be covered, including manufactured homes, and local building inspectors should enforce compliance with codes. Inspectors need to be properly trained in new elements of the codes.

"Beyond Code" Building Design Incentives and Programs for Smart Growth (RCI-5)

The CCAG recommends that building energy performance standards be implemented in State-funded and other (such as local) government buildings. It also recommends promotion of similar standards for use in other buildings,

such that new buildings achieve high standards of energy efficiency, and existing buildings are renovated or retrofitted to yield significant energy efficiency improvements. Specifically, this policy option includes:

- Implementation of the energy-efficiency elements of LEED (Leadership in Energy and Environmental Design) standards/certifications and/or other "green building" certifications and/or measured or modeled building energy performance criteria to specify building energy performance standards.
- A performance standard for State-owned or state-leased buildings to demonstrate the feasibility of not only achieving the minimum code requirements but also significantly exceeding code requirements.
- A requirement that State-owned or leased facilities use life-cycle costing, including full consideration of future energy costs, in the selection and implementation of building designs and components (including energy-using equipment such as heating, ventilation and air conditioning systems) for both new and renovated space, or for the selection of replacement components. Further, following life-cycle cost analysis, require that the most cost-effective design/equipment/component options be chosen.
- Financial or tax incentives for non-public and non-state public buildings (such as municipal buildings) to improve their energy performance beyond that required by existing codes.

Distributed Generation/Combined Heat and Power (RCI-6)

Distributed generation with clean combined heat and power (DG/CHP) systems improves the overall efficiency of fuel use as well as electricity system benefits. The CCAG recommends that the implementation of DG/CHP systems should be encouraged through a combination of regulatory changes and incentive programs. CHP systems of 10 MW or smaller (or of equivalent mechanical power) would be covered, and policies in place by the end of 2006, and in force thereafter, with periodic review as needed. Regulatory changes and incentives should be designed to enable a significant fraction of Arizona's estimated remaining CHP potential to be realized. The full policy description for RCI-6, as provided in Appendix G, notes possible funding mechanisms and regulatory standards that could be considered.

Distributed Generation/Renewable Energy Applications (RCI-7)

Customer-sited distributed generation powered by renewable energy sources provides electricity system benefits such as avoided capital investment and avoided transmission and distribution losses, while also displacing fossil-fueled generation and thus reducing greenhouse gas emissions. Customer-sited renewable distributed generation can include solar photovoltaic systems, wind power systems, biogas and landfill gas-fired systems, geothermal generation systems, and systems fueled with biomass wastes or biomass collected or grown as fuel.

The CCAG proposes that Arizona promote the increased use of renewable distributed generation in Arizona through a combination of regulatory changes and incentives.

Policies to encourage and accelerate the implementation of customer-sited renewable distributed generation include direct incentives for system purchase, market incentives (including "net metering") related to the pricing of electricity output by renewable distributed generation, state goals or directives, and favorable rules for interconnecting renewable generation systems with the electricity grid.

Non-electric renewable energy applications also covered by this policy include solar water heat and solar space heat and cooling. It is suggested that Arizona should, at a minimum, set as its target the addition of customer-sited distributed renewable generation consistent with the overall generation capacity by year goals for renewable distributed generation in the West as expressed in the WGA CDEAC reports.

Electricity Pricing Strategies (RCI-8)

As with other energy and non-energy commodities, the pricing of electricity—including electricity from the grid used by consumers and electricity generated on the consumers' premises flowing to the grid—can have a significant impact on consumers' usage decisions. Proper and clear electricity tariffs and price signals can provide significant encouragement to distributed generation, energy conservation (in many forms), and reduction of electricity use during times of peak electricity demand.

Creating such tariff structures may involve restructuring tariffs to provide incentives for "shoulder" and peak usage period demand reductions—for example, through implementation of time-of-use energy charges—as well as setting net metering or other rules for sales from distributed generation to the grid that provide appropriate credit for the electricity generated during periods of high power demand. Changes in tariff structures are also needed that revise the balance between energy and demand charges and change the way that demand charges are fixed.

The CCAG recommends that changes in Arizona electricity pricing and tariffs be designed to provide improved incentives for end-users to adjust the timing of energy use so as to reduce greenhouse gas emissions as much as possible. The implementation of inverted block rates, where higher tariffs are charged once electricity use per household (for example) reaches a threshold level each month, is also recommended.

Mitigating High Global Warming Potential Gas Emissions (RCI-9)

The CCAG recommends a combination of voluntary agreements with industries and new specifications for key equipment to reduce the emissions of process gases that have high global warming potential.[53] In particular, the CCAG suggests consideration of specifications and possible voluntary incentives

[53] Based on the current AZ emissions inventory and projection, GHG emissions from hydrofluorocarbons (HFCs) could grow from about 1 $MMtCO_2e$ or <1% of Arizona GHG emissions in 2000 to over 7 $MMtCO_2e$ or about 5% of state emissions by 2020. Most HFC emissions are expected to result from leaks in mobile air conditioning and refrigeration applications. Other sources of high Global Warming Potential (GWP) gases, which include the emission of perfluorocarbons (PFCs) and HFCs and from semiconductor manufacture and leakage of sulfur hexafluoride (SF6) from electricity distribution equipment, contribute less to state emissions, and these emissions are expected to decline based on existing emission reduction efforts, such as the semiconductor industry's voluntary worldwide agreement.

for new commercial refrigeration equipment, such as the specifications currently under consideration by the California Air Resources Board. The specifications would: a) promote the use of low global warming potential (GWP) refrigerants in refrigerators in retail food stores, restaurants, and refrigerated transport vehicles (trucks and railcars); and/or b) require or provide incentives that centralized systems with large refrigerant charges and long distribution lines be avoided in favor of systems that use much less refrigerant and lack long distribution lines.

The CCAG further recommends that the Governor explore working with California and other states in addressing HFC emissions from refrigeration systems. Maintaining momentum of voluntary industry-government partnerships (such as the semi-conductor industry agreement) should also be a high priority.

Demand-Side Fuel Switching (RCI-10)

The CCAG recommends the adoption of options for encouraging consumers to switch to the use of less carbon-intensive fuels to provide key energy services. Fuel switching opportunities can include using natural gas in the place of electricity for thermal end-uses, natural gas in the place of coal for key industrial end-uses, biomass fuels in the place of electricity or natural gas for thermal end-uses, and solar thermal energy in the place of electricity or natural gas for thermal end-uses.

The CCAG recommends a two-part approach to promote demand-side fuel switching. Phase I consists of efforts to promote switching from high-carbon fuels to lower-carbon fuels (such as from oil or coal to natural gas). Phase II targets inducing consumers to switch to "low or zero carbon" fuels by offering incentives to do so. In particular: a) the promotion of solar water heating through a combination of incentives and targeted research, and b) the substitution of biodiesel for diesel in commercial and industrial equipment, are recommended.

Solid Waste Management (RCI-12)

The CCAG recommends pursuing several options to increase recycling and reduce waste generation in order to limit greenhouse gas emissions associated with landfill methane generation and with the production of raw materials. In 2005, over 3 million residents in 39 Arizona communities had access to residential curbside recycling, representing slightly over 50% of the state's population. To further increase the diversion of waste from landfill and the amount of materials recycled, the State should aim to:

- Ensure that curbside recycling programs are provided in all communities over 50,000 in population;
- Increase the penetration of recycling programs in multi-family dwellings;
- Create new recycling programs for the commercial sector;
- Provide incentives for the recycling of construction materials;
- Develop markets for recycled materials;
- Increase average statewide participation/recovery rates for all existing recycling programs;
- Develop a statewide recycling goal.

Implementation options to increase recycling and reduce waste generation may include the following: expanded ADEQ Waste Reduction Assistance (WRA) grants; mandatory source separation and recycling laws or ordinances in urban areas; tax breaks or other incentives to make recycling financially attractive for private commercial sector waste haulers; full recycling as a contract requirement for state facilities; government purchasing requirements for recycled content of items purchased (paper, carpets, etc.); a waste education campaign, aiming at waste reuse and reduction, and targeting greenhouse gas reductions; and general awareness building, such as working with community leaders to appreciate benefits and cost-effectiveness of curbside recycling.

Water Use and Wastewater Management (RCI-13)

Arizona currently uses about 7.2 million acre-feet (MAF) of water, an estimated 78%[54] of which is delivered to agricultural consumers, 18% to municipal consumers, and the remainder to industrial users. A significant amount of energy is used to pump this water from underground aquifers (3.6 MAF), from the Colorado River (2.6 MAF), and other sources (1.2 MAF), and to treat it in wastewater facilities after it is used. The CCAG has the following five recommendations:

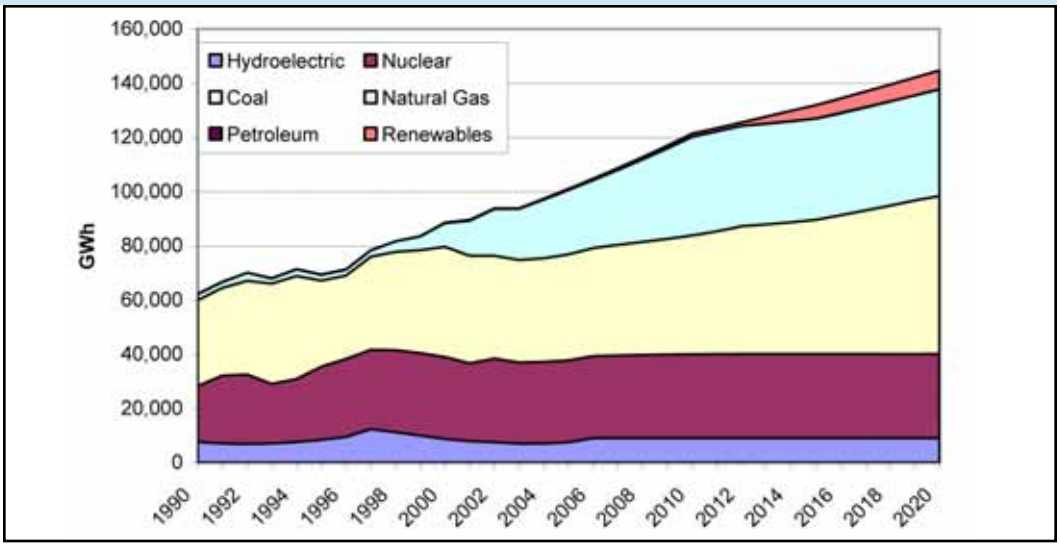
- Accelerate investment in water use efficiency. Elements may include implementing best management practices and efficient water management practices, and providing incentives for implementation of water management improvement measures. Consideration should also be given to developing a statewide water and wastewater savings plan, based on a thorough assessment of water and wastewater options in all water using sectors.
- Increase the energy efficiency of all water and wastewater treatment operations, and develop long-term programs to better mesh with the long-term investments in water and wastewater infrastructure. Two specific suggestions with respect to improving pump efficiency are detailed in the full policy description for RCI-13 provided in Appendix G.
- Increase energy production by water and wastewater agencies from renewable sources such as in-conduit hydropower generation and biogas production from sewage sludge.
- Encourage and create incentives for technologies with the capability to reduce water use associated with power generation.
- Ensure that power plants use the best management practices and economically feasible technology available to conserve water (via siting, evaluation, permitting, or other processes).

[54] Arizona Department of Water Resources statistic, July 2006.

Overview of Greenhouse Gas Emissions

Arizona's historical sources of electricity generation by fuel type are shown in Figure 6-1, with projections to the year 2020.[55] Natural gas generation has grown considerably during the past decade, while coal, nuclear, and hydro generation have stayed relatively constant. Based on the CCAG reference case forecast, natural gas will continue to dominate new generation through 2010, at which point coal assumes an increasing market share, reflecting that natural gas prices may continue to rise.

Figure 6-1 Electricity Generated by Arizona Power Plants, 1990-2020[56]

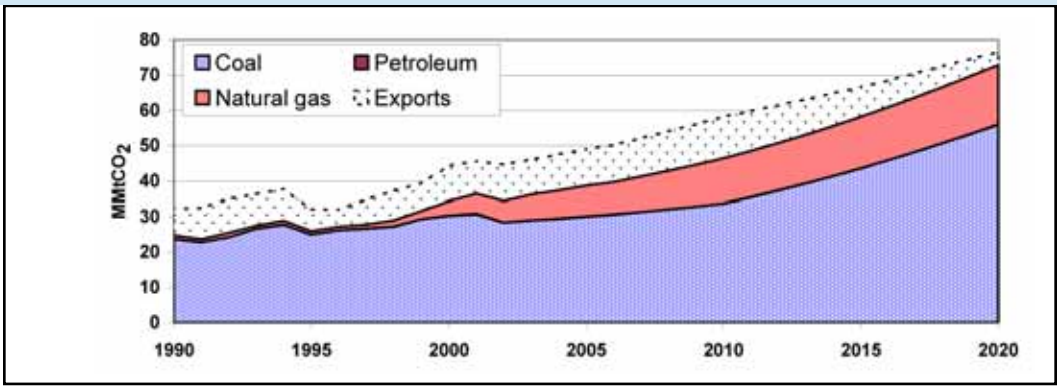


Electricity emissions are estimated both on a consumption basis (i.e., accounting for the GHG emissions associated with electricity consumed within the State) and on a production basis (i.e., based on the GHG emissions associated with electricity produced within Arizona, much of which is currently exported). Figure 6-2 shows the GHG emissions associated with electricity consumption and exports, based on the assumptions mentioned above. From 1990 to 2000, electricity sales in the state grew by about 4% per year, with CO_2 emissions growing at roughly 3% per year in this period. Emissions grew more slowly than electricity sales because the share of natural gas generation increased while the coal share decreased. The decreasing share of coal led to a slight decrease in CO_2 emissions per MWh generated (1,142 lb CO_2/MWh in 1990 to 1,107 lb CO_2/MWh in 2000). From 2000 to 2020, emissions associated with electricity use are projected to grow at 3.8% per year, as the fraction of coal generation increases, especially after 2010.

[55] Values are based on the assumptions described in Appendix D, *Final Arizona Greenhouse Gas Inventory and Reference Case Projections, 1990-2020*.

[56] This same data and graphic are also presented in Figure 6-4 herein as the "Reference Case Electricity Supply by Fuel Type" for purposes of comparison with the projected impact of the CCAG's recommended policy options on electricity generation fuel supply.

Figure 6-2 Historical and Projected CO_2 Emissions Associated with Electricity Use (Consumption-Basis) and Exports, 1990-2020



Key Challenges and Opportunities

The principal challenge in addressing GHG emissions from Arizona's electricity sector is the State's extraordinary growth rate, specifically the accompanying increase in baseload demand expected over the next 15 years, coupled with natural gas price uncertainty. Absent any carbon policy, the least-cost choice for new baseload capacity in the 2010 to 2020 timeframe is expected to be pulverized coal. Commercial scale applications of advanced coal technologies like integrated gasification combined cycle (IGCC) with carbon capture and storage are currently under development in many states (including Arizona) with commercial operation anticipated between 2011 and 2014. These advanced coal technologies offer the opportunity for the implementation of low carbon policies. If low carbon policies are implemented, advanced coal technologies like IGCC will likely be less costly (in terms of electricity produced) than pulverized coal, albeit at a cost higher than today's cost for pulverized coal.

Arizona's most plentiful renewable resource, of course, is solar energy, and the State has a significant leadership opportunity in the commercialization of solar technologies. Solar photovoltaic (PV) is commercial in certain applications, particularly for peak shaving and for off-grid applications, but requires cost-effective storage technology in order to provide baseload power. Concentrating solar power (CSP) is an emerging technology on the cusp of commercialization. Some CSP technologies can dispatch electricity for six or more hours after sundown, providing power for all but the lowest demand hours. Arizona has untapped, but limited, wind resources. Wind's intermittency inhibits its value for baseload capacity, but wind can provide baseload power if wind facilities are carefully planned at multiple sites and coupled with backup combustion turbines.

Arizona may also face unusual challenges in reducing electric sector GHG emissions as a result of the nature of its electric power industry. Generating stations in Arizona are subject to substantially different oversight regimes depending on whether they are regulated by the Arizona Corporation Commission (e.g., APS, Tucson Electric), overseen by independently elected board (e.g., the Salt River Project), or are located on tribal lands (e.g., the Four Corners and Navajo generating stations). This disparity may make broad adoption of some of the CCAG's recommendations more difficult.

Overview of Policy Recommendations and Estimated Impacts

The CCAG recommends a set of eight policy options for the Energy Supply (ES) sector that offer the potential for significant emission reductions. Of these policies, three (ES-3, Direct Renewable Energy Support; ES-9, Reduce Barriers to Renewables and Clean Distributed Generation; and ES-11, Pricing Strategies) are quantified under the RCI sector. These results are noted in Table 6-1 below, but they are not included in the Energy Supply sector totals in order to avoid double-counting. The CCAG has recommended ES-4, GHG Cap and Trade, as a policy option that Arizona should explore at the regional or national level. The estimates in Table 6-1 are based on modeling of a national cap and trade program and the likely impact on only Arizona's power sector. The CCAG has recommended an economy-wide cap and trade program, but the estimates do not include any projected reductions from sectors other than the power sector. Values for the range of results are shown. ES-10, Metering Strategies, is an enabling policy for greater penetration of clean distributed generation and energy efficiency technologies. The reductions attributable to this greater penetration are quantified under other CCAG policy options.

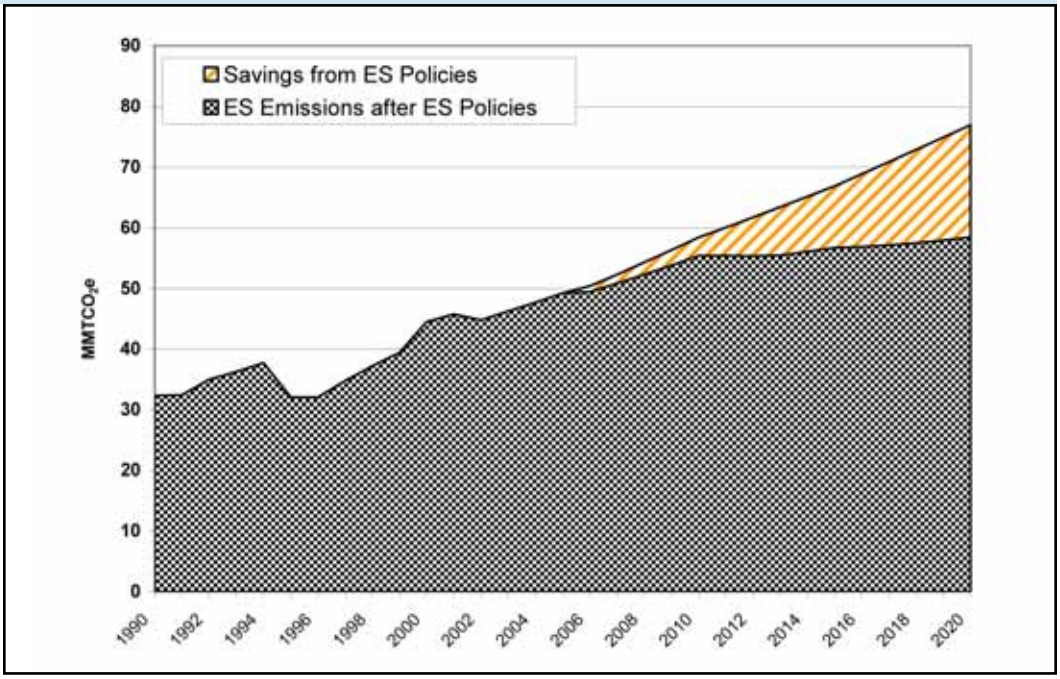
Three policies are quantified as Energy Supply options that Arizona can implement on its own, including ES-1, Environmental Portfolio Standard/Renewable Energy Standard and Tariff; ES-6, Carbon Intensity Targets; and ES-12, Integrated Resource Planning. Because the purpose of ES-12 would largely be accomplished by (i.e., overlap with) the activities that would be undertaken to satisfy ES-1 and ES-6, only the results from ES-1 and ES-6 are included in the totals in Table 6-1. (The results of ES-12 are indicated in the Table, but not counted in the totals in order to avoid double-counting.) Further, because either ES-1 or ES-6 would exhaust all available wind, biomass, and geothermal generation capacity within Arizona, GHG reductions from these resources are included only in ES-6 in order to avoid double-counting.[57]

If implemented as part of a comprehensive package of the CCAG's recommendations, ES-1 and ES-6 would need to be evaluated with respect to the reference case electricity demand forecast in order to take into account the fact that other measures (e.g., energy efficiency and distributed generation) would reduce the demand for grid electricity generation. Because the GHG reductions associated with ES-1 and ES-6 are directly related to total MWhs generated, GHG reductions for ES-1 and ES-6, in this situation, would have to be adjusted downward to reflect this lower demand. Specifically, GHG reductions achieved by the ES policies would have to be reduced by the same percentage as the RCI policies reduced grid electricity generation in order to approximate the combined results of ES and RCI policies. See the Appendix H for further information.

[57] ES-6 was chosen for relative ease of calculation; wind, biomass, and geothermal could have been included in ES-1 instead.

Figure 6-3 shows the impact of ES-1 and ES-6 on GHG emission projections in Arizona.

Figure 6-3 Impact of Policy Recommendations on Energy Supply (ES) GHG Emissions Compared to Reference Case



The individual CCAG policy recommendations described briefly below (and in more detail in Appendix H) provide substantial GHG emission reductions, and when combined with the options recommended jointly by Energy Supply and RCI, substantial cost savings and additional benefits as well. These benefits include (but are not limited to) reduced need for electric generation facilities, reduced local air pollution, greater energy reliability and security, and greater contribution to local economic development, including the creation of jobs in rural communities and job-needy areas due to the development of alternative energy opportunities (i.e., biomass, biofuels and wind) in these areas. It is estimated that a 50 MMgal/year ethanol plant in Arizona would yield approximately 70 full-time positions, with additional job creation resulting from the production and processing of feedstocks used in production of ethanol. Given the estimates for ethanol production assumed in this Action Plan, 14 plants would be required by 2020 resulting in nearly 1,000 new jobs in rural Arizona.

Implementing the policies recommended by the CCAG to reduce carbon emissions associated with electric generation, increase renewable energy, and enhance energy efficiency would have a profound effect on the character of Arizona's future energy supply sector. This is evident in the contrast between Figure 6-4, the reference case, and Figure 6-5, which reflects the carbon-intensity-reducing and demand-reducing policies recommended by the CCAG from the ES and RCI sectors.

Figure 6-4 Reference Case Electricity Supply by Fuel Type

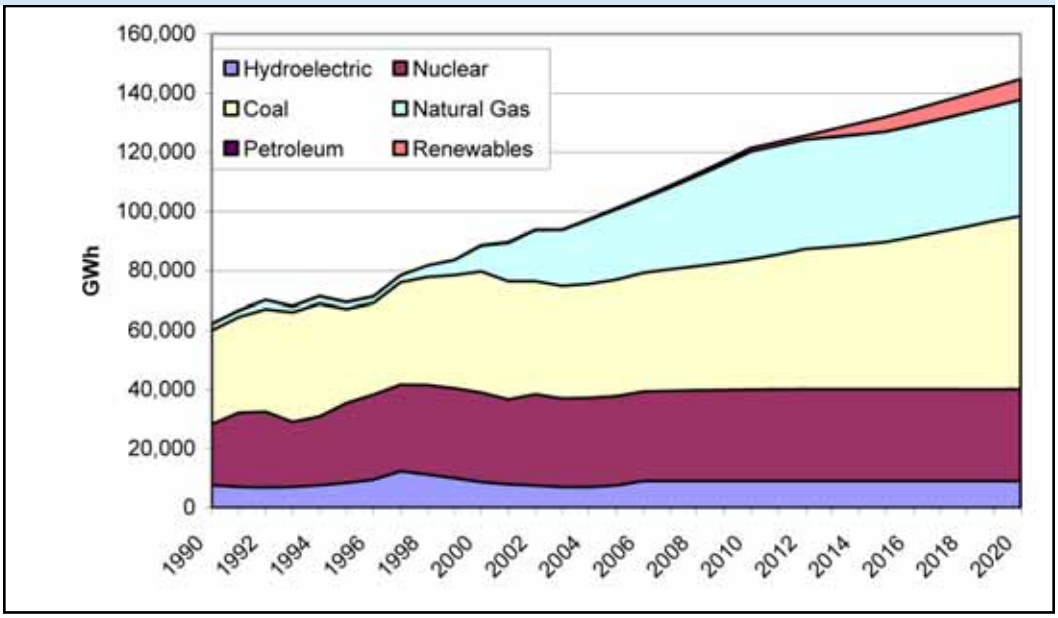
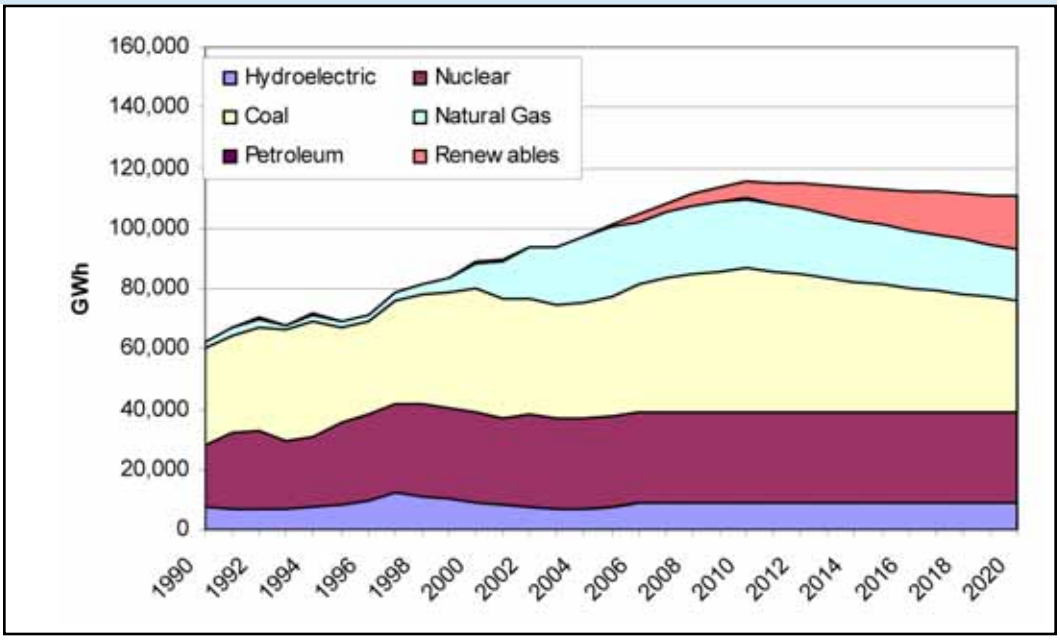


Figure 6-5 Policy Case Electricity Supply by Fuel Type (Reflecting CCAG ES and RCI Recommendations)



Not directly evident from the above figures is the fact that the dramatic expansion of renewables would be accompanied by a corresponding increase in the number of jobs in Arizona associated with this expansion. This would be paid for in large measure by the corresponding reduction in imports to Arizona of fossil fuels.

The CCAG's Energy Supply recommendations will not provide the levels of savings indicated here, of course, unless they are implemented in a timely, aggressive and effective manner, along with corresponding enabling policies. Careful, comprehensive, and consistent regulatory policies to reduce barriers and provide incentives for the adoption of consumer-sited combined heat and

power, waste energy recovery, and renewable electricity generation will be crucial to the success of these and several RCI policy options recommended by the CCAG. Similarly, public education and outreach, and institutional incentives such as GHG reporting and registry programs – also recommended by the CCAG – will be essential for maximum effectiveness.

Table 6-1 CCAG Recommended Policy Options, By Sector

ENERGY SUPPLY (ES)						
	CCAG Policy Option	**2010 Annual GHG Reduction ($MMtCO_2e$)**	**2020 Annual GHG Reduction ($MMtCO_2e$)**	**2007-2020 Cumulative Reduction ($MMtCO_2e$)**	**Cost or Cost Savings Per Ton GHG Removed ($\$/tCO_2e$)**	**Level of CCAG Support**
ES-1	Environmental Portfolio Standard/Renewable Energy Standard and Tariff	4.2	16.4	116.0	$6	Majority
ES-3	Direct Renewable Energy Support (including Tax Credits and Incentives, R&D, and siting/zoning)	This option is quantified under RCI-7, Distributed Generation / Renewable Energy Applications. Values are shown below for completeness, but not included in cumulative totals to prevent double-counting.				Unanimous
		0.1	2.1	10.0	$31	
ES-4	National or Regional GHG Cap and Trade	These estimates are based on modeling of a national cap-and-trade policy and the likely impact on Arizona's power sector. The values presented here show the range of results for GHG reductions and costs.				Unanimous
		- 0.28–0.18	2.0–18.5	7 - 88	$7 - $19	
ES-6	Carbon Intensity Targets	0.0	14.0	70.4	$44	Majority
ES-9	Reduce Barriers to Renewables and Clean Distributed Generation	This option is quantified under RCI-6, Distributed Generation / Combined Heat and Power. Values are shown below for completeness, but not included in cumulative totals to prevent double-counting.				Unanimous
		0.4	2.7	16.0	-$25	
ES-10	Metering Strategies	ES-10 is an enabling policy for RCI-6 and RCI-7; its quantification is incorporated as part of those options.				Unanimous
ES-11	Pricing Strategies	This option is quantified under RCI-8, Electricity Pricing Strategies. Values are shown below for completeness, but not included in cumulative totals to prevent double-counting.				Unanimous
		1.1	1.5	16.0	-$63	
ES-12	Integrated Resource Planning	This option overlaps substantially with ES-6, Carbon Intensity Targets. Values are shown below for completeness, but not included in cumulative totals to prevent double-counting.				Unanimous
		0.1	5.4	28.0	-$2	
	Total All Options, Adjusted for overlap and interaction	**3.0**	**17.9**	**120.6**		**Note: Total includes only ES-1 and ES-6.**

CCAG Energy Supply (ES) Sector Policy Descriptions

The Energy Supply sector includes emissions and mitigation opportunities related to electrical energy supply options, including the generation, transmission, and distribution of electricity, whether generated through the combustion of fossil fuels or by renewable energy sources, and whether generated in a centralized power station supplying the grid or by distributed generation facilities. Arizona has relatively little oil and gas production, so the CCAG has made no recommendations concerning the oil and gas energy supply options.

Fully detailed descriptions of the individual Energy Supply policy options as presented to and approved by the CCAG can be found in Appendix H.

Environmental Portfolio Standard /Renewable Energy Standard and Tariff (ES-1)

An environmental portfolio standard (EPS) is a requirement that utilities must supply a certain percentage of electricity from environmentally-friendly sources. An EPS differs from a Renewable Portfolio Standard (RPS) in that an EPS can include more options than renewables for meeting the requirement. Utilities can meet their requirements by purchasing or generating environmentally-friendly electricity or by purchasing clean energy credits. By giving utilities the flexibility to purchase clean energy credits, a market in these credits will emerge that will provide an incentive to companies that are best able to generate clean energy, either through energy efficiency or renewables.

The CCAG initially considered four option scenarios as variations of the changes that the Arizona Corporation Commission (ACC) is expected to make to the State's existing EPS. The EPS, of course, applies only to ACC-jurisdictional utilities. Major aspects of the anticipated ACC changes include:

- RPS of 5% in 2015, 15% in 2025.
- Starting in 2007, 5% of this total renewable requirement must be from distributed renewables, increasing to 30% by 2011 and remaining at 30% in future years.
- Renewable Energy Credit (REC) trading is allowed, provided that all other associated attributes are retired when applying RECs to the annual renewable energy requirement.
- Out-of-state resources can be used provided that the necessary transmission rights are obtained and used.

The CCAG narrowed the list of options from four to two:

- ES-1a(1): The ACC's likely changes to the EPS, with the Salt River Project (SRP) continuing with its sustainable resource program. (SRP plans to supply 15% of energy for retail sales with renewable or demand-side sources by 2025.)
- ES-1c: A more aggressive alternative proposal, applicable to all utilities in the state (not just ACC-jurisdictional utilities) starting with the 1% RPS in 2005 and increasing 1% each year to 26% in 2025, and allowing out-of-state renewables and REC trading.

The CCAG recognized that the ACC has related proceedings underway and believes that approval of the ACC's current rule-making effort would provide significant GHG emissions reductions. The CCAG recommended the more aggressive alternative (ES-1c) because of its cost-effectiveness and significant emissions reductions.

Direct Renewable Energy Support (ES-3)

The purpose of this suite of policies is to encourage investment in renewables by providing direct financial incentives and by removing siting and zoning barriers to renewable energy facilities. Development of new renewable technologies is also encouraged through research and development funding. Direct renewable energy support can take many forms including:

1) direct subsidies for purchasing/selling renewable technologies given to the buyer/seller;
2) tax credits or exemptions for purchasing/selling renewable technologies given to the buyer/seller;
3) tax credits or exemptions for operating renewable energy facilities;
4) feed-in tariffs, which are direct payments to renewable generators for each kWh of electricity generated from a qualifying renewable facility;
5) tax credits for each kWh generated from a qualifying renewable facility.

This option is closely related to RCI-7, Distributed Generation / Renewable Energy Applications, and is quantified under that option.

Greenhouse Gas Cap and Trade Program (ES-4)

A cap and trade system is a market mechanism in which CO_2 emissions are limited or capped at a specified level, and those participating in the system can trade allowances (where each allowance represents one ton of CO_2 emissions) in order to lower overall costs of compliance. For every ton of CO_2 released, an emitter must hold an allowance. The total number of allowances issued or allocated represents the cap. The government can give allowances away for free to those participating in the cap and trade system (or even to those who are not) using many different approaches (e.g., based on generation output, based on historical emissions, etc.), or it can auction them, or use a hybrid approach. Participants can range from a small group within a single sector to the entire economy, and the program can be implemented on "upstream" sources (where fuel is extracted or imported) or "downstream" sources (where fuel is consumed).

The CCAG recommendation is to encourage the Governor to explore development of a regional or national, economy-wide cap and trade program.

Carbon Intensity Targets (ES-6)

Rather than a fixed cap on carbon emissions, a carbon intensity target is a limit on the ratio of carbon emissions to a measure of output. Absolute emissions can increase as output increases. Measures of output are clear for some sectors like electricity generation (i.e., MWh), but are less clear for sectors where outputs vary widely (e.g., manufacturing). One measure of output for

such sectors could be dollars equal to the value of the output. The CCAG's recommendation reflects consideration of a mandatory carbon intensity target for Arizona beginning in 2010 (i.e., set equivalent to carbon intensity in 2010) and declining by 3% each year through 2025. The annual carbon intensity target would be translated into a cap, and trading would be allowed under that cap.

Reduce Barriers to Renewables and Clean Distributed Generation (ES-9)

By removing barriers to renewables and clean distributed generation (DG), more clean generation can come into the energy supply mix, displacing fossil fueled generation and thereby reducing CO_2 emissions. The CCAG's recommendation proposes to remove barriers by standardizing interconnection policies; improving procurement policies (e.g., state power purchases, loading order requirements, long-term contracting with clean DG, etc.); and requiring environmental disclosure, among other approaches. This option is closely related to RCI-6, Distributed Generation/Combined Heat and Power, and is quantified under that option.

Metering Strategies (ES-10)

There are two common metering strategies and policies: net metering and advanced metering. Net metering is a policy that allows owners of grid-connected distributed generation (i.e., generating units on the customer side of the meter) to generate excess electricity and sell it back to the grid, effectively "turning the meter backward." This policy allows for low transaction costs (e.g., by avoiding the need to negotiate individual contracts for the sale of electricity back to the utility) and is attractive to distributed generation (DG) owners because they are compensated equal to the full cost of purchased electricity (i.e., the sum of wholesale generation, transmission and distribution, and utility administration costs), rather than just the utility's avoided costs.

Advanced metering technology allows electricity consumers much greater opportunity to manage their electricity consumption. For example, consumers could set their meter to turn off air conditioning during the day while they are away. Coupled with pricing strategies whereby prices reflect actual costs, advanced metering could be set to automatically reduce power demand by turning off lights or appliances during peak times when the price reaches a threshold set by the consumer. Advanced metering could be encouraged by subsidizing or requiring their installation.

The CCAG approved this policy option as a recommendation, but because it is more of an enabling policy (for clean, distributed generation) than a reduction policy per se, it was not quantified for GHG reduction potential or cost effectiveness. It is an enabling policy for RCI-6 and RCI-7, which are quantified.

Pricing Strategies (ES-11)

Pricing strategies can take many forms including: (a) real-time pricing in which utility customer rates are not fixed, but reflect the varying costs that utilities themselves pay for power (which vary substantially during the day and over the seasons); (b) "time-of-use" rates which are fixed rates for different

times of the day and/or for different seasons; (c) "increasing block" rates whereby unit prices rise as consumption increases; (d) green pricing whereby customers are given the opportunity to purchase electricity with a renewable or cleaner mix than the standard supply mix offered by the utility; and (e) taking advantage of advanced metering to allow electricity consumers far greater opportunity to manage their electricity consumption to reduce use and cost.

The CCAG approved this option as a recommendation, but decided not to quantify it because of uncertainties surrounding it (e.g., load-shifting under time-of-use rates would reduce costs but could actually increase GHG emissions). However, this option is closely related to RCI-8, Electricity Pricing Strategies, which is quantified.

Integrated Resource Planning (ES-12)

Integrated Resource Planning (IRP) is a process that diverges from traditional utility least-cost planning. Rather than focusing only on supply-side options to meet a forecasted growth in electricity demand, IRP also incorporates demand-side technology and policy options to meet the anticipated future demand. Demand-side measures include energy efficiency, distributed generation, waste energy recovery, and peak-shaving measures. Typically, IRP also takes into account a broader array of costs, including environmental and social costs.

IRP is an involved, iterative process that, by its nature as a bottom-up planning methodology for individual utilities, does not lend itself to setting broad implementation levels per se. An emissions value, or "shadow price", can be specified for use in the IRP planning process, however. In making decisions about which resources to use to satisfy future energy demand, utilities would be required to apply this shadow price as a CO_2 adder in the course of their evaluation of technologies and options. Utilities would not actually be required to pay the shadow price.

The CCAG's analysis and recommendation reflects a shadow price of $15 per ton of CO_2 emitted to approximate the results of an IRP process.

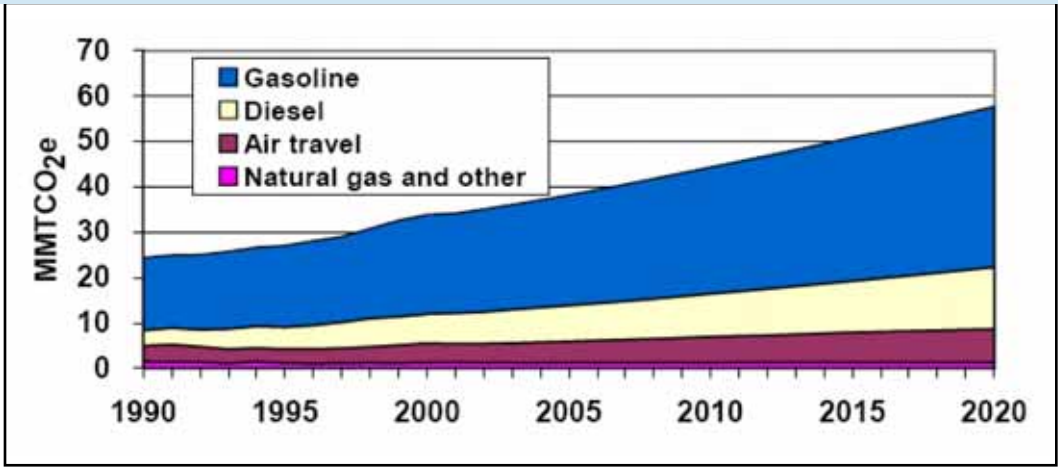
Chapter 7: Transportation and Land Use

Overview of Greenhouse Gas Emissions

The transportation sector is a major source of GHG emissions in Arizona – currently accounting for about 40% of Arizona's gross GHG emissions. The transportation technologies and fuels used are key determinants of those emissions, along with population, economic growth, and various land use policies that all affect the demand for transportation services. GHG emissions from the transportation sector totaled about 35 $MMtCO_2e$ in 2000. Carbon dioxide accounts for about 97% of transportation GHG emissions from fuel use; much of the remaining 3% is due to nitrous oxide emissions from gasoline engines.

Figure 7-1 shows historical and projected Transportation and Land Use (TLU) GHG emissions by fuel and source, and illustrates their rapid growth. TLU emissions are expected to more than double from 1990 from 2020. Arizona studies suggest on-road vehicle miles traveled (VMT) will continue to grow faster than the population, and rapid growth in freight VMT is also expected, reflecting continued economic growth and cross-border trade.

Figure 7-1 Historical and Projected TLU GHG Emissions, from 1990 to 2020



Key Challenges and Opportunities

The principal means to reduce TLU emissions include improving vehicle fuel efficiency, substituting gasoline and diesel with lower-emission fuels, modal switches to lower-emission means of travel, and various strategies to decrease the growth in fuel use and VMT.

In Arizona and in the nation as a whole, vehicle fuel efficiency has improved little since the late 1980s, yet many studies have documented the potential for substantial increases consistent with maintaining vehicle size and performance. The use of biofuels with lower GHG emissions is growing in

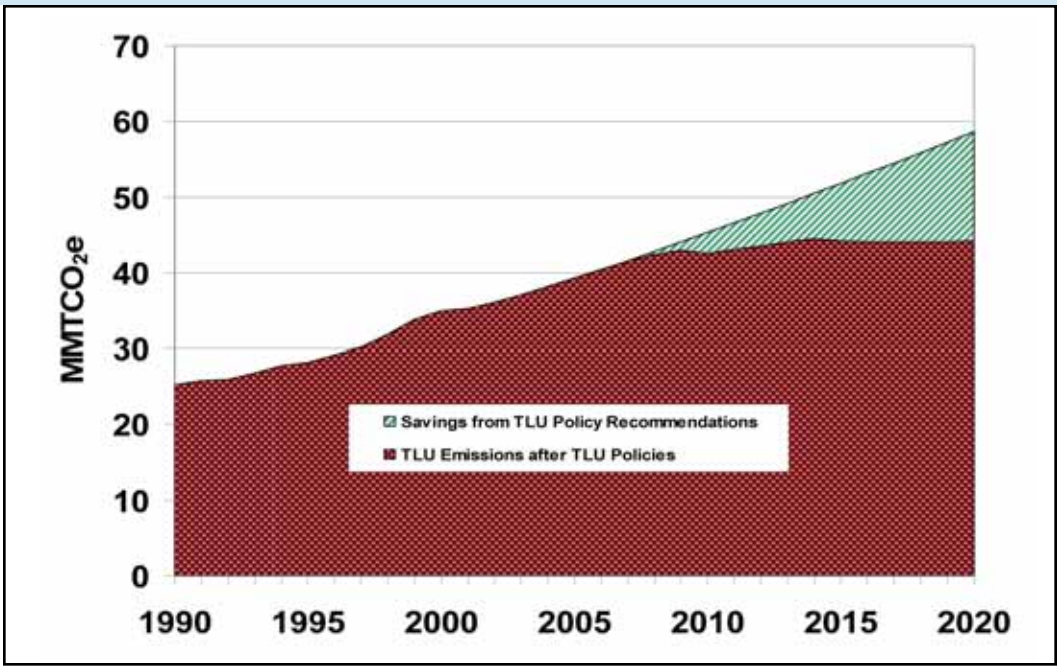
Arizona, but many obstacles remain in the way of large market penetration. Arizona also has taken some steps to increase transit options and encouraging Smart Growth.

Overview of Policy Recommendations and Estimated Impacts

The CCAG recommends a set of 13 policy options for the TLU sector that offer the potential for major GHG emissions reductions from the reference projection. As summarized in Table 7-1, these 13 policy recommendations could lead to emissions savings from reference case projections of 14.5 $MMtCO_2e$ per year by 2020 and cumulative savings of 91 $MMtCO_2e$ from 2007 through 2020. The weighted average cost of saved carbon from the policy options for which quantitative estimates of both costs and savings were prepared was minus $32 per metric ton of CO_2 equivalent, meaning that there is a net savings to the Arizona economy in implementing these options.

The estimated impacts of the TLU policies recommended by the CCAG are shown in Figure 7-2. Aggressive implementation of these policies could keep TLU emissions growth relatively flat, increasing only to about 44 $MMtCO_2e$ in 2020.

Figure7-2 Impact of Policy Recommendations on TLU Emissions



The CCAG policy recommendations described briefly here (and in more detail in Appendix I) result not only in the significant emissions and costs savings, but offer a host of additional benefits as well. These benefits include (but are by no means limited to) reduced local air pollution, more livable, healthy communities, and economic development and job growth from in-state biofuel production.

In order for the TLU policy options recommended by the CCAG to yield the levels of savings described here, the options must be implemented in a timely, aggressive, and thorough manner. Notably, the State Clean Car Program

for light-duty vehicles (TLU-1) accounts for a large portion of the reductions in this sector (e.g., more than 5 of the 16 $MMtCO_2e$ of reductions in the year 2020). This option must clear several hurdles before Arizona or any other state can adopt it, including EPA approval of the original California Clean Car Program (that other states can then opt into) and a court challenge to the underlying notion of regulation of GHG emissions from vehicles. If, for any reason, Arizona is not able to implement the Clean Car Program, other options could play a larger role. For example, Hybrid Promotion and Incentives (TLU-7) and Feebates (TLU-8) would improve fuel efficiency. A multi-state approach

Table 7-1 CCAG Recommended Policy Options, By Sector

TRANSPORTATION AND LAND USE (TLU)						
	CCAG Policy Option	2010 Annual GHG Reduction ($MMtCO_2e$)	2020 Annual GHG Reduction ($MMtCO_2e$)	2007-2020 Cumulative Reduction ($MMtCO_2e$)	Cost or Cost Savings Per Ton GHG Removed ($\$/tCO_2e$)	Level of CCAG Support
TLU-1	State Clean Car Program	0.3	5.6	32.5	-$90	Unanimous
TLU-2	Smart Growth Bundle of Options	1.5	4.0	26.7	$0 (Net Savings)	Unanimous
TLU-3	Promoting Multimodal Transit	Not available (included in TLU-2)				Unanimous
TLU-4	Reduction of Vehicle Idling	0.7	1.3	11.8	-$22	Unanimous
TLU-5	Standards for Alternative Fuels	Not available (enabling policy for TLU-12 and A-3)				Unanimous
TLU-7	Hybrid Promotion and Incentives	Not available (include in TLU-1)				Unanimous
TLU-8	Feebates	Not available				Super-Majority
TLU-9	Pay-As-You-Drive Insurance	0.0	2.8	12.3	$0 (Zero net cost)	Unanimous
TLU-10	Low Rolling Resistance Tires and Tire Inflation	0.0	0.8	4.8	Not available	Unanimous
TLU-11	Accelerated Replacement/ Retirement of High-Emitting Diesel Fleet	0.2	0.03	1.2	Not available	Unanimous
TLU-12	Biodiesel Implementation	0.1	1.1	6.2	$0 (Zero net cost)	Unanimous
TLU-13	State Lead-By-Example (via Procurement and Smart Way)	0.03	0.04	0.4	$0	Unanimous
TLU-14	60 mph Speed Limit for Commercial Trucks	0.3	0.5	5.2	$35	Super-Majority
Total all options adjusted for overlap and interaction		3.1	14.5	91.0		

to feebates is recommended here because of the drawbacks of Arizona (or any state) acting alone in this area.

To be most effective, Smart Growth (TLU-2) will require change at every level of government, and as such will be most effective with focused leadership by the State, including training, outreach, and technical assistance to local governments.

Transit-Oriented Development (TLU-3), as well, will require integrated action by state, regional, and local governments. The State can lead by ensuring that state investments support regional and local smart growth, by both how and where it makes those investments. Finally, TLU-2 and TLU-3 are mutually supportive, and implementing one will increase the benefits generated by the other.

CCAG Transportation and Land Use (TLU) Sector Policy Descriptions

The TLU sector includes emissions and mitigation opportunities related to vehicle technologies, fuel choices, transit options, and demand for transportation services. Fully detailed descriptions of the individual TLU policy options as presented to and approved by the CCAG can be found in Appendix I.

State Clean Car Program (TLU-1)

Arizona should adopt the State Clean Car Program in order to reduce GHG emissions from new light-duty vehicles. The standards, which must still be approved by US EPA, would take effect in model year 2011 (calendar year 2010). Other Clean Car Program elements include standards requiring reductions in smog- and soot-forming pollutants, and promoting introduction of very low-emitting technologies into new vehicles.

New cars and light trucks in all states must comply with Federal emission standards, and, generally speaking, states have the choice of adopting a stronger set of standards applicable in California.

Eleven (11) states already have adopted the Clean Car Program standards: California, Connecticut, Maine, Massachusetts, New Jersey, New York, Oregon, Pennsylvania, Rhode Island, Vermont and Washington.

Smart Growth Bundle of Options (TLU-2)

Arizona should implement a bundle of options to reduce GHG emissions driven by land use practices and policies. The options include:

- *Infill, increased density and brownfield redevelopment:* Shifting housing and commercial development toward location efficient sites, such as brownfields and infill parcels, and away from location inefficient sites, such as greenfields, reduces overall travel demand and expand lower emitting mode choices. Brownfields are commercial or industrial properties that are abandoned or are not being fully used because of actual or perceived environmental contamination. These properties have potential for redevelopment, but the uncertainty and risk of environmental liability and the cost of investigation and cleanup keep them from being redeveloped. Brownfields can be former industrial properties, abandoned gas stations,

vacant warehouses, or former dry-cleaning establishments. Redevelopment of these contaminated properties creates jobs, revitalizes neighborhoods, increases property and sales tax revenues, decreases urban sprawl, and reduces potential health risks to the local community. Infill development and increased density can also revitalize neighborhoods, increase tax revenues, and decrease urban sprawl.

- *Transit-oriented development:* Enables shifts to lower emitting modes by building compact, mixed-use development around transit stops so that people can meet daily needs by foot, bicycle, or transit.
- *Smart growth:* Smart growth allows for mixed land uses with a range of housing opportunities and multiple transportation options including pedestrian/bike access. State actions to support smart growth include planning, modeling, and regulatory tools that support location efficient growth; and making State-funded investments in smart growth communities that are proximate to household amenities (such as jobs, shopping, school, services, entertainment, etc.) as opposed to growth in areas that are not proximate and require greater travel distance and have less mode choice.
- *Targeted open space protection:* Includes programs designed to protect and conserve State lands and other open spaces, and develop and improve neighborhood, community, and regional parks in ways that encourage location efficient growth and broader mode choice.

Multi-Modal Transit Options (TLU-3)

Arizona should enable and support multimodal transit and promote shifts in passenger transportation mode choice (auto, bus, rail, bike, pedestrian, etc.) to lower emitting choices. This includes: making optimal use of Community Multi-scale Air Quality (CMAQ) funds; expanding transit infrastructure (rail, bus, bus rapid transit [BRT]); improving transit service, promoting and marketing transit (including tax-free and employer-paid commuter benefits); improving bike and pedestrian infrastructure; exploring commuter rail using existing rail corridors; considering re-establishing train service between Phoenix and Tucson; reviewing all proposed transportation projects for multi-modal flexibility (e.g., add BRT or light rail if feasible); and conducting research into new transportation technologies and urban planning techniques.

Reduction of Vehicle Idling (TLU-4)

Arizona should implement policies to reduce idling from diesel and gasoline heavy-duty vehicles, buses, and other vehicles through the combination of a Statewide anti-idling ordinance and by promoting and expanding the use of technologies that reduce heavy-duty vehicle idling. These technologies include: automatic engine shut down/start up system controls; direct fired heaters (for providing heat only); auxiliary power units; and truck stop electrification. The goal of this policy is to implement a Statewide vehicle idling restriction rule that can be enforced and that minimizes allowable exemptions, in place by 2008, with plans for providing the necessary resources for enforcing the ordinance. The policy also aims to develop and pilot truck stop electrification programs. The policy target is an overall reduction in idling of 80% by 2010 and 100% by 2020.

This policy would be implemented through the following primary mechanisms: information and outreach to provide information indicating when and where idling is prohibited, and indicating the benefits of reducing idling, including fuel savings, toxic emission reductions, and GHG reductions; technical assistance for coordination with anti-idling product manufacturers; funding mechanisms to partially fund idling technology loan grants; a well-defined anti-idling ordinance; and a phased enforcement program.

Standards for Alternative Fuels (TLU-5)

Arizona should promote more widespread acceptance of alternative fuels by developing and enforcing a State standard for neat biodiesel (B100), biodiesel blends, and ethanol blends to ensure fuel quality and good vehicle performance. For biodiesel blends, the biofuel portion and the petroleum diesel portions of the fuel are separately regulated through ASTM standards;[58] however, no standard is currently in place for the blended biodiesel. Similarly, for ethanol blends, E85 and the gasoline portion of ethanol blends are regulated by ASTM standards.

Arizona recently passed legislation in 2006 (House Bill 2590) that regulates biodiesel blends and E85 blends. The base gasoline for ethanol blends must meet the standards for gasoline sold in that area. This measure should now focus on enforcement of the standard to ensure that fuel taxes are being paid and that blenders are registered with the State. To reduce fraud, the measure should ensure fuel that is delivered is as advertised, and eliminate consumer problems. Enforcement of this standard would be led by the Arizona Department of Weights and Measures. Certain exemptions might be acceptable (e.g., a school district blending biodiesel for use in its own school buses and not for outside sale).

Through the National Energy Act, growth in alternative fuels is expected in the near term. This measure will ensure that these alternative fuels sold in Arizona meet quality standards. This measure would also be broadened to include other alternative fuels that may be sold in Arizona.

Hybrid Promotion and Incentives (TLU-7)

Arizona should adopt a combination of public education and information efforts with financial incentives to promote the sales of light-duty vehicles with hybrid gasoline-electric power trains. This could include reduction in fees and taxes and giving preferential infrastructure access to hybrids on carpool lanes or metered parking spaces.

Hybrid promotion and incentive programs should be implemented from the time period between the near-term years when production is limited and the medium-to-long term years when expansion of production capabilities makes it more likely that promotion and incentive policies will have a significant effect on consumer choices. The State needs to study further the level and design of incentives necessary to achieve the goal set forth here.

In the near term (2006-2008), the hybrid vehicle sales are constrained on the producer side by an inability of automobile manufacturers to keep up with already existing consumer demand. In the medium-to-long term (2009 forward

[58] American Society for Testing and Materials (ASTM).

for Arizona), automobile manufacturers are likely to increase production capabilities for hybrid power train vehicles, and provide consumers with many more choices of hybrid cars. As a result, hybrid promotion and incentive programs are likely to have some incremental positive net effect on consumer purchase behavior.

Feebates (TLU-8)

Arizona should initiate a cost-shared, multi-state study of "feebate" program benefits and costs. At a minimum, the effort should include California and New Mexico. Feebates would provide incentives for reduce GHG emissions by creating:

1) fees on relatively high emissions/lower fuel economy vehicles and

2) rebates or tax credits on low emissions/higher fuel economy vehicles.

A multi-state approach is useful because of drawbacks in a single state adopting feebates in isolation.

Pay-As-You-Drive Insurance (TLU-9)

Arizona should authorize insurance companies to offer "Pay-As-You-Drive" (PAYD) auto coverage, under which a portion of auto insurance premiums are linked to miles driven (while the remaining portion remains a "fixed cost" as under current practice). Arizona should promote a PAYD pilot program in 2008, evaluate the results, and, if successful, promote this form of auto insurance.

Assuming this pilot is successful, market penetration could increase to 100% by 2020. This could happen either through competitive pressure (i.e., increasing numbers of companies offer it in order to stay competitive) or through a change in State policy mandating PAYD insurance at some point after it has been shown to work.

PAYD insurance has been promoted by a variety of groups for reasons that include emissions reduction and safety (through decreased driving), and fairness (by changing insurance costs to more closely track the portion of individuals' risk that is created by miles driven).

Low Rolling Resistance (LRR) Tires and Tire Inflation (TLU-10)

Arizona should establish minimum energy efficiency standards for replacement tires and require that greater information about high-efficiency "low-rolling resistance" (LRR) replacement tires be made available to consumers at the point of sale. Arizona should also promote proper inflation of tires by consumers to improve mileage and reduce emissions.

Manufacturers currently use LRR tires on new vehicles, but they are not easily available to consumers as replacement tires. When installing original equipment tires, carmakers use low rolling resistance tires as a way to contribute to meeting the federal automobile fuel economy (CAFE) standards. When replacing the original tires, consumers often purchase less efficient tires. Currently, tire manufacturers and retailers are not required to provide information about the fuel efficiency of replacement tires. In addition, there is no current minimum standard for fuel efficiency that all replacement tires must meet. A

combination of minimum standards and better consumer information could lead to a gain in fuel efficiency of about 3%. Improperly inflated tires decrease fuel efficiency and result in greater GHG emissions. Properly inflated tires will improve mileage, decrease fuel consumption and reduce GHG emissions.

Accelerated Replacement/Retirement of High-Emitting Diesel Fleet (TLU-11)

Arizona should reduce GHG black carbon emissions from heavy-duty diesel vehicles by developing and implementing an incentives program in Arizona to accelerate the replacement and/or retirement of the highest-emitting diesel vehicles.

Starting with the 2007 model year, the federal emission standards for new heavy-duty diesel vehicles will be improved. In conjunction with these more stringent emission standards, the sulfur content of diesel fuel is being lowered from 500 parts per million (ppm) to 15 ppm. These measures will combine to significantly reduce GHG black carbon emissions from heavy-duty diesel trucks and buses. However, a large number of older, more-polluting diesel vehicles will remain in the fleet. This measure is aimed at developing methods to incentivize the owners of these older vehicles to retire their vehicles early and replace them with vehicles meeting the 2007 emission standards.

The goal of this policy is to target 25% of vehicles from model years 1990 through 2006 (e.g., vehicles that still have over four years of expected useful life and do not meet the 2007 emission standards) for early retirement/replacement.

Biodiesel Implementation (TLU-12)

Arizona should increase market penetration of biodiesel fuels sold within the State. (Ethanol-related reductions are accounted for in the agriculture sector.) The State should conduct a review of any technical impediments to biodiesel use, and, if these are not significant, proceed to policies and measures that significantly increase biodiesel use and substitution for conventional diesel fuel. This program should be targeted to applications with the greatest likelihood of success and with a certainty of obtaining significant GHG emission reductions. This measure will help to ensure that Arizona is actively pursuing and meeting or exceeding the alternative fuel penetration goals specified in the Energy Security Act of 2005.

The goal of this program is to achieve a 75% penetration of B2 by 2010 (e.g., 1.5% total penetration of biodiesel). The State should review the program success by 2015 and determine whether further penetration of biodiesel fuel is desirable. This review should take into consideration the interactions of biodiesel blends with the ultra-low sulfur diesel to be sold nationally by 2010 and the technologies used to meet the new diesel vehicle emission standards starting in 2007. If the program is determined to be successful at that point and if biodiesel supply is not an issue, a goal of 50% penetration of B20 by 2020 (e.g., 10% total penetration of biodiesel) should be set.

Implementation mechanisms for this measure should include information on the benefits and potential performance issues associated with using biodiesel fuels; voluntary agreements targeting certain fleet segments with good likelihood of success in this program; a possible biodiesel use requirement

for fuel vendors; and an early pilot program for State diesel vehicles to begin using B10 or B20.[59]

State Lead-By-Example via Vehicle Procurement and SmartWay (TLU-13)

Arizona state agencies should "lead by example" by enacting procurement policies and/or joining the EPA SmartWay program to achieve a lower-emitting vehicle fleet for the State. There are numerous activities Arizona could pursue to participate fully in enacting procurement policies or programs such as SmartWay. For example:

- State agencies with vehicle fleets could sign on as SmartWay carrier partners. They would then measure their environmental performance with the FLEET model and come up with a plan to improve that performance. The partnership provides information and suggested strategies to improve fuel economy and environmental performance of vehicle fleets.
- State agencies that buy transportation services, or ship goods could sign on as SmartWay shippers. As shipper partners, state agencies would seek to select SmartWay partners when they purchase the services of carriers. One way that the State could help would be to add SmartWay certification to the list of factors that they may consider when selecting carriers. Alternatively, they could just encourage the carriers that they do business with to join the partnership. Shippers can also implement direct strategies, for instance developing no-idle policies for their loading areas.
- State agencies could sign onto SmartWay as affiliates. As affiliates, they would help to distribute information on the program to interested parties. This could be as easy as putting a link on their web site, or it could involve a more active role.
- State agencies should purchase only vehicles that are hybrids, meet low-GHG emission standards, or use E-85, biofuels or other low-GHG alternative fuels.
- The State also should set a goal for replacement of the State vehicle fleet, so that by a date certain (e.g., 2010), all State vehicles shall be hybrids, meet low-GHG emission standards, or use E-85, biofuels or other low-GHG alternative fuels.

60 mph Speed Limit for Commercial Trucks (TLU-14)

Arizona should reduce the speed limit for commercial trucks to 60 mph on Arizona highways and freeways. Enforcement of this measure should begin by 2008, with a goal of reducing the portion of Class 8[60] diesel truck traffic currently traveling above speeds of 60 mph on interstates, freeways, and major arterials by 50 percent.

This measure would primarily be implemented by requiring all interstates, freeways, and major arterials in the State to be signed with a maximum speed of 60 mph for Class 8 commercial trucks. Additionally, significant enforcement resources will be needed for this measure to achieve the expected reductions.

[59] Legislation adopted in 2006 allows fleets required to meet alternative fuel conversions to get credit for biodiesel consumption. See www.azleg.gov/legtext/47leg/2r/laws/0388.htm.

[60] Class 8 commercial trucks are those above 33,000 lb gross vehicle weight rating. They are primarily trucks that pull one or more trailers of freight (i.e., the typical "18-wheeler").

Education and outreach would also be needed to provide information to the trucking industry and the general public emphasizing the fuel economy benefits and resulting GHG emission reductions that are obtained when reducing speeds from 70 mph to 60 mph. The associated fuel cost savings and increased safety effects of this measure should also be emphasized.

Chapter 8
Agriculture and Forestry

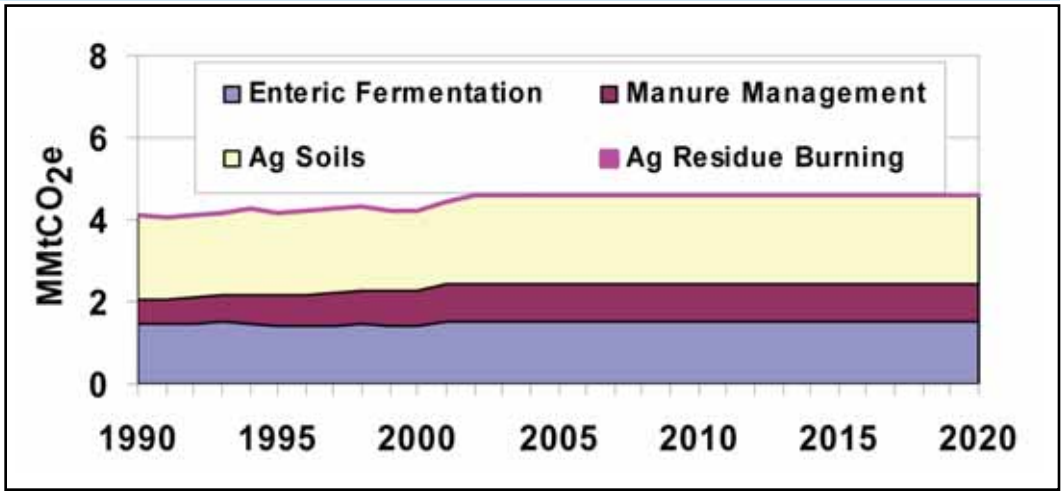
Overview of Greenhouse Gas Emissions

The agriculture and forestry (AF) sectors are directly responsible for only a small amount of Arizona's current GHG emissions. Net emissions are -2.4 $MMtCO_2e$ in 2000, reflecting 4.2 $MMtCO_2e$ emitted by the agricultural sector and a forestry sink of -6.7 $MMtCO_2e$. Agriculture emissions include methane (CH_4) and nitrous oxide (N_2O) emissions from enteric fermentation, manure management, agriculture soils, and agriculture residue burning. Emissions from agriculture soils account for the largest portion (about 50%) of agricultural emissions; this category includes N_2O emissions resulting from activities that increase nitrogen in the soil, including fertilizer (synthetic, organic, and livestock) application and production of nitrogen fixing crops. Other important agricultural sources are methane emissions from enteric fermentation in cattle and manure management at dairies.

Forestland emissions refer to the net CO_2 flux[61] from forested lands in Arizona, which account for about 16% of the state's land area. Recent U.S. Forest Service estimates suggest that Arizona forests and the use of forest products sequestered on average 6.7 $MMtCO_2e$ per year from 1987 to 2002.

Figure 8-1 shows historical and projected AF GHG emissions. The graph shows that no growth in the agricultural sector is assumed beyond 2004. Similarly, for the forestry sector, no change in carbon sequestration rate was assumed beyond 2002.

Figure 8-1 1990-2020 GHG Emissions by Sectors: Agriculture



[61] "Flux" refers to both emissions of CO_2 to the atmosphere and removal (sinks) of CO_2 from the atmosphere.

Opportunities for GHG mitigation in the AF sector involve measures that can reduce emissions within the sector or reduce emissions in other sectors. For example, production of liquid fuels can offset emissions in the transportation sector, while biomass energy can reduce emissions in the energy supply or RCI sectors. The primary opportunities for GHG mitigation are as follows:

- *Production of renewable fuels:* production of renewable fuels, such as ethanol from crops, crop residue, forestry residue or municipal solid waste, can produce significant reductions, when they are used to offset consumption of fossil fuels (gasoline consumption in the transportation sector);
- *Beneficial use of forest biomass:* expanded use of biomass removed from forested areas during treatments to reduce fire risk can achieve GHG benefits by offsetting fossil fuel consumption (either to produce electricity or heat);
- *Control and utilization of* CH_4 *at dairies:* methane emissions from manure management can be reduced through the use of anaerobic digesters or other technology. The methane captured can then be used to create electricity, steam, or heat to offset fossil fuel use;
- *Protection of forest and agricultural land from conversion to developed use:* by protecting these areas from development, the carbon in above-ground biomass and below-ground soil organic carbon can be maintained and additional emissions of CO_2e to the atmosphere can be avoided; and
- *Restoration of forested lands:* a great deal of forested land has been lost to wildfire and disease in recent years. To the extent that the forests on these lands can be restored, the carbon sequestration potential of the land can also be restored.

Additional opportunities for reducing GHGs include: the use of agricultural residues, such as orchard trimmings and wheat straw, as biomass energy for the production of electricity, steam or heat; and programs to support local farming, which seek to reduce the amount of food trucked for long distances and the associated GHGs.

Key Challenges and Opportunities

In the forestry sector, restoration of forested areas has the potential for GHG benefits (0.1 $MMtCO_2e$/yr by 2020). However, the CCAG recognizes that restoration projects in many cases could be limited by available precipitation. Additional analysis is needed to identify areas where restoration programs are likely to be successful. Fairly significant GHG benefits were also estimated for utilization of biomass energy from forest treatment projects (to reduce fire risk). These benefits will total nearly 0.7 $MMtCO_2e$/yr in 2010 and 2020 based on current levels of treatment. Success will be achieved through close cooperation between Arizona, federal agencies (USFS), and private industry to identify biomass resources and effective end uses for the resource. Through recommendation of the option to support development of biomass gasification and combined cycle technology (BGCC), the CCAG recognized the need to promote efficient biomass energy resource utilization.

In the agricultural sector, production of ethanol was found to offer the most substantial GHG reduction potential (range of 0.6 to 4.0 $MMtCO_2e/yr$ depending on the level of production targeted). While the policy recommendation is technology neutral, cellulosic ethanol production offers much larger GHG benefits than starch-based production. Available information on cellulosic production technology was used to estimate the benefits and costs for the policy recommendation. Additional information on the ethanol issues can be found in Appendix J. Combining the agricultural and forestry land protection options, 0.5 $MMtCO_2e/yr$ in GHG savings is estimated to be saved by 2020. To achieve these reductions, the State will need to work closely with local planning agencies, land owners, and non-governmental organizations to identify lands suitable for acquisition/conservation easements and funding mechanisms. Another benefit to these options, which was not quantified, is the reduction in vehicle-miles traveled due to more efficient development patterns.

Overview of Policy Recommendations and Estimated Impacts

The CCAG recommends a set of 11 policy options for the AF sectors. These options are shown in Table 8-1 below. These policy recommendations could lead to emissions savings from reference case projections of nearly 6 $MMtCO_2e$ per year by 2020 and cumulative savings of over 51 $MMtCO_2e$ from 2006 through 2020. The weighted average cost of saved carbon from the policy options for which quantitative estimates of both costs and savings were prepared was $2 per metric ton of CO_2 equivalent.

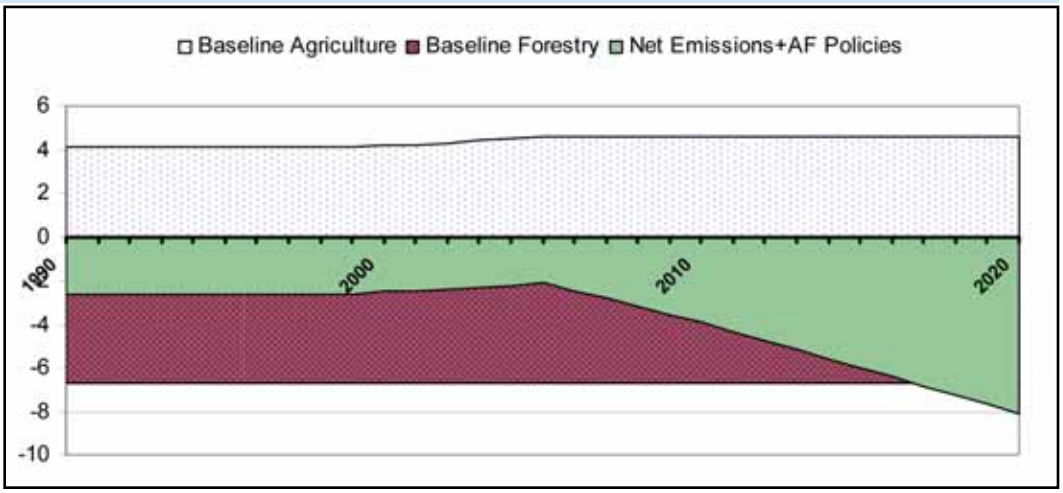
The emissions savings from the AF options are primarily a combination of reduced carbon dioxide and methane emissions. The carbon dioxide reductions come mainly from avoided gasoline or other fossil fuel emissions (e.g., from gasoline offset by ethanol produced within the State or other fossil fuels offset by biomass energy). Emissions are also reduced through forestry measures that protect or enhance Arizona forests in sequestration of carbon dioxide from the atmosphere. Methane emissions are reduced mainly from dairy operations. None of the other GHGs emitted by the AF sectors (e.g., nitrous oxide) are significantly affected by these options.

The estimated impacts of the AF policies recommended by the CCAG are shown in Figure 8-2. As shown in this graph, the effects of the recommended AF policies begin to appear prior to 2010 on the “Net Emissions + AF Policies” line. This line shows historical to 2005 net emissions (agricultural emissions plus forestry sinks) and the subsequent effects of recommended options. The net negative emissions of about -2.4 $MMtCO_2e$ in 2005 begin to decrease to an estimate of -8 $MMtCO_2e$ by 2020.

Table 8-1 CCAG Recommended Policy Options, By Sector

AGRICULTURE (A) AND FORESTRY (F)						
	CCAG Policy Option	2010 Annual GHG Reduction ($MMtCO_2e$)	2020 Annual GHG Reduction ($MMtCO_2e$)	2007-2020 Cumulative Reduction ($MMtCO_2e$)	Cost or Cost Savings Per Ton GHG Removed ($\$/tCO_2e$)	Level of CCAG Support
A-1	Manure Management – Manure Digesters	0.2	0.5	3.8	$1	Unanimous
A-2	Biomass Feedstocks for Electricity or Steam Production	0.05	0.1	4.5	-$8	Unanimous
A-3	Ethanol Production and Use	0.5	4.0	28.0	$0	Unanimous
A-7	Convert Agricultural Land to Forest or Grassland	Not available				Unanimous
A-8	Reduce Conversion of Farm & Rangelands to Developed Uses	0.1	0.2	1.6	$65	Unanimous
A-9	Programs to Support Local Farming/Buy Local	0.01	0.02	0.1	$6	Unanimous
F-1	Forestland Protection from Developed Uses	0.3	0.3	3.7	$17	Unanimous
F-2	Reforestation/Restoration of Forestland	0.02	0.1	0.6	$44	Unanimous
F-3a	Forest Ecosystem Management – Residential Lands	0.5	0.5	6.4	-$21	Unanimous
F-3b	Forest Ecosystem Management – Other Lands	0.2	0.2	2.9	-$21	Unanimous
F-4	Improved Commercialization of Biomass Gasification and Combined Cycle	Not Quantified				Unanimous
Total all options adjusted for overlap and interaction		1.8	5.9	51		

Figure 8-2 Impact of Policy Recommendations on AF Emissions



Agriculture and Forestry (AF) Sectors Policy Descriptions

The Agriculture and Forestry (AF) Sectors include emissions and mitigation opportunities related to use of biomass energy, protection, and enhancement of forest and agricultural carbon sinks, control of agricultural methane emissions, production of renewable fuels, and reduction of transport emissions from imported agricultural commodities. Fully detailed descriptions of the individual Agriculture and Forestry policy options as presented to and approved by the CCAG can be found in the Technical Appendix.

Manure Management - Manure Digesters (A-1)

Methane emissions from livestock manure should be reduced through the use of manure digesters installed at dairies. Energy from the manure digesters is used to create heat or power, which offsets fossil fuel-based energy production and associated CO_2 and black carbon emissions. The goal is to manage dairy manure using anaerobic digesters and energy capture technology (e.g., electricity generators) covering 15% of the state-wide dairy population by 2010, and then increase this level to 50% of the dairy population by 2020.

Biomass Feedstocks for Electricity or Steam Production (A-2)

Arizona should set a goal of using 20% of available biomass by 2010, and 50% of available agricultural biomass by 2020 to displace fossil fuel usage through the use of agricultural waste (e.g., orchard trimmings, and other crop residue) as a feedstock for electricity or steam production. The CO_2 savings occur as a result of displacing fossil fuel use in the production of electricity or steam. There also would likely be a reduction in black carbon emissions to the extent that coal-based combustion is offset.

Ethanol Production and Use (A-3)

The State should provide incentives for the production of ethanol from crops, agricultural waste, or other materials to offset fossil fuel (gasoline) use.

Different incentive programs will be needed for crop (starch-based) ethanol production versus agricultural waste (cellulosic) ethanol production processes. Cellulosic production technology achieves much greater GHG benefits than starch-based processes and was used to estimate the benefits of this option (starch-based production is estimated to achieve about one-fourth the benefit of cellulosic production).

The CCAG considered three production goal options:

- By 2010, produce enough ethanol to support the use of E10 (10% ethanol by volume in gasoline) year round in areas that currently use it during the winter season (Maricopa, northern Pinal, and Pima counties). This would require the production of 207 MMgal/yr. (Year-round use would more than double the current usage levels of ethanol in Arizona.)
- By 2020, produce enough ethanol to support alignment with the New Mexico CCAG goal of 20% ethanol usage by volume in gasoline by 2012. This would require the production of 858 MMgal/yr in 2020.
- By 2050, produce enough ethanol to support alignment with the New Mexico CCAG goal of 40% ethanol by 2030. This would require production of 3,450 MMgal/yr by 2050.

Note: Production from the new Pinal County facility is included in the forecasted goals.

Convert Agricultural Land to Grassland or Forest (A-7)

Arizona should increase carbon sequestration in the state's agricultural land by converting marginal land used for annual crops to permanent cover, either grassland or forests. The state would determine a goal of converting a number of acres of marginal agricultural land to grassland or forest by 2010, 2020 and 2040. A loss of carbon to the atmosphere from tillage and fallow land would result by converting land to permanent cover. This action would have the effect of increasing soil carbon content and above-ground carbon stocks would also be increased by converting to cover with a greater ability to sequester carbon (i.e., higher biomass).

Reduce Conversion of Farm and Rangelands to Developed Uses (A-8)

The rate at which existing crop and rangelands are converted to developed uses should be reduced. The carbon sequestered in soils and above-ground biomass is higher in crop and rangelands than in developed land uses. The 2010 goal is to reduce the rate of crop and rangeland loss to 20% of the loss rate that occurred from 1982-1997. By 2020, the rate of loss should be lowered to 50% of that loss rate. Agricultural land protection is expected to occur through the promotion of land acquisition or conservation easements.

Programs to Support Local Farming/Buy Local (A-9)

Arizona should promote consumption of locally-produced agricultural commodities, which would offset consumption of commodities transported from other states or countries. It includes the modification, enhancement,

and further development of local farm programs employed in Arizona to reduce transport-related GHG emissions. The goal of this option is to increase consumption of Arizona-grown commodities by 5% by 2010 and another 5% by 2020 (total of 10% offset in 2020).

Forestland Protection from Developed Uses (F-1)

Arizona should reduce the rate at which existing forestlands and forest cover are cleared and converted to developed uses or damaged by development that reduces productivity.

The CCAG proposes that policy initiatives decrease the conversion of forest and woodlands to urban and other developed uses to 50% or less of the rates of loss to these uses during the 1987-1997 period by 2010 and continuing through 2020. A 50% reduction would decrease the conversion rate from 380 acres/year to 190 acres/year. If the rangeland type were assumed to include about 50% pinyon-juniper type, a 50% reduction in conversion rate would decrease the conversion rate of woodlands to urban or developed uses from 8,530 acres/year to 4,260 acres/year.

Reforestation/Restoration of Forestland (F-2)

Arizona should expand forest cover (and associated carbon stocks) by regenerating or establishing forests in areas with little or no forest cover at present.

The CCAG estimated the number of acres of previously forested lands to be restored to their native forested state at 155,000 acres, with a stocking rate of 35 tons of above-ground biomass per acre. Stocking this number of acres at the specified rate from 2008-2020 would result in approximately 26,000 acres regenerated/established by 2010 and 130,000 acres between 2010 and 2020. This equals an average of about 12,000 acres per year.

Forest Ecosystem Management (F-3a & 3b)

Sustainable thinning or biomass reduction from residential forestlands (intended to address fire and forest health issues) should be managed so that harvested biomass is directed to wood products and renewable energy instead of open burning or decay. F-3a is directed at residential lands (the wildland-urban interface or WUI) and F-3b is directed at non-WUI areas.

Most efforts to reduce biomass in residential forests and woodlands for forest health/sustainability and wildfire suppression include some emphasis on using the extracted woody biomass for wood products and/or energy production, rather than eliminating these materials through open burning, or storage or decay off site. The CCAG recommends placing a greater emphasis on wood products and/or energy production, through appropriate mechanisms, incentives, etc. More specifically, the CCAG recommends:

- Using 50% or more of biomass extracted from residential lands for wood products and/or energy production by 2010 and continuing through 2020.
- Accelerating current and planned fuels treatments in Arizona so that all high priority areas (e.g., in wild land urban interface) are treated by 2015.

The Governor's Forest Health Oversight Council and Forest Health Advisory Council should review forest management practices and policies aimed at GHG reduction and carbon sequestration.

Improved Commercialization of Biomass Combustion, Gasification and Combined Cycle (F-4)

Carbon savings occur when biomass energy combustion processes are converted from conventional technology to new technologies with greater thermal efficiency and reduced emissions with lower pollution outputs. Arizona should accelerate the rate of technology development and market deployment of biomass combustion, gasification, and combined cycle (BGCC) technologies. The State should set a goal of 10 megawatts of biomass energy between 2006 and 2010, and an additional 25 megawatts between 2010 and 2020 (or the equivalent amount of new biomass thermal energy.