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Texas' Global Warming Solutions - A Study for: The World Wildlife Fund

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December 24, 2003

MEMORANDUM FOR : DOUGLAS THURMAN
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FROM: TERRY GOOD
OFFICE OF RECORDS MANAGEMENT
THE WHITE HOUSE

RE: CLINTON ADMINISTRATION FILES

These files in four boxes were located in a 5th floor store room this past week.

They appear to be from the White House Climate Change Task Force.
Staff members whose names appear on many of the documents include Roger Ballantine, Paul Bledsoe, and Julie Anderson.
A cursory review reveals that the records are mainly dated from 1998 – 2000.
No inventory was found in the boxes.

TEXAS' GLOBAL WARMING SOLUTIONS

A Study for:

The World Wildlife Fund

Prepared by:

Tellus Institute
Resource and Environmental Strategies

February 2000

TEXAS' GLOBAL WARMING SOLUTIONS

A Study for:

The World Wildlife Fund

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February 2000

Acknowledgments

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Summary

The threat of global climate change and the challenge of averting it have important implications throughout the world. Scientists have shown that there is a serious risk of dangerous climate disruption if we do not dramatically reduce greenhouse gas emissions, especially carbon dioxide from fossil fuel combustion. Global warming is caused by the continued buildup of these gases in the atmosphere, which trap excessive amounts of incoming solar radiation, thus increasing the Earth's temperature. Such climate change could unleash ecological, economic and social disruptions throughout the world, many irreversible or lasting for generations. Climate change could have severe impacts in Texas, which has a long and important coastline along the Gulf of Mexico, large semi-arid lands, and other vulnerable human communities, natural environments and economic activities throughout the State.

Fortunately, there are promising resources, technologies and practices that can be mobilized to meet the challenge of climate change by implementing effective policies and measures. A recent national policy study, *America's Global Warming Solutions* (Bernow *et al* 1999), outlined and evaluated a plan through which the United States could reduce its annual carbon-dioxide emissions by about 654 million metric tons of carbon (MtC) by 2010, 36 percent below business-as-usual (baseline) projections for that year. This brings 2010 emissions to 14 percent below 1990 emissions, thereby exceeding the reductions required under the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC). The study found that these reductions could be obtained with net economic savings, almost 900,000 net additional jobs, and significant decreases in pollutant emissions that damage the environment, and are harmful to human health, especially of children and elderly.

The policies and measures are targeted to four sectors; transportation, industry, electricity generation, and residential and commercial buildings. In the *transportation* sector, the measures call for stronger fuel economy standards and efficiency incentives for cars and trucks, a carbon content standard for motor fuels, and urban/regional demand management. In the *industrial* sector, the proposed measures are a mix of tax incentives and technical assistance to promote more advanced energy using equipment, regulatory refinement and assistance to promote cost-effective combined-heat-and-power (CHP). For *electricity generation*, a renewable portfolio standard with tradable credits is recommended, along with a tighter national sulfur dioxide cap, and output based generation performance standards for nitrogen oxides, fine particulate matter and carbon dioxide. In the *buildings* sector, the proposed measures include stronger and expanded appliance and building standards, market transformation, manufacturer incentives and consumer education, and initiatives to promote district heating/cooling using CHP systems. There are also *cross cutting* measures, such as research, development and demonstration of advanced, efficient energy technologies, systems and resources.

Texas plays an especially important role in climate change and its mitigation. Its contributions to the threat, its ecological and economic vulnerabilities, and its opportunities, loom large. Texas is responsible for a large share of the global burden of carbon dioxide. It has the highest annual emissions of greenhouse gases in the U.S., and contributes about one-seventh of the national total. If it were a country it would have the seventh highest in the World, following the U.S., the Russian Federation, China, Japan, Germany and the United Kingdom.

Sea-level rise, more severe storms, higher temperatures and precipitation changes from climate change could threaten Texas' sensitive aquatic and terrestrial ecosystems, its vulnerable fresh water supplies, its citizens' health and it's economy. Climate change could also exacerbate existing environmental and health problems. The major urban areas in Texas are at or near "non-attainment" with EPA air quality requirements. Thus, reducing combustion of fossil fuels to mitigate greenhouse gas emissions could also help to meet the State's air quality goals.

At the same time, Texas has important opportunities to contribute to and benefit from policies to avert dangerous climate change. It has a unique combination of energy supply and demand -- large supplies of clean energy resources, such as wind, solar, biomass and natural gas, and high demand for energy, with significant potential for more efficient energy technologies in its industry, transportation, homes and offices. It also has a strong technology and knowledge-based economy, which could contribute to the development and deployment of these twenty-first century energy resources and technologies. A shift to these new energy technologies and resources to reduce carbon dioxide emissions would have ecological, economic, health and social benefits throughout the State.

The economic analyses of *America's Global Warming Solutions* indicated that Texas would be the state with the highest net job creation from the national policies evaluated. This report presents a new detailed analysis of the benefits that Texas would derive from those national policies and measures to combat global warming. Many of these policies and measures could be pursued in the State, appropriately tailored to its conditions and institutions, with similar results and benefits for Texas citizens. Texas has passed an electric industry restructuring bill that contains elements to help ensure a significant role for clean energy under increased competition. Moreover, as many Texas agencies (including the Energy Coordinating Council and the Natural Resource Conservation Commission) are undergoing Sunset reviews, the State is developing its State Implementation Plan to meet EPA's air quality requirements. It is thus an opportune time to harmonize the State's economic, environmental and public health goals with a national energy and climate strategy.

Overall, the set of national policies in *America's Global Warming Solutions* would begin to shift the basis of the State's economy towards more advanced, energy-efficient technologies and cleaner resources. Specifically, this study finds that:

- ***Primary Energy Use and Carbon Emissions*** in Texas would decrease by 25 percent and 34 percent, respectively, below levels that would otherwise be reached by 2010.
- **Renewable Energy Resources** would increase six-fold between 1990 and 2010, reaching over 4 percent of total primary energy use by 2010 (and about 12 percent in the electric sector). Industrial co-generation would almost double over this timeframe.
- ***Increasing Net Annual Savings*** in Texas result from the national policies, reaching about $700 per-capita in 2010 and averaging about $200 per-capita per year through 2010. Thus, the State would cumulatively save about $35 billion over that period in present value terms.
- ***Approximately 84,000 net additional jobs*** created in Texas by 2010.
- ***Air Pollutant Emissions*** in Texas, harmful to its citizens and environment, are reduced by the national policies. By 2010, annual emissions of sulfur dioxide are cut by 60 percent, nitrogen oxides by 32 percent and fine particulate matter by 39 percent.

Figure S.1 shows how the upward baseline trend in Texas carbon emissions, which contributes to climate change and local environmental and health problems, would be reversed by the proposed national policies and measures. It shows the contributions to the overall emissions reductions, from changes in emissions from end-use energy consumption by each sector – transportation, industrial, commercial and residential, with reductions in carbon emissions produced during electricity generation allocated to the end-use sectors based on their use of electricity.

Figure S.1: Carbon Emission Reductions in Texas Demand Sectors due to the National Policies

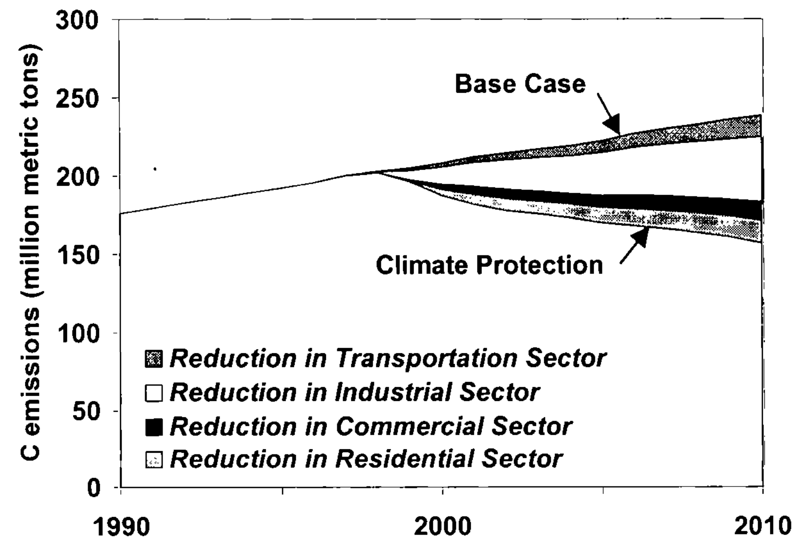


Table S.1 summarizes the energy savings, the reductions in carbon and air pollutant emissions, and net economic benefits that would be achieved in the State as a result of the national policies.

Table S.1: Summary of Policy Impacts in Texas

	1990	2010 Base Case	2010 Policy Case
End-use Energy (Quads)	8.1	11.2	8.7
Primary Energy (Quads)	9.8	13.4	10.1
Renewable Energy (Quads)	0.07	0.10	0.44
Carbon Emissions (MtC)	184	239	157
Other Emissions ('000 tons)			
Sulfur Dioxide		1,003	402
Nitrogen Oxides		1,907	1,300
Fine Particulates (PM-10)		135	53
Net Savings (billion 1998$)			
In the year	--	--	$15.6
Cumulative (discounted)	--	--	$34.7

These changes in the Texas energy system would help the U.S. reduce its global warming emissions, meet its Kyoto Protocol targets in the near term, and establish momentum for the deeper reductions needed for climate protection in subsequent decades. At the same time, they would contribute to the economic vitality, environmental integrity and quality of life in the State.

1. Introduction

1.1. Global Climate Change

The international community of climate scientists has moved toward the consensus, expressed by the Intergovernmental Panel on Climate Change (IPCC), that "...human activities are having a discernible impact on global climate" (IPCC 1996). Concentrations of carbon dioxide (CO_2) in the atmosphere are now approximately 360 parts-per-million (ppm), about 30 percent above the natural, pre-industrial levels. This is unprecedented in many tens of millennia.

Annual global CO_2 emissions (measured as carbon) are about 6 billion metric tons from fossil fuel combustion and 1 billion from land-use changes (mainly burning and decomposition of forest biomass). Under a business-as-usual future, annual global emissions of carbon are expected to increase about threefold by the end of the next century, and atmospheric concentrations would approach three times pre-industrial levels (IPCC 1996). Climate models, recent empirical evidence and the paleo-climatological record indicate that this would cause global average temperature to rise between 1.4 to 2.9 degrees Centigrade (2.5 to 5.2 degrees Fahrenheit), with even greater increases in some regions (IPCC 1995; 1996).

The potential consequences of such change are myriad and far-reaching. Sea level rise could approach one meter (IPCC 1995; 1996), with severe implications for coastal and island ecosystems and human communities. Shifts in regional climates, and more frequent and prolonged extreme weather events (droughts, hurricanes and floods), could cause severe geophysical, ecological, economic, health, social, and political disruptions.

While the precise timing, magnitude and character of such impacts remains uncertain, our climate and ecological systems could undergo very large irreversible changes. The probabilities of extremely adverse outcomes in such complex and sensitive systems may not be extremely small, as is normally the case in simpler systems (Shlyakhter *et al.* 1995). Global warming itself would increase the rate of greenhouse gas accumulation, thus accelerating global warming and its impacts. For example, runaway warming could be precipitated by the release of methane from a thawing of the arctic tundra and decreased uptake of carbon by a warming of the oceans. Moreover, large changes could occur very rapidly once a threshold is reached, perhaps on the time-scale of a single decade (Schneider 1998; Severinghaus *et al.* 1998). Rapid change could cause additional ecological and social disruptions, further limiting the abilities of natural and social systems to adapt. The rapid onset of climate disruption and its impacts could render belated attempts to mitigate climate change more hurried, more costly, less effective, or too late. The environment, economy and citizens of Texas have unique vulnerabilities to such climate change impacts.

Recently, officials from Corpus Christi, Austin and other Texas cities joined in a statement on global warming that was issued by 567 mayors and local officials throughout the country. It expressed concern about the dangers of climate change and urged federal action to reduce domestic emissions of greenhouse gases. It also noted the important role of local government in promoting energy efficient technology and renewable resources, which would strengthen their economies and improve the livability of their communities.

1.2. Regional Impacts

The potential damages from climate change will not likely be distributed evenly around the world; they will vary depending on geophysical, ecological and socio-economic factors (IPCC 1998; Harvell et al, 1999; EPA, 1999). For example, the combination of sea-level rise and increased frequency and severity of storms would be especially problematic for regions with low-lying coastal communities, economies and ecosystems. Well-known examples include small islands and coastal communities. In many regions, the uncertain fates of agriculture and forests, and the ecological and economic and social stability that depends upon their viability, are among the consequences of climate change.

Texas is especially vulnerable to climate change (USEPA, 1999; North et al, 1995; Schmandt et el, 1992). It has a large population already exposed to the extremes of drought, flooding, heat waves, and urban and aquatic pollution. It has a great diversity of sensitive ecosystems, including coastal salt mashes, wetlands, river systems, forests, grasslands and shrublands, with a wealth of habitat-specific flora and fauna, many of which are particularly vulnerable to climate change.

Texas has a relatively long, 1400 mile coastline on the Gulf of Mexico, with human communities and important economic activities and ecological systems. These would be at great risk from projected temperature increases, precipitation changes, warmers waters, higher sea level and greater storm activity that would likely occur with climate change. The coastal ecosystems of Texas provide breeding grounds and habitats for numerous native and migratory birds, fish, shrimp and shellfish, which are connected to the wider life of flora and fauna in these systems. Scientists have identified the potential for global warming to induce the spread of disease in such marine ecosystems (Harvell et al 1999), which are important to Texas as an economy and as steward of its natural endowments. Warmer seas could increase the intensity, duration and range of algae blooms ("red tide"), a phenomenon with which Texans are already familiar. These blooms are harmful to shellfish, toxic to humans and detrimental to the shellfish industry.

Texas coastal waters could become severely undermined by beach erosion, coral bleaching and saltwater intrusion onto freshwater systems. As sea level rises, beach erosion could cause losses of habitat, species, property, and commercial and sports fishing. Damages and losses could be exacerbated by higher tides and increased storm surges. A twenty-five percent drop in fishing activities has been projected. Revenue from tourism, a $2.6 billion business in Texas, could diminish from these changes. Other economic activities on or near the coast, such as oil refining, would be threatened with losses from climate change or would incur high costs of protection. It has been estimated that it would cost about $7 million per mile, or up to $13 billion to protect the Texas coast (EPA, 1999; Schmandt, 1992).

The State's semi arid areas could be at greater risk from climate change. Its vulnerable fresh water and drinking water supplies would be threatened by temperature increases, precipitation changes, sea-level rise and severe storms. Stream flows could be reduced by 35 to 75 percent. More severe droughts and floods could undermine the amount and reliability of freshwater resources. Texans have had experience with these impacts in recent years. Global warming could cause a greater incidence of wildfires, especially in the forests in eastern Texas, resulting in property damage, habitat loss. Livestock and crop production in the State would face an uncertain future from these changes.

Texas would be on the front lines in vulnerability of public health to climate change. The ranges of vector-borne diseases, such as dengue and malaria, which have been recently reported in the

State, could spread further north from more tropical areas (Epstein 1999; Patz et al 1996). Texans could suffer from increased heat-related illnesses and deaths, as the intensity and duration of its heat waves increase. Ground-level ozone, already a severe health problem in Texas' urban areas such as Houston-Galveston and El Paso, and a threat to crops and ecosystems, would likely increase with the warming trend. It is formed by reactions between nitrogen oxides and volatile organic compounds in the presence of sunlight, with the highest levels usually occurring on the hottest days. Higher concentrations would increase the risk of acute respiratory problems, asthma attacks and deaths. Inhabitants of Texas cities such as Dallas would also face increased suffering and death (which could increase several-fold) from the expected greater number of high temperature (e.g., 100+ °F) days (IPCC, 1998; EPA 1999).

1.3. Climate Protection

Reducing the ultimate magnitude of human-induced climate change and slowing down its rate would help to protect vital ecosystems, economies and communities. To avert dangerous climate disruption, the current global emissions of about 6 billion tons carbon equivalent, now projected to increase to about 20 billion tons by the end of the next century, would have to decrease to less than three billion tons by that time. Even then, the carbon equivalent in the atmosphere would reach about 450 parts per million, about 60 percent above pre-industrial levels, which would still entail some climate change, sea-level rise and ecological impact.

Already, the industrialized world contributes 4 billion tons per year, two-thirds of global emissions, with almost 1.5 billion or about one quarter of annual global emissions from the U.S. alone. Thus, for stabilization at 450 ppm the world would have to decrease from about 1 ton per capita to less than 0.3 tons per-capita by the end of the twenty-first century. To match this global average per-capita target, the U.S. would have to reduce its emissions intensity more than 15-fold from more than 5 tons per-capita current level. At about 10 tons per-capita, the carbon intensity of Texas is about twice that of the U.S. as a whole. Thus, given both its size and carbon intensity, Texas has an important role to play in climate change mitigation.

In December 1997, countries throughout the world adopted the Kyoto Protocol to the UN Framework Convention on Climate Change, as a first step towards stabilizing concentrations of greenhouse gases in the atmosphere to reduce the risk of dangerous climate change. The Kyoto Protocol requires that carbon emissions during the period 2008 to 2012 be reduced below 1990 levels by 7 percent for the U.S., 6 percent for Japan, 0 percent for Russia, and an average of 8 percent for the European Union.

The Protocol affords the U.S. and other industrialized nations considerable flexibility in meeting these reduction targets. These options include offsets amongst different greenhouse gases, offsets from biomass carbon sinks, the Clean Development Mechanism (CDM) that could create offsets from actions in developing countries, Joint Implementation projects, and industrialized nation trading of emissions allocations. Exploiting such options could allow the United States to undertake correspondingly lower reductions in carbon emissions from its own energy sector while still meeting its 7 percent net reduction commitment, at lower near-term costs. However, these flexibility mechanisms have certain problems that will need to be resolved before implemented on a large scale. Otherwise they could seriously threaten climate protection and environmental integrity (GACGC 1998), socio-economic development, and the credibility of the Kyoto Protocol.

Moreover, given the rather modest reduction targets of the Protocol relative to the much deeper long-term reductions needed for climate protection, use of the flexibility mechanisms may permit too slow a start and too weak a signal for the necessary technological transition in energy production and use (WWF 1998). The focus of our climate protection activities must thus be on where the heart of the problem and its solution lies – beginning a sustained process to achieve deep reductions in domestic energy-related carbon-dioxide emissions. In rising to that challenge, we could spur technological modernization and innovation, pollution reduction, increased productivity and economic benefits.

Notwithstanding marked regional variation in its destructive potential, climate change is a global problem that requires solutions at all levels -- global, regional, national and local. The demographic, economic and political interconnection of peoples within nations and around the world could produce serious secondary impacts that would reverberate within and across national boundaries. Among such impacts could be decreased production, decline of markets for locally and internationally traded goods, increases in the number of environmental refugees, and exacerbated political instability and conflict. Moreover, both the scope of the problem and the moral interconnectedness of peoples demand cooperative action to curb climate change, based on the principles of adequacy, equity and capability embodied in the Climate Convention.

Arguably, as the limited carbon carrying capacity of the atmosphere has been nearly exhausted by the U.S. and other industrialized nations in amassing their economic power and wealth, both the responsibility and the capability for addressing climate change fall largely on their shoulders. As developing country economies will need to grow in the near term, early global carbon emissions reductions will have to come from the industrialized countries; this would both slow the rate of carbon accumulation in the atmosphere and inaugurate the technological and institutional transition to a low-carbon economies. At the same time, the industrialized countries could provide technological and financial assistance to the developing countries to help ensure that their economic growth is along a path of low-carbon intensity. The developing countries could thus advance in a manner that does not recapitulate the North's history of energy-inefficient, fossil fuel based economic growth; and there is already evidence that many have begun to pursue such a path. But with these responsibilities come opportunities -- for pollution reduction, improved public health and environmental quality, for technological innovation and productivity improvement, and for the institutional and human capacity building that can help to ensure sustainable development in the coming century.

1.4. U.S. Policies and Measures

America's Global Warming Solutions showed that the U.S. could reduce its carbon emissions by 14 percent below its 1990 levels with solely domestic energy policies and measures, and enjoy net economic savings, increased employment and pollution reductions. Thus, the U.S. could significantly reduce its greenhouse gas emissions and go beyond its target under the Kyoto Protocol without use of the flexibility mechanisms, through policies and measures that would affect energy choices, resources, technologies and systems throughout the country. The economic and environmental benefits of these policies and measures would be widespread across the country. While there would be many common impacts in each region or state, there would be some variation that would reflect differences in current and projected energy and economic conditions.

This report provides an analysis of the impact that these national policies and measures would have in the State of Texas. The impacts that we estimate include changes in energy demands, energy supply technologies and fuel mix, carbon emissions, pollutant releases, costs, savings and employment.

2. Energy Use and Carbon Emissions in Texas

The Texas energy system and carbon emissions reflect its unique geographic, climatic and economic conditions. Thus, the State's relative contributions to national carbon-dioxide emissions and to national emissions mitigation will also reflect these conditions. So too will the opportunities for and impacts of emissions mitigation policies.

2.1. Current Energy and Emissions

In 1996, Texans consumed about 9.2 quadrillion Btu's (Quads) of fuels and electricity to meet their end-use energy demands in residential and commercial buildings, industry and transportation. This was nearly 13 percent of national energy consumption. Since the Texas population is about seven percent of the national population, its end-use energy intensity of about 480 Million Btu (MMBtu) per -capita is about 80 percent higher than the national energy intensity. This is in part a consequence of the relatively large role that the energy-intensive industrial sector plays in the State. Industrial energy use in Texas is about one-fifth of national energy use, far higher than its population share of about one-fourteenth. Its transportation energy use is about ten percent of national energy use, about 40 percent higher than the population ratio, while for buildings it is about six percent, slightly lower than the population ratio.

Texas has a very different sectoral energy use mix than the nation as a whole. Industry in Texas consumes about 64 percent of the State's total end-use energy, while industry consumes about 38 percent of the national total. Texas residential and commercial energy use comprise about one-eighth of the State total, while for the nation it is about one-fourth. Transportation contributes about one-quarter of the total in Texas and about one-third in the country as a whole.

The end-use fuel mix is also very different for Texas than for the nation as a whole. Oil and natural gas dominate the fuels used for end-use energy services at 56 percent and 33 percent, respectively, with electricity at about ten percent. For the U.S. these fractions are 50 percent, 28 percent and 15 percent, respectively. Industrial energy use comprises 49 percent oil and 44 percent gas. Only in residential and commercial buildings, whose energy use is small compared with industry and transportation in the State, is electricity the dominant energy form at about 57 percent, with natural gas following at 39 percent. Nationally, building energy use is about 36 percent electricity and 44 percent natural gas.

Texas electricity generation is dominated by oil and coal, at about 45 percent each, with nuclear at about 10 percent. In the U.S. about one half of electricity is produced by coal, about 20 percent by nuclear energy. While hydro-electricity contributed about 11 percent nationally, it is virtually absent in Texas.

Texas carbon-dioxide emissions reflect its overall energy use and fuel mix, about 196 million tons carbon in 1996, about 13.7 percent of total national emissions of 1428 million tons. Thus, Texas emits about 10.4 tons per-capita, almost twice the nation's approximately 5.4 tons per-capita.

A comparison of Texas and U.S. carbon emissions is given in the figures on this page. Figure 1.A, in which emissions from electricity generation are allocated to the sectors in proportion to their demands, shows Texas far larger share of carbon emissions from industry and its smaller shares from transportation and residential and commercial buildings. While on a share basis, buildings contribute far less in Texas than the U.S., on a per-capita basis they are about the same. On the other hand, Texas industry consumes more than 3 times per-capita than the nation and transportation about 30 percent more.

Figure 1.A: 1996 Carbon Emissions - Electricity Allocated to Other Sectors

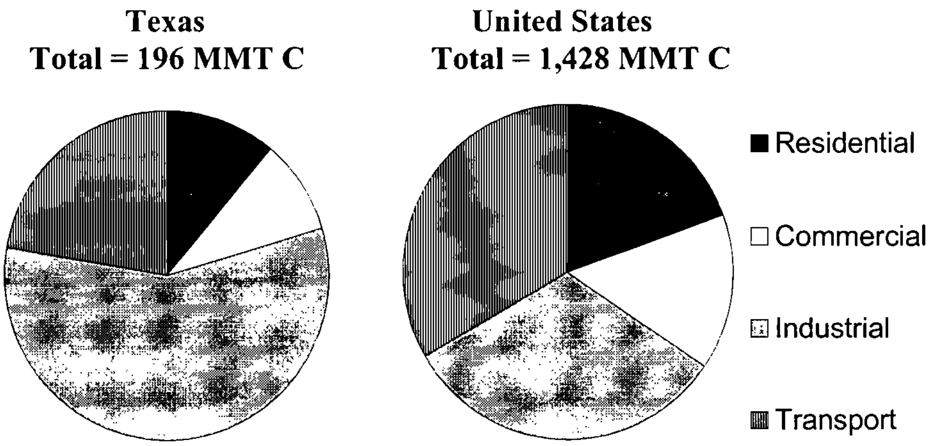
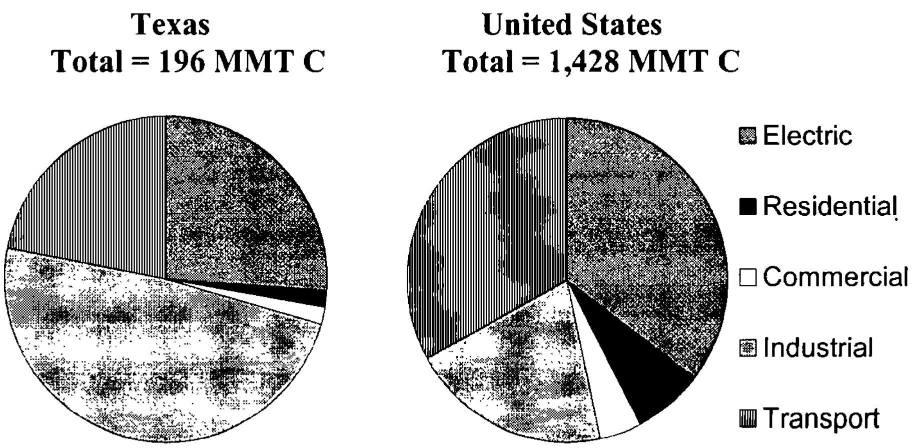


Figure 1.B, in which emissions are ascribed to the points of fuel combustion, shows Texas' much larger share from industry and its much smaller share from electricity generation. A large portion of industrial carbon emissions in Texas arises from energy combustion in its oil refineries, which produce about one half of the national output. A policy to reduce national carbon emissions would likely entail significant reduction in petroleum use, production and emissions in Texas.

Figure 1.B: 1996 Carbon Emissions from Primary Energy Use by Sector



On the other hand, these facilities and their contribution to the State's economy economic could be at risk with sea-level rise and storm activities associated with climate change, or could incur high costs for protection from such threats.

2.2. Future Emissions and Mitigation Options

Overall energy use in the state is projected to increase by 38.2 percent between 1990 and 2010, a growth rate of 1.63 percent per year; from 1996 to 2010 the increase would be about 22.1 percent or 1.44 percent per year, indicating a slowing of growth. Carbon and pollutant emissions, already exceptionally high in Texas, will thus continue to rise steadily in the absence of national and State policies designed to mitigate them. Figure 2.A summarizes these trends.

From 1996 to 2010, under business-as-usual conditions, Texas carbon emissions would grow by about 22 percent to about 239 million tons, while U.S. carbon emissions would grow by one-fourth to almost 1800 million tons. Thus, the Texas share of the national total would remain about the same, declining only slightly from 13.7 to 13.5 percent, still far above its share of national population. Figure 2.B summarizes these trends.

Figure 2.A: Base Case Primary Energy Use in Texas

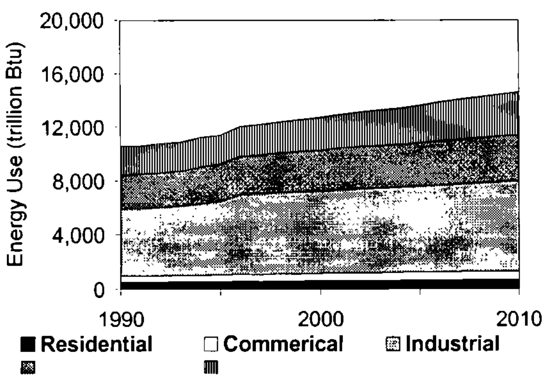
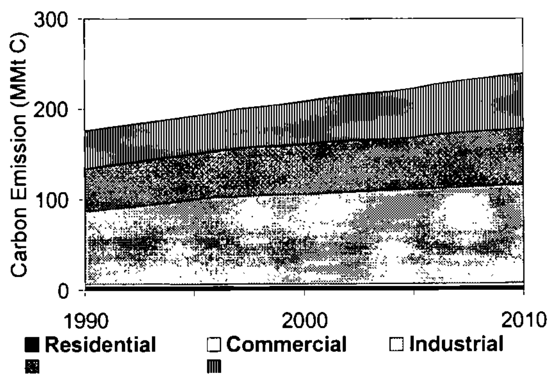


Figure 2.B: Base Case Carbon Emissions in Texas

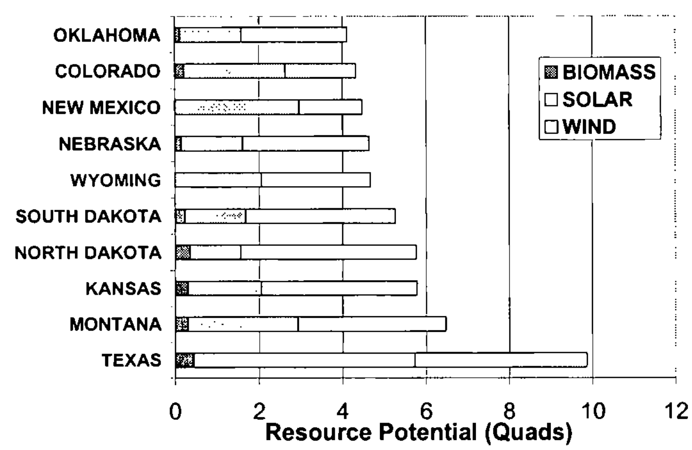


National and state policies could help to stimulate investments in energy efficiency and renewable resources to reverse the trend in Texas of increasing carbon and other pollutant emissions. Texas has the natural, human and economic resources to transform its energy system to a more modern, efficient and clean technological basis, and thus reduce its emissions of carbon dioxide and other pollutants while improving its economy. It has large supplies of natural gas and great potential for solar, wind and biomass energy resources. It has strong agricultural and manufacturing sectors, including aerospace and high tech industries, which could contribute to that transition. In taking this path Texas could provide leadership in a national process of technological transformation, climate protection and environmental stewardship. Reports from various agencies and organizations in Texas -- including the Public Utilities Commission (PUC), the Sustainable Energy Development Council (SEDC), the State Energy Conservation Office (SECO), Environmental Defense Fund (EDF), the Texas Natural Resource Conservation Committee (TNRCC) and the City of Austin Energy and Conservation Services Department -- have surveyed the potential for cleaner, more efficient energy use. They have also identified policies to help to realize this potential and reap economic benefits.

The potential for highly efficient co-generation, or combined-heat-and-power (CHP), in Texas is very strong, mainly in the Chemicals and Paper and Pulp industries. Texas already has a very high level of industrial co-generation, about 8 GW (Planergy et al 1995; PUC 1998). This is about 13 percent of installed capacity in Texas and 10 percent of net system capacity including purchases. More than half of this is in the Houston Power and Light service territory. CHP in Texas could more than double to about 17.5 GW, according to a study by the University of Texas Center for Energy Studies (Baughman et al 1986). This estimate has been corroborated in current modeling analysis (ICF 1999; Gerhardt 1999) and in the present study. These co-generation systems could use the ample supplies of natural gas in the State, thereby complementing its efficiency benefits with a clean fuel benefit. Other opportunities for greater energy efficiency in the Texas industrial sector have been identified in work sponsored by the Texas SEDC (Planergy et al, 1995). The important high-tech manufacturing industries in Texas, for which reliability is very important could also benefit from on-site co-generation and design for whole system efficiency (Robertson 1999).

Texas has enormous potential for renewable energy in end-uses, such as solar heating and on-site photovoltaics, and wind, solar, biomass and geothermal resources in electricity supply. The *Texas Renewable Energy Resource Assessment* (Planergy *et al* 1997; VERA 1995), sponsored by the SEDC, found that Texas ranks first in the nation in supplies of solar and biomass energy resources, second in wind energy resources, and first in overall renewables potential as shown in Figure 3. It also leads in carbon emissions and overall energy demands, thereby completing a synergy of circumstances unique in the U.S.

Figure 3: Top 10 States in Renewable Resource Potential (based on Ogden and Nitch, 1993)

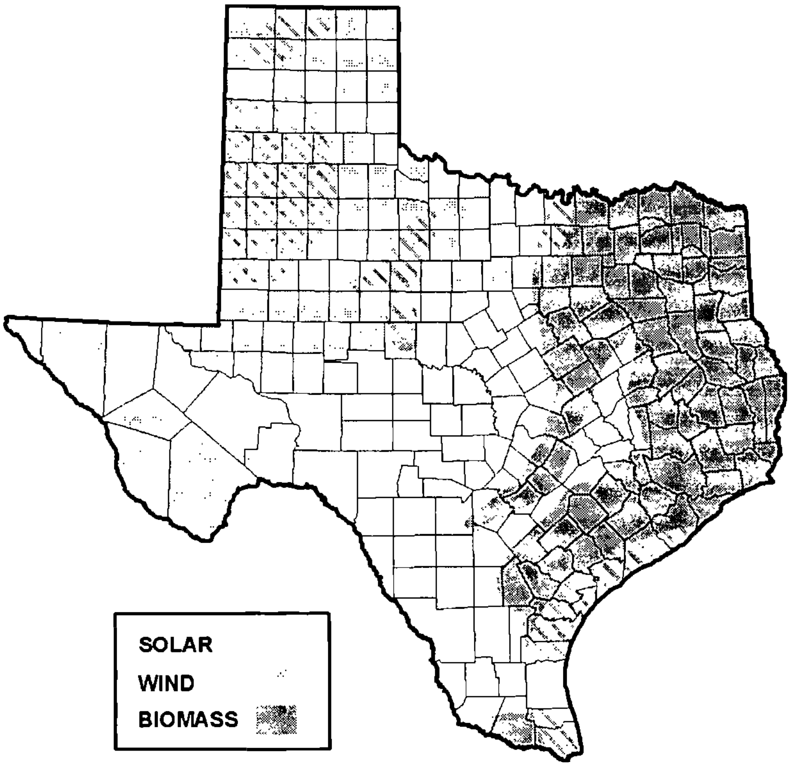


Note: wind & solar as electricity generation; biomass as fuel

Together, these vast renewable resources of resources are dispersed throughout the State, with biomass and geothermal primarily in the eastern region, and wind and solar primarily in the southern, western and northern regions (see Figure 4). The opportunity for customer sited grid connected photovoltaics in the State was identified in a national screening analysis (Wenger et al 1996). The State's ample biomass resources, from forest and mill residues, urban wood waste, and woody crops (Walsh et al 1999) could be used in power plants, or converted to cellulosic (wood based) ethanol to replace or blend with gasoline.

In a vision of the State's energy future, *Texas Energy for a New Century* (SEDC 1995a) developed an aggressive strategy for renewables and efficiency. It projected that within fifteen years about one-half of the State's electricity requirements would be met by these options, with over 20 percent from renewables alone. Environmental Defense Fund's *The Next Texas Energy Boom* charted a future for renewables and energy efficiency in the State in the first decade of the 21st century (Brower et al 1995). It included 5000 Megawatts of wind electricity, 700 megawatts

Figure 4: Areas of High Solar, Wind and Biomass Potential in Texas (source: Vitrus Energy Research Associates)



of solar electricity, solar equipment in 50% of new homes, 20% efficiency improvement in industry and 40% in buildings. In that scenario renewables would provide about 6% of electricity within ten years. An EPA sponsored study of strategies for joint SO_2/CO_2 reductions in electricity generation also found a large role for renewables and efficiency. As much as 18% of electricity requirements would be met by wind and biomass, 38% by end-use efficiency, 12% by new co-generation and 38% by natural gas, in a large Texas utility system (Bernow et al 1994). Recent work has shown that such an energy transition in Texas would likely yield economic and employment benefits (Goldberg and Laitner 1998; Bernow *et al* 1999).

The SEDC-sponsored Texas Transportation Energy Savings (CTR/Tellus 1995) examined how demand management measures, technologies, alternative fuels, and policies could reduce energy use and emissions from personal and freight transportation in the State. It showed that annual energy use for transportation could be reduced about 26 percent by 2010 and 33 percent by 2020, with commensurate reductions in carbon dioxide and criteria pollutant emissions. The reductions in passenger vehicles alone were 42 percent by 2010 and 53 percent by 2020. Coupled with innovative land use, urban planning and transportation infrastructure and modal choice initiatives, these technologies, resources and measures could enhance quality of life, especially in urban areas, as well as reap energy, economic and emissions benefits (SEDC 1995b).

Transportation emissions in the State could be reduced through actions by its various state, regional and municipal agencies. Options being pursued or considered include demand management, mode switching, and alternative fuel vehicles (e.g. in Houston), particularly in urban fleets. Other opportunities could be pursued in fuel-efficiency and emissions standards, incentives and procurement, public education, pricing, land-use, and infrastructure and mode alternatives. Texas is now considering adopting California's clean vehicles program, is considering mass transit in Dallas, Houston and Austin, as well as inter-city rail proposals.

The electricity supply industry in Texas is undergoing restructuring, moving it towards deregulated retail electricity markets. In the absence of complementary policies, retail competition, in which price would play the major factor in electric supply development and generation, could undermine the progress in end-use efficiency, clean energy resources and environmental protection that was intended by integrated resource planning under a regulated regime. Existing coal units whose capital costs are sunk, and whose running costs are low would likely continue to run up to their full availability. Moreover, cleaner and more efficient natural gas plants would tend to enter the mix only to the degree that load grows; and these would tend to limit the entry of renewables and demand-side efficiency. This is why restructuring legislation discussed at the national and state levels often has many elements – such as renewable portfolio standards, output based emissions standards, system benefits charges -- explicitly designed to meet these energy and environmental objectives.

The Texas restructuring legislation (SB7) has provisions to help achieve these goals. It includes a modest renewable portfolio standard with tradable credits to reach the target of 2,000 MW of new renewable capacity by 2009. Combined with existing renewable capacity, a total of about 4 percent of installed capacity would be reached. If this were mainly wind and solar, generating about 35 percent of the time as assumed by the PUC (1999), it would provide about 2 percent of the State's electricity. The restructuring bill also requires that 50 percent of generating capacity installed after 2000 will use natural gas, with a credit trading amongst suppliers. Texas also has a net metering program to provide incentives for small scale dispersed renewables; it is designed to ensure that all customers with on-site renewable generation can sell their excess back to the grid at avoided costs. Several utilities have green pricing programs for solar, wind, small hydro, biomass and geothermal electricity. Recent examples of the growing development of renewable electricity in the State include a 75 MW wind farm in McCamey, which is selling its output to CSW Power Company, and a 20 kW rooftop photovoltaic array at the Health Sciences Center of the University of Texas at Houston.

Texas is a partner in the federal government's million solar roofs initiative to support development of on-site solar electricity and solar thermal systems. Maintaining state funding and federal support is a key to reaching these goals.

Currently, Texas has no residential or commercial building energy codes. A residential energy code has been proposed as one method to reduce pollutant emissions as part of a State Implementation Plan (NTCG, 1999). The LoanSTAR program of State Energy Conservation Office provides low interest financing for energy efficient retrofits of public offices, schools hospitals and other buildings, and the city of Austin has a home energy rating program, Austin Energy Star, to assist builders with energy efficient design and construction.

The city of Austin is a "government ally" and more than a dozen Texas firms are "partners," in the Climate Wise program jointly sponsored by the U.S. Department of Energy and Environmental Protection Agency. Though this program firms can obtain access to technical and financial information and technical assistance on a wide range of energy saving and emissions reducing opportunities, including process changes, materials substitution, and fuel switching.

There are numerous companies in the State that deliver energy-efficiency and renewable energy resources, equipment and services, and many more companies and households stand to benefit from the energy bill reductions from improved energy efficiency. With its strong aerospace, computer and high tech industries and natural resource endowments, Texas is well situated to provide clean energy resources, such as biomass production and its conversion to liquid fuel, and to manufacture and utilize advanced energy systems, such as fuel cells for stationery power and vehicles.

3. The National Policies and Measures

America's Global Warming Solutions presented analysis of national policies and measures within each sector, which would stimulate faster adoption of more energy-efficient technologies and low-carbon energy resources, and induce innovation, learning and further diffusion. These included a robust mix of complementary approaches, including incentives, market creation and transformation, regulatory modernization, technical assistance, efficiency and performance standards, research and development, and tax reform. Specifically they were:

For transportation:

- A vehicle efficiency initiative, including: progressively stronger fuel economy standards for cars and sports utility vehicles; an efficiency and emissions based rebate system for vehicle purchases; R&D for improved design, materials and technologies; public sector market creation programs for cleaner and more efficient vehicles; and standards and incentives for freight trucks and other commercial modes.
- Urban/regional transportation demand management and related incentives; pricing reforms, including congestion and emissions-based pricing; land-use and infrastructure planning for improved access to alternative and complementary travel modes, including transit, walking and biking; facilitation of high speed intercity rail development; pricing, planning and informational initiatives to promote intermodal freight movement.
- A progressively stronger cap on the carbon intensity of motor fuels, reaching a 10 percent reduction by 2010; R&D for cellulosic ethanol, other renewable fuels and associated vehicle technologies; renewable fuels commercialization programs in various market segments, including public sector procurement programs.

For industry:

- Tax incentives to stimulate more investment in new more efficient energy-using manufacturing equipment, and RD&D to bring down the costs and speed the availability of more efficient equipment;
- Regulatory refinement and technical assistance to remove disincentives for industrial combined heat and power (CHP), whereby electricity is generated on-site, rather than imported from the grid, by using the same fuels producing heat for manufacturing processes.

For electricity generation:

- A progressively increased renewable portfolio standard, that would require suppliers to collectively provide 10 percent of generation by 2010 with renewable resources, with a credit trade system to ensure that the national target is met with a regional distribution that results in lowest cost.
- A tightening of the 1990 Clean Air Act Amendment SO_2 cap, which now halves the sector's emissions from 1990 levels to 9 million tons by 2000, to reduce them further to about 3.5

million tons by 2010. Also, a cap and trade system for NO_x and fine particulates to reduce their levels. These pollution restrictions would both reduce coal use and carbon emissions.

- A requirement for co-firing of biomass in coal plants, with credit trading, which is progressively increased to 10 percent by 2010, providing near-term carbon reductions and stimulating development of that resource.
- A cap and trade (or tax) for carbon emissions to reduce the carbon intensity of the sector between 1990 and 2010 by about 40 percent.

For commercial and residential buildings:

- Appliance and building standards, which would establish norms for equipment, design and performance which, through purchases and practices, would reduce energy used to provide services in homes and offices.
- Market transformation incentives including technology demonstrations, manufacturer incentives, and consumer education to reduce barriers to energy savings and renewables.
- Initiatives to expand the use of combined heat and power for district energy systems.

4. Energy, Carbon and Cost Impacts

The national policies and measures were estimated to achieve a 22 percent reduction in primary energy use and a 36 percent reduction in carbon emissions by 2010 relative to baseline projections for the U.S. that year, about 14 percent below 1990 emissions. These carbon emission reductions are realized entirely through energy-related policies and measures, with net economic savings. The analysis showed that national savings in energy bills would exceed the net incremental investments in more efficient technologies and expenditures for low carbon fuels through by an average of about $150 per capita per year from 1998 through 2000. Cumulative discounted savings to the nation's economy would reach more than $300 billion over that period.

In Texas, these national policies would reduce carbon emissions by about 34 percent below baseline projections for 2010. These reductions reflect a 25 percent reduction in primary energy use by 2010, owing to increased investment more energy efficient equipment, as well as a shift to less carbon-intensive fuels for electricity, transportation and industry. Net annualized savings were estimated to average about $200 per-capita from 1998 through 2010, reaching over $700 per-capita or $19 billion in that year. Cumulative discounted savings would be about $41 billion over that period.

This section presents a summary of the methods and assumptions for the national and Texas impact analysis and a more detailed energy, carbon and cost/benefit results.

4.1. Analyses and Results for Energy and Carbon

National and regional energy demand, supply and cost data for the both the Base Case and Policy Scenario were taken from the models used, and were benchmarked to recent energy demand, supply and price data for Texas. The modeling approach for the national analysis is described in *America's Global Warming Solutions* (Bernow et al 1999) and its predecessor study *Policies and Measure to Reduce CO_2 Emissions in the U.S.* For example, NEMS provides detailed information and policy impacts on electric power supply by reliability region, including the

ERCOT and SPP regions, which include Texas, and it provides building sector results for the Southeastern U.S. census region. Relative demographic and economic growth rates were used to map national and regional projections onto Texas. The LIEF model was run for the Base and Policy cases using Texas fossil and electricity prices. For transport modes we used regional data from NEMS projections for various modes and vehicle types, combined with Texas data on the mode and vehicle mix and energy use, and applied the policy variables in the models reflecting transport demand, stock turnover, fuel-efficiency and costs.

4.1.1. Transportation

Analyses of the policy impacts in the transportation sector took account of vehicle stock turnover, fuel-efficiencies and travel indices, and were benchmarked to the structure, data and baseline projections of the EIA (1998). The analyses were further benchmarked to transportation data for Texas. For light duty vehicles (LDVs), we assumed a progressively improving national fuel efficiency standard, increasing by 1.5 miles per gallon (mpg) per year from 1998 through 2010. This results in new cars at an average of 45 mpg and new light trucks at 37 mpg in 2010. For the entire fleet in operation, the average would be about 25 mpg, about 19 percent below baseline projections for that year. For heavy-duty freight trucks fuel efficiency improvements would be about 8 percent by 2010 relative to baseline projections. The demand management and mode shift policies would reduce LDV energy use by another 8 percent.

We assumed that the carbon content and renewable fuel policies would result in a progressive increase to a 10 percent contribution of cellulosic (wood derived) ethanol as a blend with gasoline in cars by 2010. In Texas, this would require about 98 trillion Btu (about three-quarters of a billion gallons). This resource could be provided from the State's biomass resource potential, comprising urban wood wastes, forest and mill residues, and short rotation woody crops. This demand could be met by one-third of the State's potential biomass resources at less than \$50 per dry ton (about \$3 per MMBtu), and by about one-half of its potential at less than \$40 per dry ton, (Walsh *et al* 1999).

Figure 5A and 5B summarize the impacts of the national policies on energy use and carbon emissions in the Texas transportation sector. Under the business-as-usual (baseline) projections, Texas energy use for transport -- by cars, commercial and freight trucks, trains, airplanes and boats -- would grow by about 47 percent between 1990 and 2010, following national trends.

Figure 5.A: Transport Energy Use by Fuel Type -- Base Case vs. Policy Case

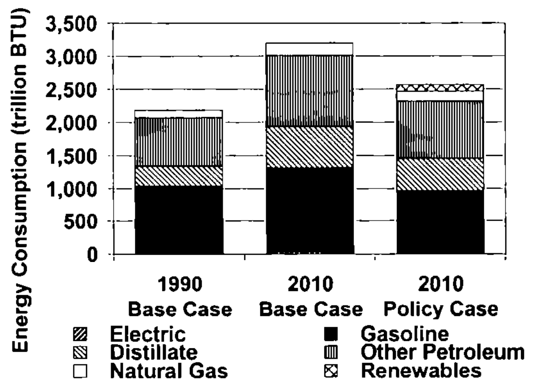
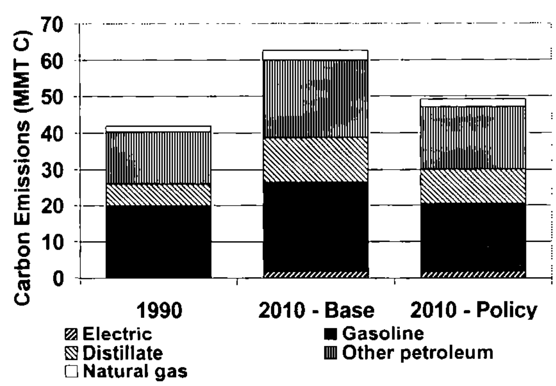


Figure 5.B: Transport Carbon Emissions by Fuel Type – Base Case vs. Policy Case



The efficiency and demand management policies would reduce transportation energy use in Texas by increasing levels over time, reaching 20 percent below baseline projections for 2010.

An additional 7.6 percent reduction in gasoline use would arise from the use of cellulosic ethanol blends.

The fuel use reductions from the efficiency and demand management policies would reduce carbon emissions from the sector by about 12 MtC or 20 percent in 2010. The carbon content/ethanol policy would reduce emissions by about 2 MtC or 3.2 percent by 2010 from gasoline displacement (and an additional 0.5 MtC from displaced grid-based electricity owing to electricity generated in the ethanol production). An additional 2.8 MtC would be saved at refineries owing to reduced energy use in producing less gasoline. This is part of an overall carbon reduction (about 21 MtC) from lower energy use in Texas refineries (which consume about 55% of the national energy use at refineries) owing to oil use reductions throughout the U.S. from the national policies; these refinery emissions reductions are accounted in the industrial sector.

4.1.2. Industry

For industrial energy efficiency policies, we used the empirically based LIEF model, benchmarked to the AEO 1998 baseline energy price and consumption projections. A high effective discount rate of 27.8 percent, owing to market and institutional barriers, was used in the Base Case in order to match observed energy demands with LIEF. We assumed that this would be reduced to 12.3 percent by the policies of technical assistance, information, tax credits and R&D. We found that national industrial energy consumption could be decreased by more than 10 percent by 2010, relative to the Base Case, through investments in cost-effective energy efficiency induced by the policies. For analysis of the impacts of these policies on Texas, we benchmarked LIEF to recent data on the industrial mix, energy use and energy prices in the State. We found that overall end-use energy consumption in the State would decrease by about 10 percent by 2010 owing to the energy efficiency policies, with electricity consumption reduced by about 14 percent.

For industrial combined-heat-and-power (CHP) with advanced micro-turbines, we assumed that by 2010 twenty percent of existing manufacturing steam demand would shift to cost-effective gas-fired co-generation and fifty percent of existing co-generation in the paper and pulp industry would retrofit to advanced turbines. This results in about 38 GW new CHP capacity and 236 TWh electricity generated on site by 2010. For Texas, it results in 8 GW and about 43 TWh (about 20 percent of the national CHP achieved).

The industrial demand for electricity purchased from the grid is reduced owing to this additional CHP, by about 39 percent by 2010. CHP does not appreciably affect overall end-use energy consumption in industry, since the on-site electricity generated requires additional fuel. But the additional fuel is far less than that needed for the grid electricity generation that it displaces, and its natural gas fuel is cleaner than the high-carbon avoided fuels, both on site and at the power plant. As a consequence, efficiency plus CHP reduce overall industrial fuel and purchased electricity use by about 10 percent by 2010, with purchased grid electricity alone reduced by 53 percent.

Finally, an additional impact on Texas industrial energy use of the national policies is on energy use in oil refining. As Texas refines over half the oil used in the U.S. and that process requires energy as well as crude oil inputs, the large reductions in national oil consumption would have commensurate reductions in energy use at Texas refineries. Accounting for this effect would give an overall 25 percent reduction in Texas industrial energy use in 2010.

Figures 6.A and 6.B summarize the impacts of the national policies on energy use and carbon emissions in the Texas industrial sector.

Figure 6.A: Industrial Energy Use – Base Case vs. Policy Case

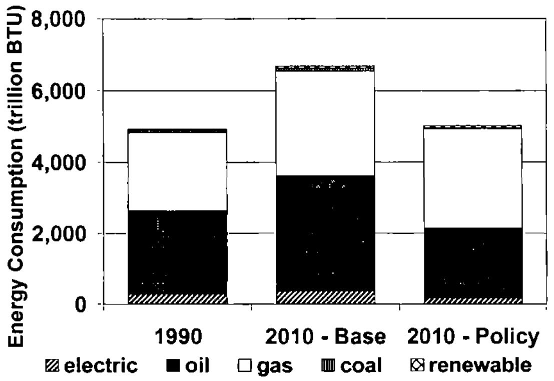
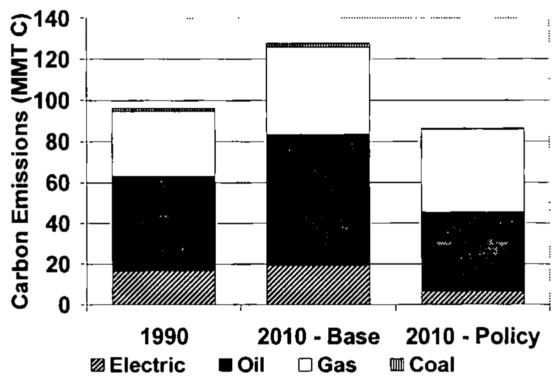


Figure 6.B: Industrial Carbon Emissions by Fuel Type – Base Case vs. Policy Case



The national energy efficiency policies for industry would reduce carbon emissions from the Texas industrial sector by about 8.7 MtC in 2010, about 8.1 percent of the total on-site fossil based emissions. They would also decrease emissions from industrial electricity use by 2.5 MtC, about 12.5 percent. The extra fuels used for CHP would increase emissions by 0.9 MtC on-site, while causing a decrease of 8.3 MtC in emissions from grid based electric generation.

Thus, the reduction in emissions from efficiency and CHP, from both on-site fossil combustion and from purchased grid electricity, would be 18.6 MtC or about 15 percent of the emissions caused by industrial energy demand in 2010. An additional reduction 21 MtC would be effected by reduced energy for refineries, owing to the national reduction in demand for petroleum based fuels. The overall reduction in carbon emissions from the Texas industrial sector would thus be 39.8 MtC, or about 31 percent, in 2010.

4.1.3. Buildings

For residential and commercial building policies we used the NEMS model, which represents energy technologies and demand for each major fuel type and end-use, including air conditioning, space and water heating, and various types of equipment and appliances, based on building and technology characteristics and costs. The policies were modeled though changes in the availability of new more efficient technologies and of the "hurdle" discount rates that reflect non-financial influences (e.g., information) on consumer choice.

Overall national energy use in buildings was reduced about 16 percent in buildings in 2010. For Texas the reduction was found to be about 17.3 percent overall, about 17.9 percent for residential and 16.7 percent for commercial buildings. These savings are mostly in reduced electricity demand from more efficient lighting, household appliances, office equipment, and heating and cooling systems. Thus, electricity demand is reduced 27 percent in residential and commercial buildings. The national policies included an initiative to promote district energy systems (DES) using CHP for high-density commercial buildings. We assumed no DES impacts for Texas in this analysis, as the State has relatively low space-heating demand. Nonetheless, its high cooling demand high-density commercial and residential buildings could warrant selected deployment of DES, an option worthy of study.

Figures 7.A through 8.B summarize the energy use and carbon emissions impacts of the national policies on the Texas residential and commercial buildings sectors.

Figure 7.A: Residential Energy Use by Fuel Type – Base Case vs. Policy Case

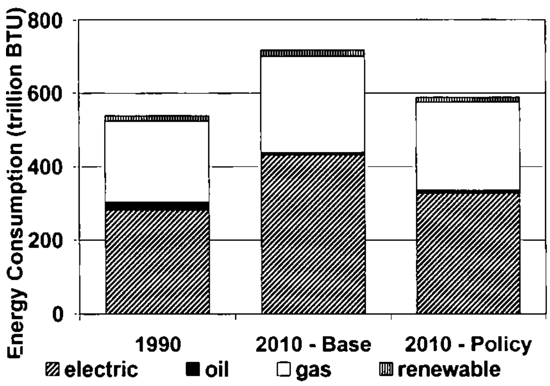


Figure 7.B: Residential Carbon Emissions by Fuel Type – Base Case vs. Policy Case

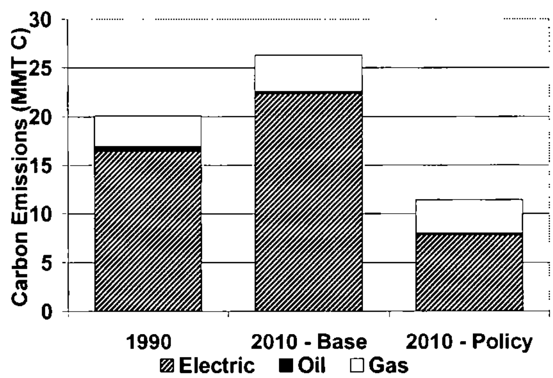


Figure 8.A: Commercial Energy Use by Fuel Type – Base Case vs. Policy Case

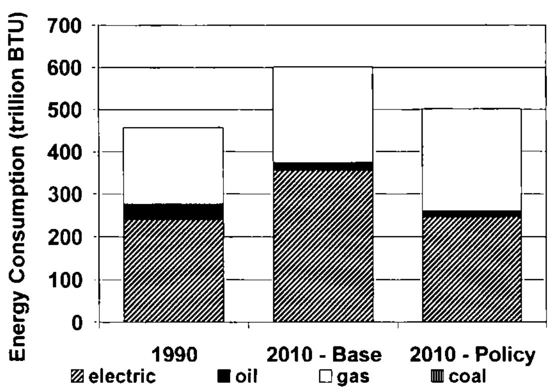
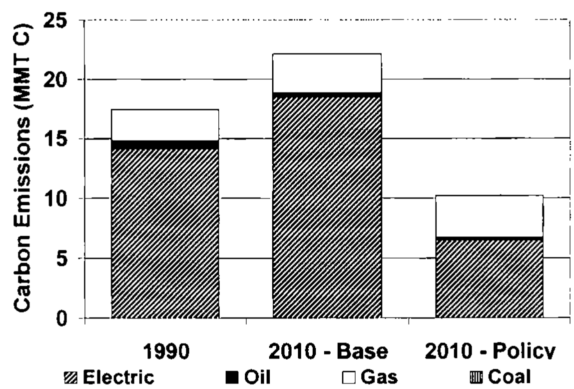


Figure 8.B: Commercial Carbon Emissions by Fuel Type – Base Case vs. Policy Case



About one-sixth of carbon emissions from energy demands at residential and commercial building in Texas arise on-site from natural gas combustion, while about five-sixths arises from purchased electricity generation. Therefore, as the efficiency policies have much greater impact on electricity demands and the mix of fuels in electricity generation are much more carbon-intensive than gas, the buildings sector carbon reductions arise almost entirely from decreased electricity demand. The national energy efficiency policies for residential and commercial buildings would reduce annual carbon emissions by increasing amounts, reaching about 12 MtC or 25 percent in 2010.

4.1.4. Electricity Supply

The electric sector policies were modeled using the Department of Energy's National Energy Modeling System (NEMS). NEMS includes data for existing power plants in the thirteen

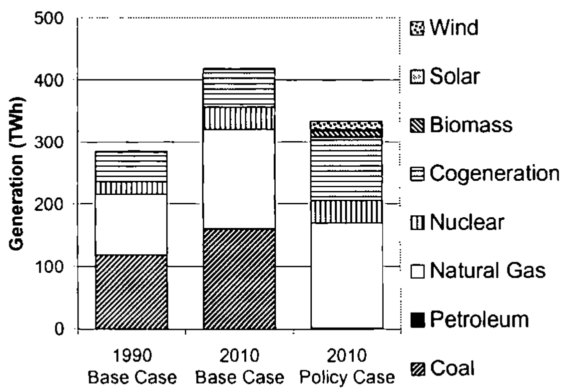
Electric Reliability Council regions of the U.S. and neighboring Canadian regions. It simulates dispatch of these plants and new plants needed to meet the growing electricity demand in each region, taking account of regional exchanges and the characteristics of existing and new electricity supply options. NEMS was used to analyze a national renewable portfolio standard (RPS) set to ramp up to 10 percent of electricity generation in 2010 from solar, wind, biomass and geothermal power plants. It was also used to model the generation performance standards, through a tighter cap on sulfur-dioxide emissions, and externality adders for particulates ($10,000 per ton), oxides of nitrogen ($2,500 per ton) and carbon ($50/ton CO_2). Based on the results of the NEMS analyses for the Texas region, the national standard for biomass co-firing in coal power plants, to displace ten percent of existing coal generation by 2010, was not modeled in Texas due to the sharp reduction in coal generation achieved by the other policies.

The national end-use efficiency and co-generation policies would reduce electricity requirements in Texas by 35 percent by 2010, from a 1996-2010 growth rate of about 2 percent per year to a decline of about 1.2 percent per year. This reduces the need for construction and operation of new coal and gas power plants and thereby their emissions.

The national RPS was found to increase renewable electricity generation in Texas, reaching 27 TWh or about 12 percent in 2010, comprising 14 TWh wind, 9 TWh biomass and 1 TWh solar. Thus, the national RPS policy requirement would be met in Texas with its own ample renewable resources. Further development of these State resources and associated technologies could be encouraged by complementing the national RPS with policies in Texas to stimulate renewable electric energy generation. Texas could become a provider of renewable generation credits to other states.

The national generation performance standards for particulates, sulfur dioxide, nitrogen oxides and carbon dioxide, would have a large effect on electric generation in Texas. Generation from its carbon and pollutant intensive coal-fired power plants would be virtually eliminated, replaced by generation from new highly efficient natural gas combined cycle plants. Notwithstanding this shift, natural gas use for electricity generation in Texas would not change much from the business-as-usual projections, as the shift from coal is accompanied by increased contribution from renewables and reduced generation overall from end-use efficiency. Thus, coal and gas would each contribute about 45 percent of Texas electricity generation in 2010 in the business-as-usual case, with nuclear adding the other 10 percent, while in the policy case, with essentially no coal generation, natural gas would contribute about 72 percent and renewables 12 percent.

Figure 9.A: Electric Sector Generation by Fuel Type – Base Case vs. Policy Case



Figures 9.A through 9.C summarize the impacts of the national electricity supply and demand policies on electricity generation and fuel mix in Texas.

The shifts in power plant fuels from the national electric sector policies would reduce carbon emissions by about 15.5 MtC or 25 percent of the total from electricity supply in 2010. The RPS would contribute about 2.6

MtC, while the generation performance standards would contribute about 12.9 MtC. An additional reduction of 23.5 MtC or 38 percent arises from end-use efficiency and co-generation policy impacts on generation.

Figure 9.B: Electric Sector Energy Use by Fuel Type – Base Case vs. Policy Case

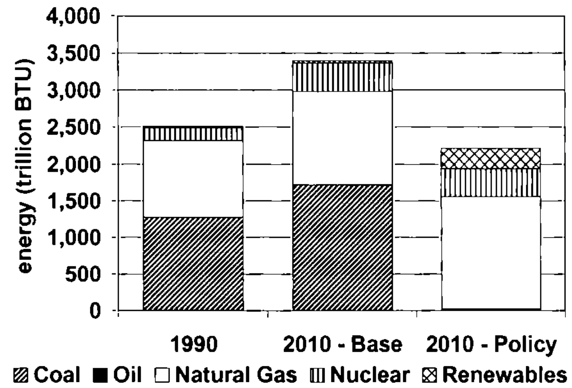
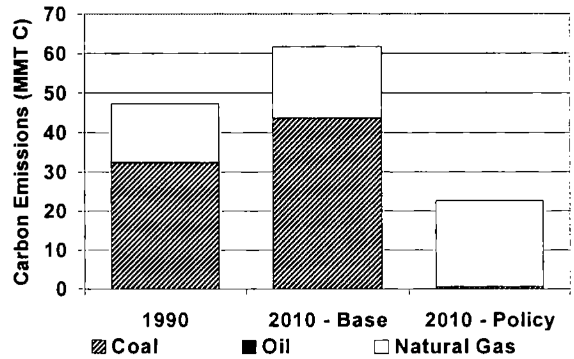


Figure 9.C: Electric Sector Carbon Emissions by Fuel Type – Base Case vs. Policy Case



4.2. Summary of Carbon and Pollutant Emissions Impacts

The two graphs below summarize the impacts of the national policies and measures on carbon emissions from energy use and supply in Texas. The first shows the emissions reductions in the sectors of their origin, that is, in which the combustion of fossil fuels occurs. Thus, it shows emissions from on-site fossil fuel combustion in buildings, industry, transportation and electricity production. It is noteworthy that the largest reductions arise in the electric sector, owing to the end-use energy efficiency policies that reduce demand, plus the emissions and renewables policies for power supply that shift the fuels for electricity generation. The second graph shows the reductions across the end-use sectors only, that is, from which the demands for fossil fuel combustion on-site or at power plants arise. In this graph electric sector emissions are allocated to the end-use sectors proportional to their demands.

The carbon emissions reductions can also be reported by policy or by the sectors to which the

Figure 10.A: Carbon Emission Reductions in all Texas Sectors

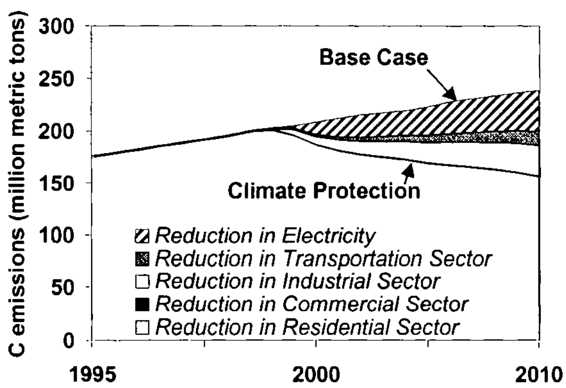
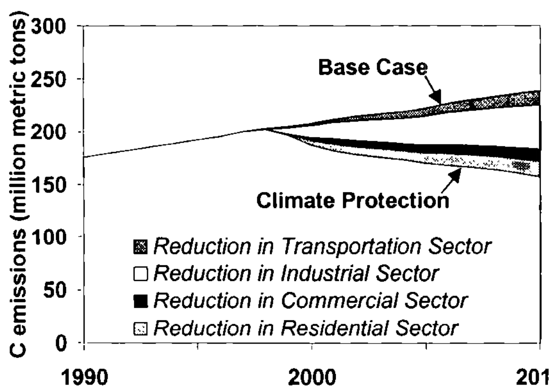


Figure 10.B: Carbon Emission Reductions in Texas End-use Sectors



policies are directed. Table 1 provides these results and compares them with the national carbon reductions realized by the policies and measures. Thus, for example: the refinery emissions reductions owing to decreased transportation oil use are attributed to the transport policies, while the refinery emissions reductions owing to decreased industrial oil use are attributed to the industrial policies; the electric generation emissions reductions and emissions increased on-site fuel use, owing to increased CHP are attributed to the industrial policies. As can be seen, Texas contributions to national reductions are roughly proportional to its contribution to emissions, at about 13 percent both far greater than its 7.3 percent share of national population. The impacts of national efficiency and CHP policies on the State's industrial sector emissions make an

Table 1: Carbon Reductions by Sector and Policy, Texas and U.S. (MMT C in 2010)

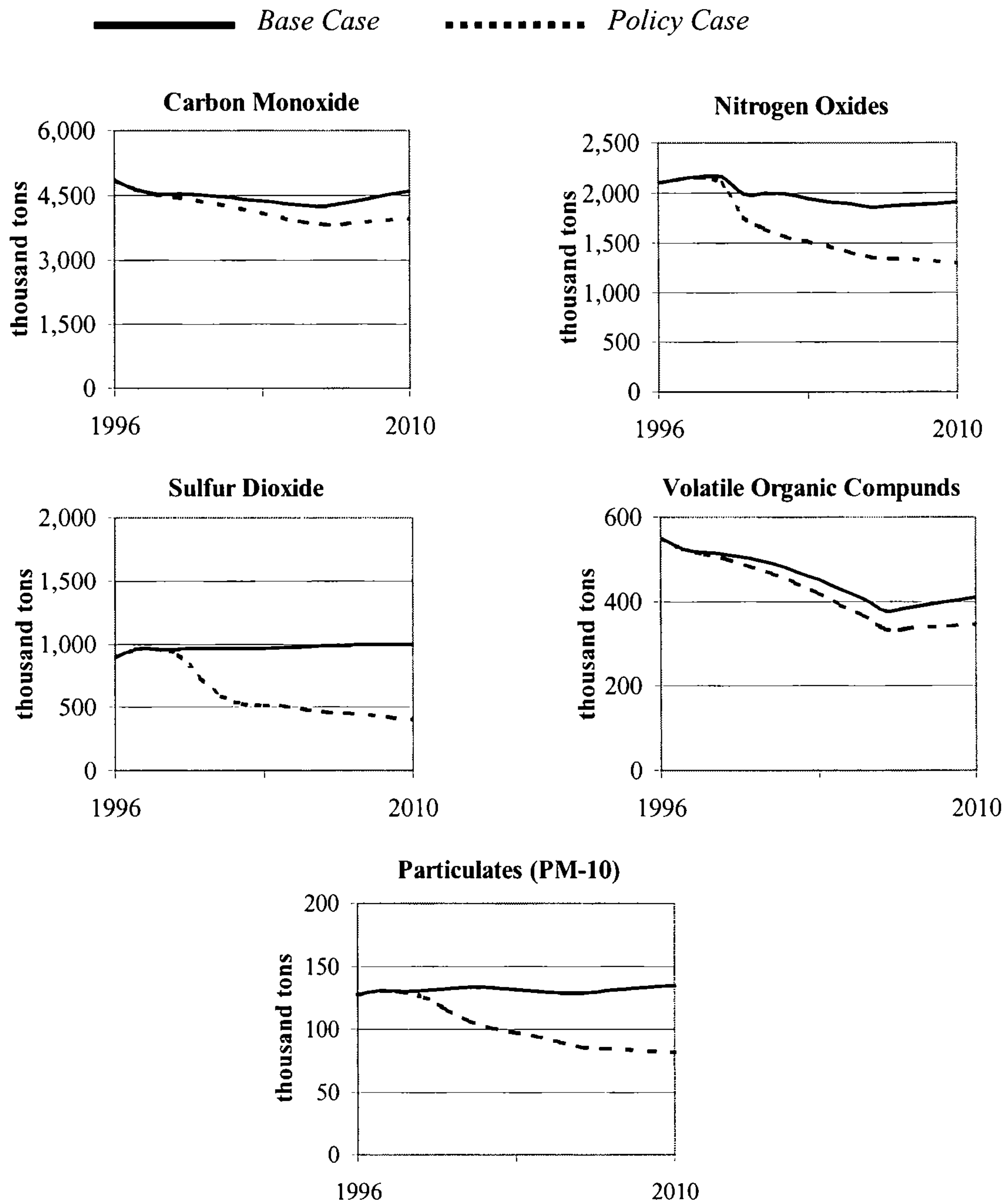
	Texas	U.S.	% U.S.
TOTAL BASE CASE EMISSIONS	239	1,806	13.2%
Transport Sector			
Vehicle Efficiency	8.6	105	8.2%
Transport demand	5.8	65	8.9%
Ethanol	2.9	31	9.4%
Total Transport Sector	17.3	201	8.6%
Industrial Sector			
Industry Efficiency	12.3	77	16.0%
Industry CHP	7.4	34	21.8%
Subtotal Industrial Sector	19.7	111	17.8%
Texas refinery impacts of non-Texas oil savings	17.3	NA*	NA*
Residential and Commercial Sectors			
Building Efficiency	12.1	98	12.4%
District Energy	----	12	----
Total Residential and Commercial Sector	12.1	110	11.0%
Electric Supply Sector			
Renewable Portfolio Standard	2.6	34	7.7%
Biomass Co-firing	0.0	22	0.0%
Generation Performance Standards	12.9	178	7.2%
Total Electric Supply Sector	15.5	234	6.6%
Total Reductions	**81.9**	**656**	**12.5%**
TOTAL POLICY CASE EMISSIONS	157	1,150	13.7%

* Note: U.S refinery impacts included in sectoral results

especially large contribution, at about 18 percent of the national impacts of these policies.

Texas will also benefit from reduced combustion-related emissions of criteria air pollutants owing to the national policies, as shown in Figure 11. Air pollutants such as fine particulates, carbon monoxide, sulfur dioxide, and ozone (formed by a mix of volatile organic compounds and nitrogen oxides in the presence of sunlight) can cause or exacerbate health problems that include premature mortality and morbidity effects. Research shows that small children and the elderly are particularly at risk from these emissions (Dockery

Figure 11: Emissions of major air pollutants: 1996-2010, Base Case and Policy Case



These emissions also account for damages to the environment such as poor air quality and acid rain. The health of Texas citizens, especially those living in urban areas that already suffer from these problems, is threatened poor air quality. By 2010, the national policies would reduce annual emissions of carbon monoxide in the State by 14 percent (4.6 to 4.0 million tons), oxides of nitrogen by 33 percent (1.9 to 1.3 million tons), sulfur dioxide by 65 percent (1.2 to 0.4 million tons), volatile organic compounds by 16 percent (410 to 346 thousand tons), and fine particulate matter by 40 percent (139 to 81 thousand tons).

4.3. Analysis and Results for Costs and Savings

The national climate change policies and measures cause shifts in energy related expenditures in Texas. These shifts entail both costs and savings. The costs are the incremental investments in more efficient energy using equipment, power supply technologies and renewable energy resources, and the savings are the net reductions in the energy bills of households and businesses.

For this analysis, the investment costs and fuel prices were obtained from the NEMS model for residential, commercial and electric power sectors, the LIEF model for the industrial sector, and DeCicco and Lynd (1997) and Lynd (1997) for the transportation sector.

The trajectories of cumulative overall costs and benefits (undiscounted) to the State are shown in Figure 12.A. By 2010 the cumulative net savings to households and businesses in Texas would reach about $70.3 billion. On an annual basis, these net savings would reach $15.6 billion in 2010, or nearly $700 per capita. As shown in Figure 12.B, the cumulative discounted net savings would reach about $34.7 billion through 2010, and the average annual (levelized) net savings over that timeframe would be about 3.7 billion per year, about $190 per capita per year. The overall benefit to cost ratio would be about 2.5.

Figure 12.A: Cumulative Costs and Savings - All Sectors (undiscounted)

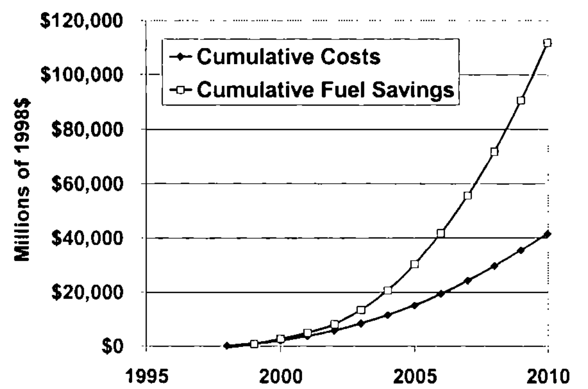
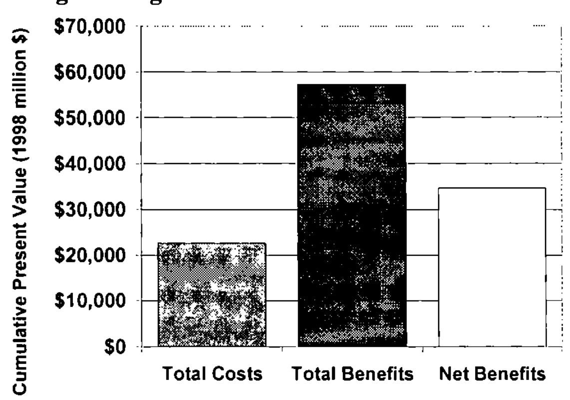


Figure 12.B: Cumulative Discounted Costs and Savings through 2010 - All Sectors



These overall costs and savings comprise contributions from policies that induce adoption of more efficient end-use technologies and policies that support less carbon and emissions intensive electricity and fuel supplies. The cumulative discounted benefits (fuel and electricity savings) and costs of the energy efficiency policies including CHP are $53.5 ($1998) and $18.1 billion respectively, for a benefit to cost ratio of 3.0. The benefit-cost ratios for the efficiency investments are 7.1 for residential and commercial buildings, 1.2 for industry and 4.8 for transportation. The full set of national policies also entail net costs for the RPS and GPS in the electricity supply and the carbon content standard for vehicle fuels, but also include savings from reduced energy use in refineries. These additional costs and savings roughly counteract one another, leaving the overall net savings to Texas citizens and businesses described above.

5. Impacts on the Texas Economy

The set of national policies and measures that affect the Texas energy system and carbon emissions would also affect its economy. Many analyses of state-level policies that induce more efficient energy technologies and renewable resources show that the net economic impact is positive. Thus, one would expect that a similar set of national policies would have similarly positive state-level impacts, particularly in states that are not energy suppliers.

Three indicators of the economic impact in Texas of the national policies and measures were developed—net incremental jobs, wages and salaries and Gross State Product for the years 2005 and 2010. These impacts were estimated using IMPLAN (Impact Analysis for Planning), an input-output (I-O) model that represents interactions between different sectors of the economy. Changes in each sector's spending patterns, owing to changes in fuel consumption and energy technology investments (energy using equipment and power supply facilities), induce changes in other sectors level of output (and inputs), and these are reflected in appropriate sectoral multipliers (jobs per dollar spent). The analytical approach used here is similar to that in Geller, DeCicco and Laitner (1992), Laitner, Bernow and DeCicco (1998), and Goldberg *et al.* (1998).

The analysis tracks changes in expenditures on more efficient lighting, residential appliances, commercial equipment, heating and cooling, building shells, motors, automobiles and trucks, industrial processes and other technologies, that reduce combustion of high carbon fossil fuels. It also tracks the savings in energy bills to households, offices and manufacturing owing to these investments. As the energy bill savings exceed the incremental investments, greater portions of incomes are available to be re-spent, not on fuels but on the myriad goods and services that households and businesses typically purchase. Some sectors, primarily those supplying conventional energy and high carbon resources could decline in the near term. Overall, both the changes in investments and the re-spending of savings stimulate the state's entire economy, as each sector must purchase materials and products from other sectors to be able to produce to satisfy the increased demand for goods and services.

Table 2 provides the net economic benefits in Texas of the set of national policies and measures that would accelerate the use of energy efficient equipment and renewable technologies and resources throughout the country, including Texas. By the year 2010, wage and salary earnings in Texas would increase by about $3 billion and employment would increase by about 84,000 relative to the reference case for that year. At the same time, Gross State Product is projected to increase by almost $2 billion in 2010.

Table 3 provides detailed results for the Texas economy, broken out into the 23 sectors analyzed in this study, for the year 2010. The table shows how each of the major economic sectors are affected in the year 2010 in the Policy Scenario. It should be noted that the results in this table are not intended to be precise forecasts of what will occur, but rather approximate estimates of

Table 2: Macroeconomic Impacts of the Policy Scenario

Year	Net Change in Jobs	Net Change in Wage and Salary Compensation (Millions of 1996$)	Net Change in GSP (Millions of 1996$)
2005	35,300	$1,370	$1,100
2010	83,900	$2,950	$1,820

overall impact. The sectors that benefit most are construction, services, miscellaneous manufacturing, retail trade and agriculture.

Table 3. Macroeconomic Impacts of the Policy Scenario by Sector in 2010

Sector	Net Change in Jobs	Net Change in Wage and Salary Compensation (Millions of 1996$)	Net Change in GSP (Millions of 1996$)
Agriculture	5,800	$70	$110
Coal Mining	(100)	$(10)	$(10)
Construction	26,900	$940	$1,050
Education	2,200	$70	$70
Electric Utilities	(4,600)	$(620)	$(2,550)
Finance	3,900	$160	$310
Food Processing	800	$30	$60
Government	1,600	$60	$80
Insurance/Real Estate	400	$20	$100
Metal Durables	4,500	$310	$520
Motor Vehicles	1,400	$100	$120
Natural Gas Utilities	700	$130	$430
Oil Refining	(500)	$(70)	$(190)
Oil/Gas Mining	(5,000)	$(370)	$(1,390)
Other Manufacturing	12,900	$920	$1,420
Other Mining	1,200	$90	$160
Primary Metals	1,500	$110	$150
Pulp and Paper Mills	600	$50	$100
Retail Trade	6,600	$140	$210
Services	18,300	$520	$590
Stone, Glass, and Clay	1,700	$90	$120
Transportation, Communication, and Utilities	2,700	$190	$320
Wholesale Trade	400	$20	$40
TOTAL	**83,900**	**$2,950**	**$1,820**

As might be expected, the traditional energy supply industries incur overall losses. But these results must be tempered somewhat as the energy industries themselves are undergoing internal restructuring. For example, as restructuring takes place and the electric utilities engage in more energy efficiency services and other alternative energy investment activities, they will undoubtedly employ more people from the business services and engineering sectors. Hence, the negative employment impacts in these sectors should not necessarily be seen as job losses, rather they might be more appropriately seen as a redistribution of jobs in the overall economy and future occupational tradeoffs.

These analyses are approximate and indicative. They assume that labor, plant and materials would not otherwise be fully employed under baseline conditions and would be available with the policy-induced investments. They do not account for a variety of feedbacks, e.g. from price changes and inflation. The results of the analysis do not include other productivity benefits that are likely to stem from the efficiency investments, which could be substantial, especially in the industrial sector. They do not reflect the potential for policy-induced innovation and scale economies across all sectors. Finally, the analysis does not reflect the full benefit of the efficiency investments, since the energy bill savings beyond 2010 are not incorporated in the analysis.

While these increases are significant, the impacts are relatively small in comparison to overall economic activity. For instance, increasing the State's GSP by $1.8 billion in 2010 represents only 0.26 percent of the $698 billion (1996$) projected GSP in that year. The net employment increase is about 0.7 percent in that year. Nonetheless, the analysis indicates that in helping to achieve the national and international goals of climate protection, Texas would not compromise its economic vitality. At the same time, the State would shift its energy supply and use to a more advanced, efficient and productive basis, and would reduce its combustion of fossil fuels, thereby enhancing its environmental quality and public health.

6. Conclusions

Analysis and experience have shown that there are ample technological and policy opportunities for the U.S. to significantly reduce its greenhouse gas emissions at a net economic benefit. National policies and measures would overcome market, institutional and other barriers to the more rapid and widespread diffusion of advanced and more efficient energy technologies and cleaner energy resources. *America's Global Warming Solutions* showed that the U.S. could reduce its emissions 36 percent below projected levels for 2010, 14 percent below 1990 levels, with net economic savings to households, almost 900,000 net additional jobs, and significant reductions of pollutants that harm human health and the environment. These improvements in technology, environment and economy would be widespread across the country.

This study has analyzed the impacts of this national strategy on Texas, which has significant vulnerabilities to climate change, unique opportunities to help meet the challenge of climate protection, and thus substantial benefits to be reaped in taking and supporting action. The study finds that the national policies and measures of *America's Global Warming Solutions* would stimulate more rapid adoption of the new and more efficient energy technologies and cleaner resources in Texas. As a consequence, carbon emissions in Texas would be reduced by about 34 percent in 2010, bringing it about 15 percent below its 1990 level. Emissions of other pollutants would also be reduced, thus improving air quality, human health and the environment in the State. Households and businesses in Texas would enjoy annual energy bill reductions in excess of their incremental investments in more efficient and cleaner technologies. These net savings would increase over time, reaching nearly $700 per capita in 2010. The cumulative net savings would be about $70.3 billion (1998$) through 2010, about $34.7 billion in discounted terms, and about 84,000 additional jobs would be created in the State by 2010.

By focusing on domestic, energy-related carbon emissions reductions, going beyond the Kyoto target, and including cutting-edge technologies in an overall cost-effective portfolio, the proposed set of national policies and measures would serve as an effective transitional strategy to meet the long-term goals of climate protection. It could stimulate technological and institutional learning, scale economies and further innovation and invention, enhance economic productivity, and establish the basis for entry into markets for clean energy technologies and resources.

The risks of climate disruption to future generations throughout world, the U.S. and Texas are too great to delay early and sustained reductions of greenhouse gas emissions. The U.S. can fulfill its historic responsibility to meet the challenge of climate change, by taking actions that meet its Kyoto obligations, while establishing momentum to achieve the deeper long-term reductions in greenhouse gas emissions that are required for climate stabilization. Texas has a major role to play in this process. As previously noted, it has the highest annual greenhouse gas emissions in the U.S., contributing about one-seventh of the national total; it also has vast, largely untapped renewable energy resources, as well as the economic and technological capacities to develop them. The citizens and economy of Texas can support and participate in the actions and changes recommended in this report and, as a result, derive economic and environmental benefits in the near-term and well into the future.

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