GOVERNOR'S COMMISSION ON CLIMATE CHANGE

DRAFT Interim Report

August 25, 2008

The Honorable L. Preston Bryant, Jr.
Secretary of Natural Resources
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Governor's Commission on Climate Change
DRAFT Interim Report
August 20, 2008

I. About This Interim Report

Over the course of five meetings between February and June of 2008, the Governor's Commission on Climate Change received presentations from nearly 40 state and national experts about the impacts of climate change on Virginia's economy and natural resources. The purpose of this interim report is to present what the Commission has heard in the information-gathering phase of its work. The facts and figures and charts and graphs herein are among other information that have been submitted to the Commission in testimony invited subject-matter experts, as reflected in the Work Plan adopted by the Commission in February 2007.

The Commission's work is ongoing. At the time of this Interim Report's publication, the Commission's four workgroups – Adaptation/Sequestration; Electricity Generation and Other Stationary Sources; Transportation and Land Use; and Built Environment – remain at work. Commission-endorsed findings of fact and recommendations will be made in its Final Report, which is due to be published in December 2008. Therefore, the facts and figures and charts and graphs herein should not be read, at this time, as necessarily having received endorsement by the Commission as a whole.

This interim report may best be thought of as a "status report," seeking only to reflect the Commission's proceedings to date. It does not attempt to draw any conclusions at this time from the information presented, nor does it seek to interpret or validate or dispute any information herein. Last, this Interim Report does not seek to make any recommendations at this time.

Note: This report contains reproductions of PowerPoint slides used in presentations to the Commission. All presentations are available on the Commission's website: www.deq.virginia.gov/info/climatechange.html.

II. Background

The Commission was established as the result of a recommendation contained in the Virginia Energy Plan (VEP). Below is a chronology for the VEP and the Commission:

July 1, 2006	Senate Bill 262, which established an energy policy for the Commonwealth and directed the Department of Mines, Minerals and Energy to prepare a ten-year comprehensive Virginia Energy Plan, became effective.

April 5, 2007	Governor Kaine issued Executive Order 48 (EO 48), which set standards for energy efficiency in state government, and established the position of Senior Advisor to the Governor for Energy Policy as well as the Governor's Energy Policy Advisory Council (GEPAC). The responsibilities of the GEPAC include monitoring the implementation of the VEP.
September 12, 2007	The Virginia Energy Plan was released. The VEP contained four broad goals, one of which was to reduce greenhouse gas emissions by 30 percent by 2025. The VEP also recommended the creation of a Commission on Climate Change to develop a plan for how to reach the greenhouse gas reduction goal.
December 21, 2007	Governor Kaine issued Executive Order 59 (EO 59), which established the Governor's Commission on Climate Change, and announced appointments to the Commission.
February through June, 2008	The Governor's Commission on Climate Change held five day-long meetings around the Commonwealth.
December 15, 2008	The Commission's final report is due.

EO 59 states the importance of the issue of climate change to Virginia this way:

The Intergovernmental Panel on Climate Change's Fourth Assessment Report stated, with an increased confidence level over previous reports, that most of the observed increase in globally averaged temperatures since the mid-20th century is "very likely due" to the increased anthropogenic greenhouse gas concentrations. Energy consumption is the largest manmade contributor to greenhouse gas emissions. States across the nation are acting to study the effects of climate change and limit their greenhouse gas emissions.

Carbon dioxide emissions rose in Virginia by approximately 34 percent from 1990 to 2004, a rate nearly twice the national average. This increase results, in part, from growth in Virginia's economy and development patterns that have produced sprawl and long commutes. Virginia ranked in the top ten states with a 30 percent increase in gasoline-powered cars during this period.

Over the long term, climate change will affect Virginia's population, wildlife, and economy. The Virginia Institute for Marine Science estimates that the mid-Atlantic sea-level will rise between four and twelve inches by 2030, threatening coastal islands and low-lying areas. Air and sea temperature changes would cause more frequent tropical storms with increased damage to Virginia communities. The Chesapeake Bay is particularly susceptible to damage caused by climate change. Changing rain and temperature patterns would disrupt agriculture and forestry.

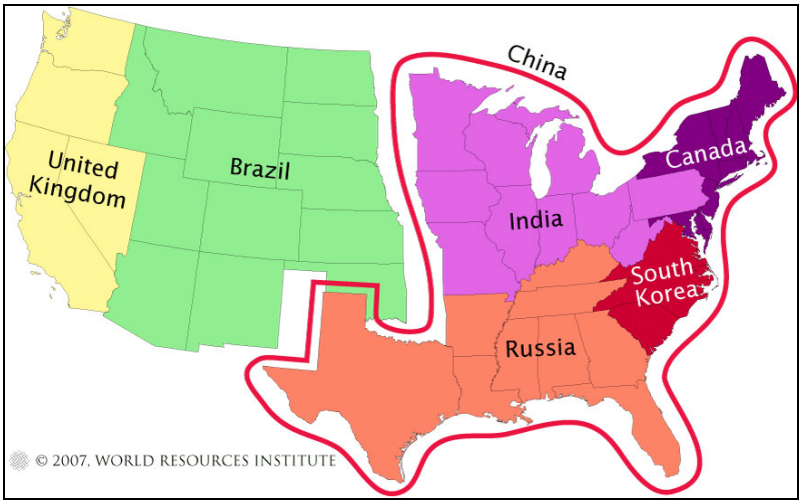
In response to these conditions, EO 59 calls on the Commission to:

- Inventory the amount of and contributors to Virginia's greenhouse gas emissions, including emissions projections through 2025;
- Evaluate the expected impacts of climate change on Virginia's citizens, natural resources and economy;
- Identify climate change approaches being pursued by other states, regions and the federal government;
- Identify what Virginia needs to do to prepare for the likely consequences of climate change; and
- Identify any actions (beyond those identified in the VEP) that need to be taken to achieve the 30 percent greenhouse gas reduction goal.

A. Governor Kaine's Charge to the Commission

At the Commission's introductory meeting, Governor Kaine pointed out that no environmental issue has captured the attention of the nation and world like global climate change. Americans have moved far in recent years in recognizing the science of climate change. Gone are the days when people are debating whether the phenomenon exists, and there is significant motivation and increasing momentum at the state level to address climate change.

The Governor told the Commission that he favors the development of a federal approach to addressing climate change, but because Congress has been slow to act and because the impact of climate change on Virginia is likely to be significant, the Commonwealth cannot wait for the federal government. It is important to recognize that actions taken at the state level can make a considerable difference. For example, according to the World Resources Institute, the greenhouse gas (GHG) emissions of the three states of Virginia, North Carolina, and South Carolina taken together equal the emissions of the Republic of South Korea.



Adapting to the effects of climate change also will be important, as some of those effects will occur even if efforts to reduce emissions are successful. Virginia has 112 miles of coastline and 3,300 miles of tidal shoreline, all of which could be affected by sea level rise. The Governor asked the Commission to seek information on possible effects of climate change on Virginia's forests, wetlands, wildlife, fisheries, military installations, and ports. He also asked the Commission to learn how climate change will affect agriculture, utility costs, the insurance industry, transportation infrastructure, and the way we think about emergency preparedness.

B. Commission Work Plan

The Commission adopted a work plan at its first meeting that listed the topics to be covered at each of eight meetings, several of which were to be held at universities around the Commonwealth. The Commission agreed that each meeting should include a roundtable discussion among Commission members and an opportunity for public comment. Because climate change is such a complex issue and the Commission's charge is substantial, at least four of the meetings were planned to last for an entire day. The sixth meeting was planned to include a public hearing, to allow citizens who could not attend meetings during work hours to be able to share their thoughts with the Commission. In addition, the Commission has accepted (via e-mail on its website) public comment without limitation.

The Virginia Energy Plan estimated that if all of the VEP's recommendations regarding energy conservation and efficiency and renewable energy were implemented, that would result in approximately a 15% reduction in GHGs by 2025. Therefore, the Commission agreed to focus on how to achieve the remaining 15% reduction.

III. Climate Change Information Presented to the Commission

Commission members all came to the Commission with some knowledge about the phenomenon of global climate change. In order to ensure that everyone on the Commission had the same basic understanding, however, it was important for the Commission to receive information from nearly 40 subject-matter experts on widely-accepted science and policy regarding climate change, its causes, and its impacts. To begin the process, the Commission received a presentation on the proceedings of Intergovernmental Panel on Climate Change. The Commission also received a presentation on nature's role in capturing and storing carbon emissions. The third and final foundational presentation received by the Commission was on sources of greenhouse gas emissions in Virginia.

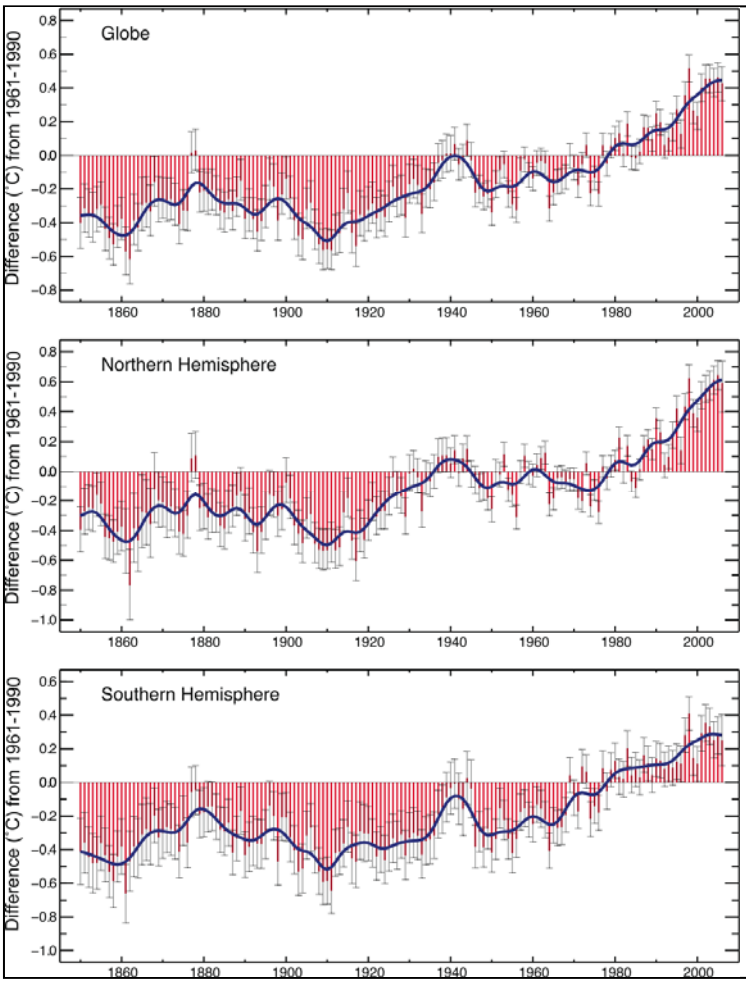
A. Intergovernmental Panel on Climate Change

The work of the Intergovernmental Panel on Climate Change (IPCC) was presented by Mr. Benjamin DeAngelo of the U.S. Environmental Protection Agency (EPA). The IPCC was established by the United Nations (UN) and World Meteorological Organization (WMO) in 1988. It is an international scientific body that is open to all member countries of WMO and the UN Environment Programme. The IPCC produces policy-relevant assessments and reports on

climate change, and hundreds of scientists all over the world contribute to its work as authors, contributors, and reviewers.

The IPCC's *4th Assessment Report*, issued early in 2008, consists of three working group reports (Working Group I – Physical Science; Working Group II – Impacts, Adaptations, and Vulnerability; Working Group III – Mitigation) and a fourth Synthesis Report. All reports issued by the IPCC undergo a rigorous four-tiered approval process, with the first three tiers each involving an expert review and revision under supervision of review editors, and the fourth and final review consisting of a line-by-line approval by government delegations in a joint plenary session.

The *4th Assessment Report* concludes that evidence of global warming is "unequivocal."



Observed Global Warming

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level

Global average warming in the past century is 0.74°C (1.3°F)

U.S. temperatures warmed during the 20th and into the 21st century; temperatures are now approximately 0.56°C (1.0°F) warmer than at the start of the 20th century, with an increased rate of warming over the past 30 years

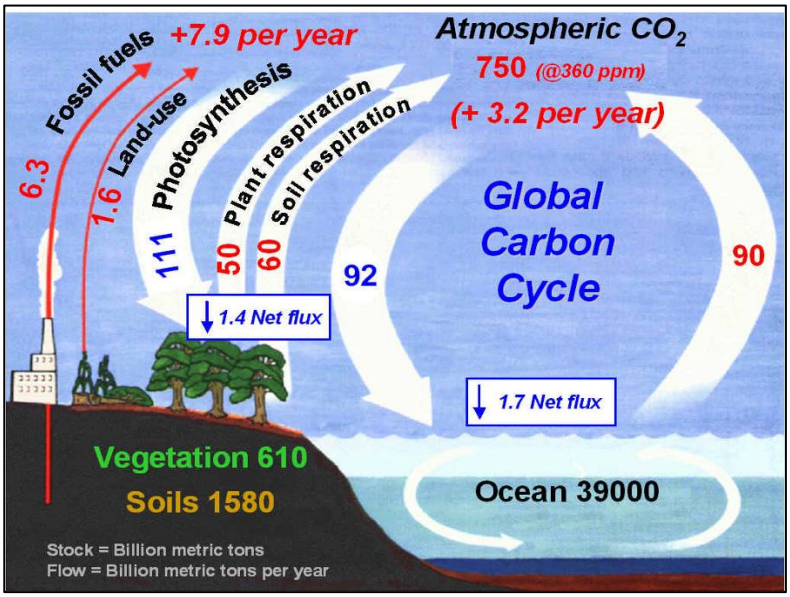
The findings of the *4th Assessment Report*, as presented to the Commission, include:

- Global GHG emissions have grown 70% between 1970 and 2004.
- Carbon dioxide (CO_2) accounted for 77% of total worldwide emissions in 2004.

- Atmospheric concentrations of CO_2 and methane (CH_4), both long-lived greenhouse gases, in 2005 far exceeded the natural range over the last 650,000 years.
- The net effect of human activities since 1750 has been of global warming.
- Most of the observed increase in globally averaged temperature since the mid-20th century is very likely due to increase in anthropogenic GHG concentrations.
- Continued GHG emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century.
- All of the U.S. is very likely to warm during this century, and most areas of the U.S. are expected to warm by more than the global average, exceeding 3.6^{o} F by the end of the century.
- An increase in the amount of precipitation is very likely in high latitudes, while decreases are likely in most subtropical regions. Increases are not evenly distributed throughout the year; rather, major rain events followed by extended droughts are expected.

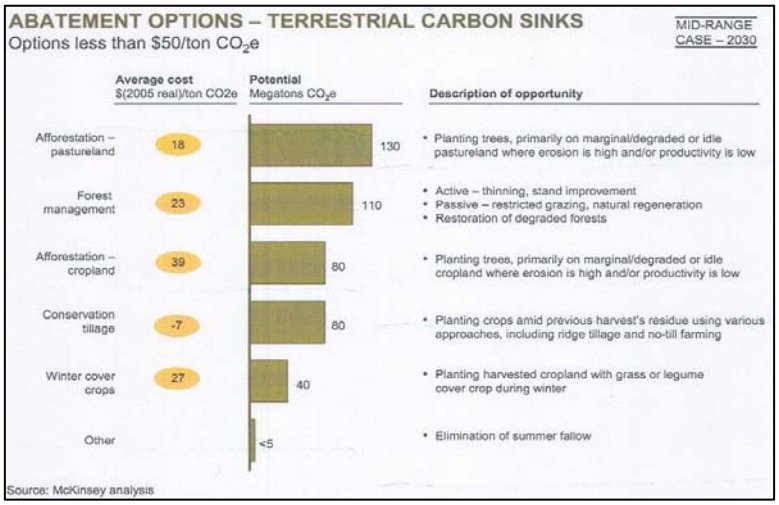
B. The Role of Nature in Storing Carbon

Nature's role in capturing and storing carbon emissions was explained by Mr. Bill Stanley of The Nature Conservancy. Global carbon currently held in vegetation is 610 billion metric tons (BMT); soils hold 1,580 BMT; and the ocean holds 39,000 BMT.

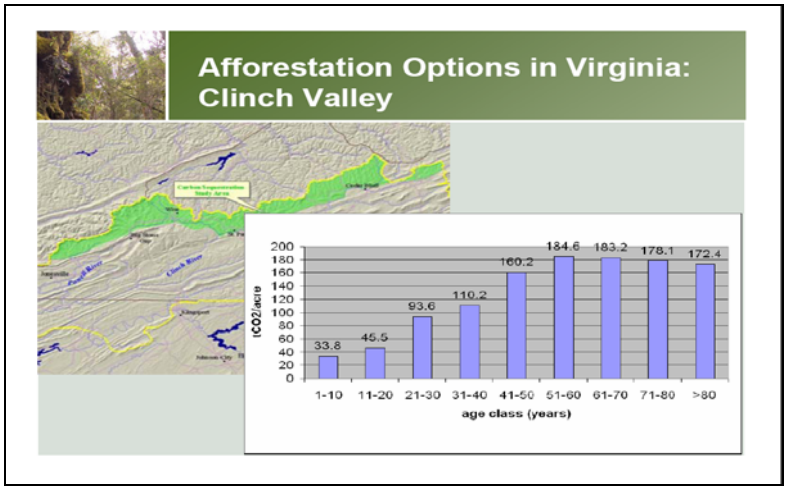


A significant correlation exists between the amount of carbon stored in Earth's different regions and deforestation rates in those regions, which demonstrates that deforestation is negatively impacting carbon retention.

As a way of demonstrating the importance of natural carbon storage, Mr. Stanley presented a list of 12 key climate change mitigation options. These are: stop global deforestation and double reforestations, double vehicle fuel economy, double coal power efficiency, increase wind power by 50 times, increase global ethanol production by 50 times, increase solar power by 700 times, cut vehicle use in half, capture carbon from 3/4 of current coal plant capacity, cut emissions from buildings and appliances by a quarter, double current nuclear capacity, replace current coal power with natural gas, and adopt conservation tillage for all agriculture. Accomplishing any seven of these twelve options by 2050 would stabilize global GHG concentrations. (GHG emissions are often measured in the aggregate as CO_2 equivalent, or CO_2e). Those options that are focused on increasing the capacity of terrestrial carbon sinks are among the most cost effective ways to abate climate change.



The Nature Conservancy has identified options for afforestation – planting trees on marginal crop and pastureland – in Virginia. Two potential sites for such activity are the Clinch River and Chesapeake River, with tons of CO_2 / acre ranging from 33.8 tons/acre to a high of 184.6 tons/acre. As a pilot project, The Nature Conservancy and the Virginia Department of Forestry have identified afforestation candidate lands in the York, Rappahannock, and lower Potomac watersheds.



C. Greenhouse Gas Inventory for Virginia

In order to assist the Commission in its responsibility of providing an inventory of the amount of and contributors to Virginia's GHG emissions, the Department of Environmental Quality has developed an inventory report for the Commonwealth based on energy consumption and other activities within the state and projected emissions in the future through 2025. This report, presented over the course of several meetings by Mr. Tom Ballou, will allow the public to assess the Commonwealth's impact on climate change and the effectiveness for potential mitigation measures. The emissions inventory covers the standard GHG pollutants:

- Carbon Dioxide (CO_2): Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement). Carbon dioxide also is removed from the atmosphere (or "sequestered") when it is absorbed by plants, as part of the biological carbon cycle, or the ocean.
- Methane (CH_4): Methane is emitted during the production and transport of coal, natural gas, and oil and combustion of fossil fuels. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills. Methane is a 20 times more potent heat-trapping gas than CO_2.
- Nitrous Oxide (N_2O): Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.
- Fluorinated Gases: Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for ozone-depleting substances (i.e., CFCs, HCFCs, and halons). These gases are typically emitted in smaller quantities, but because they are potent greenhouse gases, they are sometimes referred to as High Global Warming Potential gases ("High GWP gases").

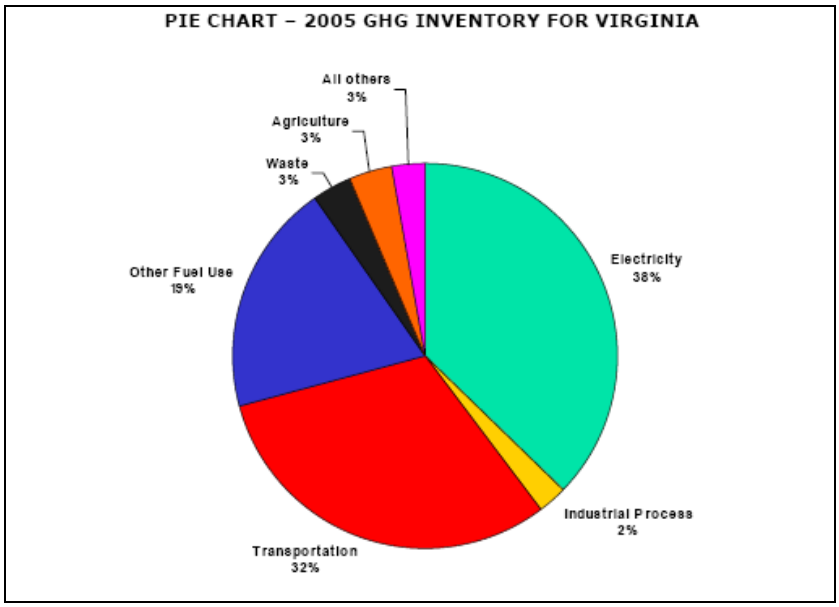
The GHG inventory has been developed using methodologies and models provided by the EPA and includes estimates for each year during the period from 2000 to 2025. For 2005 and earlier, emissions are estimated based on available published data. For subsequent years, emissions are projected using historical trends and other available growth information such as expected electricity demand and population growth and known in-state energy development projects.

Emissions from highway vehicles were developed using the EPA Mobile Source Emission Factor Model (MOBILE 6.2.03) based on likely vehicle traffic activity provided by the Virginia Department of Transportation (VDOT). Emissions from non-highway transportation uses were estimated based on fuels consumption. The report includes emissions generated within the state as well as those generated outside the state due to imported electricity consumed within the state.

The inventory identifies several source sectors that contribute to statewide GHG emissions. For example, the 2005 GHG inventory estimates a total of 175 million metric tons of carbon dioxide equivalent (MMte) emissions from the following sources:

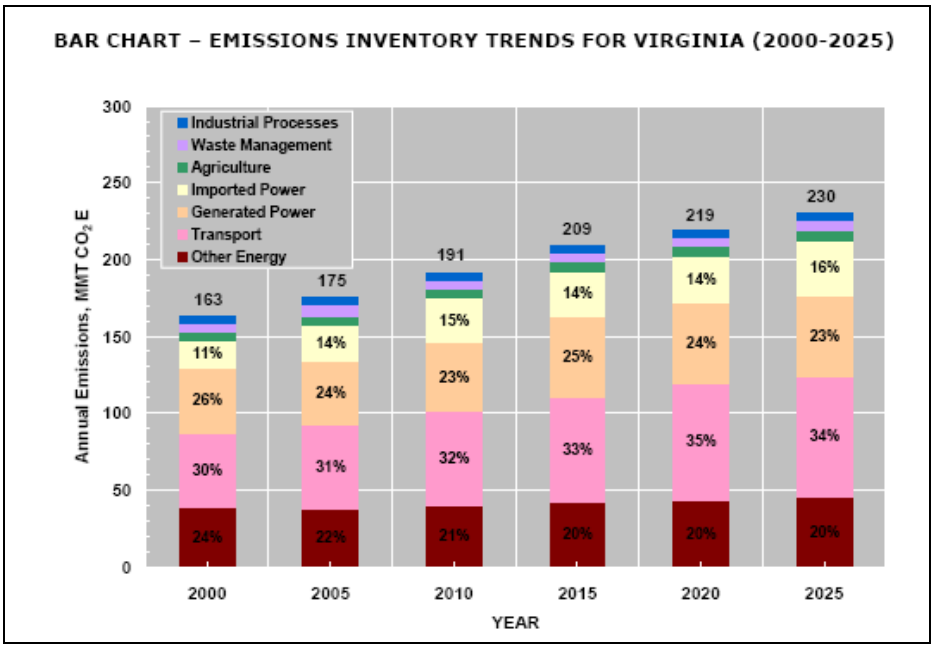
- Electricity: Mainly CO_2 emissions from the combustion of fossil fuels to generate electricity. This sector also includes electricity consumed in Virginia that is generated from outside sources.
- Transportation: Mainly CO_2 emissions from the combustion of fossil fuels such as gasoline and diesel by motor vehicles. This sector also includes emissions from other mobile sources such as aircraft, construction equipment, and ships.
- Other Fuel Use: Mainly CO_2 emissions from the combustion of fossil fuel at non-utility stationary sources (industrial, commercial, and residential).
- Waste Management: Mainly methane emissions from landfills and water treatment facilities.
- Agriculture: Methane and nitrous oxide emissions from various farming activities.
- Industrial processes: Process (non-fuel combustion) emissions of CO_2, nitrous oxide, and fluorinated gases at industrial facilities.

These six sectors were responsible for 97% of all GHG emissions attributable to Virginia in 2005.



A preliminary estimate of carbon removal resulting from natural sequestration also has been developed but has not yet been factored into the overall inventory estimate due to the current uncertainty and confidence in the estimate. This estimate will be evaluated further so that it can be included in the final inventory through a net emissions inventory calculation.

Looking to the future, projection inventories that reflect a "business as usual" (BAU) scenario have been developed for each year out to 2025. Based on the growth projections for key indicators such as population, electricity demand, and vehicle travel, it is expected that Virginia's GHG emissions will grow by 31% to 230 MMte in 2025. This growth assumption includes an estimate of 3,641 megawatts of new instate generation capacity from new generation projects. It also includes a significant increase in the need for imported electricity.



As a result of these future BAU estimates, the goal of a 30% reduction by 2025 equates to a mass emission reduction target of 69 MMte. A 69 MMTe reduction would bring GHG emissions levels back to 161 MMte, which is close to 2000 levels.

IV. Impacts of Climate Change on Virginia

A. Impacts on Natural Systems and Public Health

The Commission received several presentations on the impact of climate change on Virginia's natural systems. These presentations enabled the Commission learn about effects on terrestrial ecosystems, fisheries, and wildlife; the Chesapeake Bay; and other coastal and marine resources. The impact of climate change on public health also was of keen interest to the Commission.

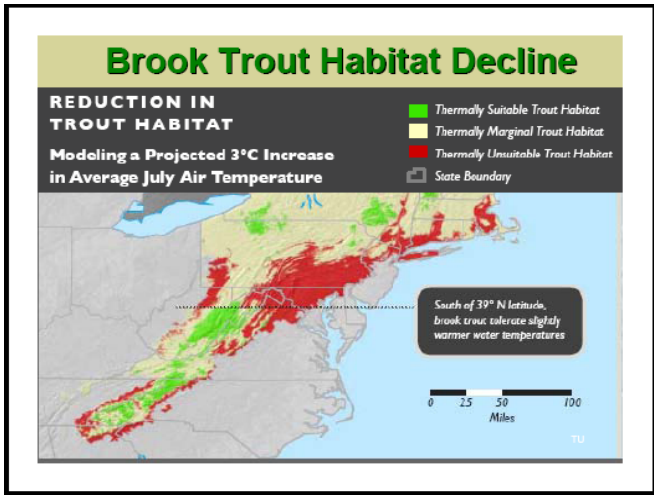
Information regarding the effects a warming climate will have on Virginia's terrestrial ecosystems and the role of Virginia's terrestrial ecosystems in context of the global carbon cycle was presented by H. H. Shugart, Ph.D., of the University of Virginia's Department of Environmental Sciences. According to Dr. Shugart, the Commonwealth is facing a climate change that is equivalent in magnitude to the end of the last ice age. Some ecosystems are more vulnerable than others, but no ecosystems are immune.

According to Dr. Shugart, current climate models predict that Virginia's average temperatures are expected to rise by 3º C and precipitation is likely to increase between 0% and 10%. This will impact both agricultural lands and native ecosystems. It is most likely that agricultural production (such as corn) will decline as the climate warms, but specific predictions are unreliable due to the confounding effects of economic systems that can influence the success or failure of crop production and distribution. Several vegetation models, which evaluate forest responses to climate change, predict that plant species are likely to move from current locations to higher altitudes and higher latitudes. As such, according to Dr. Shugart, Virginians should expect "significant changes to Virginia's forests and other ecosystems," and these changes will result in equally significant changes in the forestry sector of Virginia's economy. Some ecosystems that already occur at high elevations or which occupy narrow geographic ranges may be extirpated completely. When driven by a continuously warming climate, forests are expected to have "a delayed then abrupt" response where many trees die quickly. Once forests have died, it will be difficult, if not impossible, to replace them.

Doug Inkley, Ph.D., Senior Scientist with the National Wildlife Federation, spoke about the impacts the warming climate is having on fisheries and wildlife resources in the United States and Virginia.

The U.S. Fish and Wildlife Service maintains 127 National Wildlife Refuges in the Southeastern United States which provide habitat to hundreds of game and nongame species. Climate models indicate that, as the climate warms, as many as 78% of these areas will cease to provide the types and amounts of habitats they were created to provide.

Dr. Inkley also drew attention to Virginia's viable and valuable brook trout fisheries. However, these fish are vulnerable to rising water temperatures. The brook trout's body functions are impaired when water temperature exceeds 70º F, and water temperatures above 75º F are lethal. Climate models indicate that 40% to 100% of Virginia's brook trout habitat could be lost by 2090. As the climate warms, any remaining populations will be restricted to isolated high elevation streams. These isolated populations will need to be intensively managed if this popular game fish is to persist in Virginia.

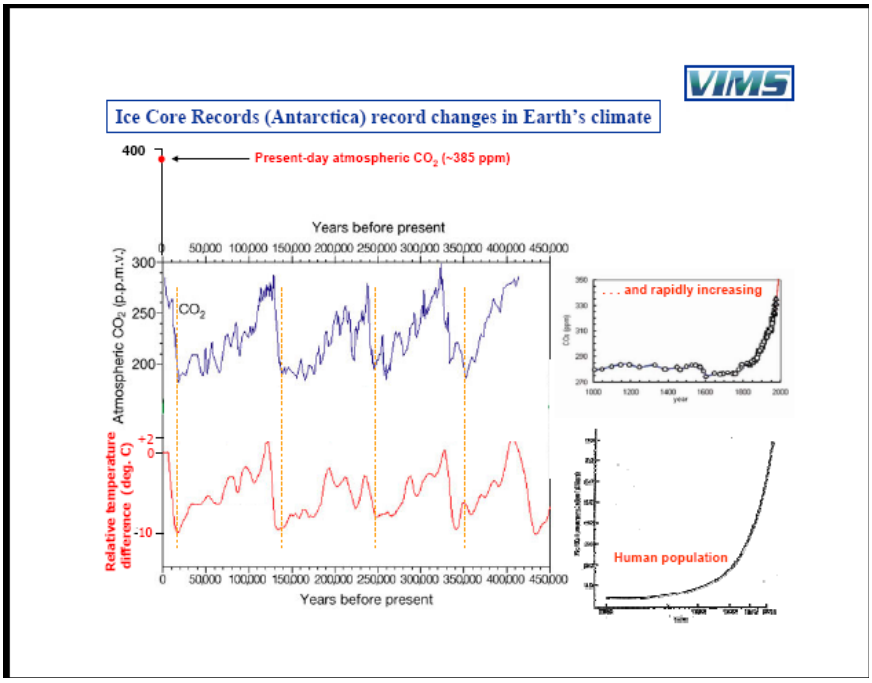


Climate change also has reduced the number and variety of waterfowl that spend winters on the Chesapeake Bay. Rising sea levels, according to Dr. Inkley, will reduce the size and quality of winter habitats currently provided by the Chesapeake Bay. Reductions in hunting opportunity could have significant social and economic ramifications for local communities.

Dr. Inkley believes that for Virginia's wildlife resources to be conserved for future generations, Virginians must reduce the pollutants that cause global warming; manage resources to maintain healthy, connected, and genetically diverse wildlife populations; reduce non-climate stressors such as pollution and invasive species, which either kill wildlife or degrade wildlife habitats; and protect and restore native habitats. The National Wildlife Federation is concerned that none of these conservation efforts may be achievable unless new sources of conservation funding are created.

Impacts to the Chesapeake Bay region were addressed by James E. Bauer, Ph.D., Professor of Marine Science at the Virginia Institute of Marine Science. Coastal Virginia is one of the most susceptible regions to climate change partly because it experiences some of the highest rates of relative sea level rise of any other region in the country. Virginia also could suffer more impacts of climate change than other states because of its latitude. Virginia currently represents the northern extent for many southern species and the southern extent of many northern species. As the climate changes, Virginia's coastal ecosystem may be much different than what we see today.

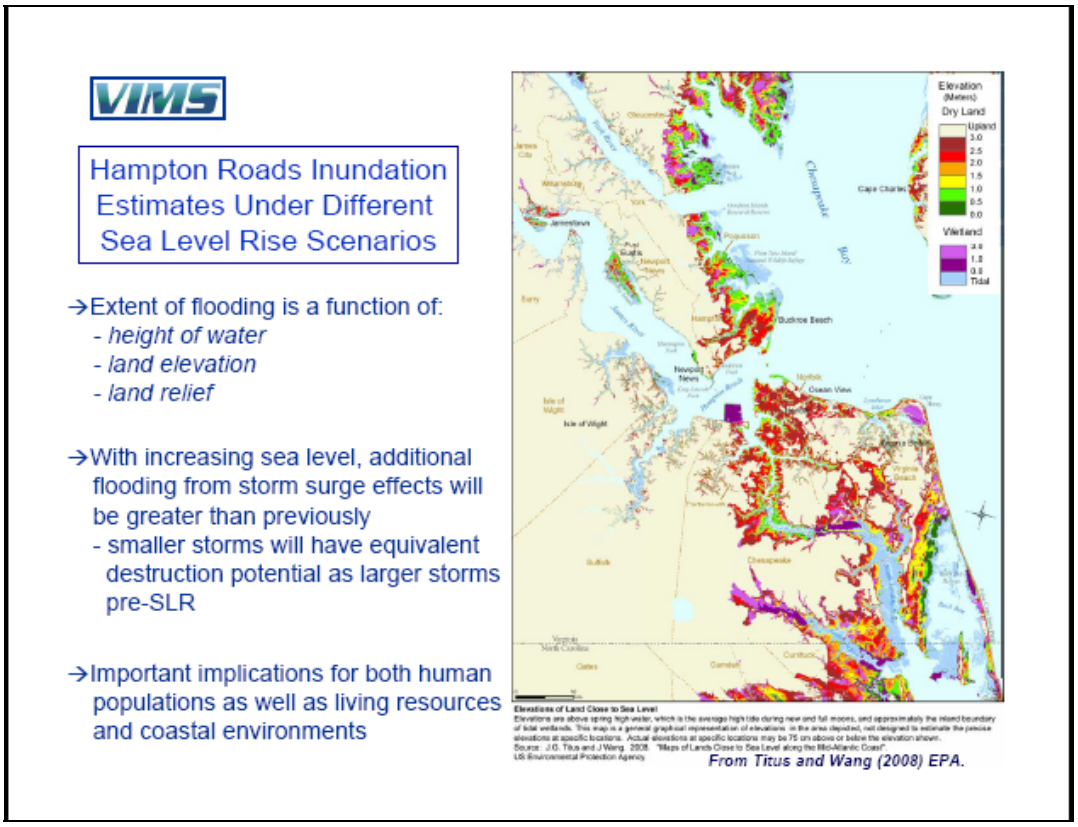
The Earth has seen several climate shifts, along with concomitant shifts in sea level and coastlines throughout time. What is drastically different now is the rate of change. According to ice core records taken in Antarctica, CO_2 levels, temperature, and worldwide populations are strongly correlated.



These records indicate that the highest historical levels of CO_2 on Earth were no greater than 300 parts per million (ppm). Today, atmospheric levels of CO_2 are ~385 ppm and steadily rising due to human activities. Air and water temperatures are showing increases above long-term averages as well. On average, water temperatures have been increasing ~0.3° C (or 0.6° F) per decade.

Dr. Bauer stated that in Virginia's coastal zone, climate change is likely to have significant impacts on people, infrastructure, and ecosystems. These changes include higher sea levels, increased salinities, increased shoreline erosion and inundation (flooding), and increased nutrient inputs from land into the Chesapeake Bay. Currently, sea level is rising at approximately 3.5 mm/year Bay-wide, with local variation from 2.7 to 4.5 mm/year. Precipitation monitoring programs show a slight increase in the amounts of rainfall in Virginia over the last decade. It is difficult to predict future precipitation patterns for the state, but most models show between a 1% to10% increase in rainfall. Increasing precipitation can carry more terrestrial material (sediment, nutrients, toxics, etc.) into the Chesapeake Bay and coastal areas, causing increasing issues for the Chesapeake Bay restoration process.

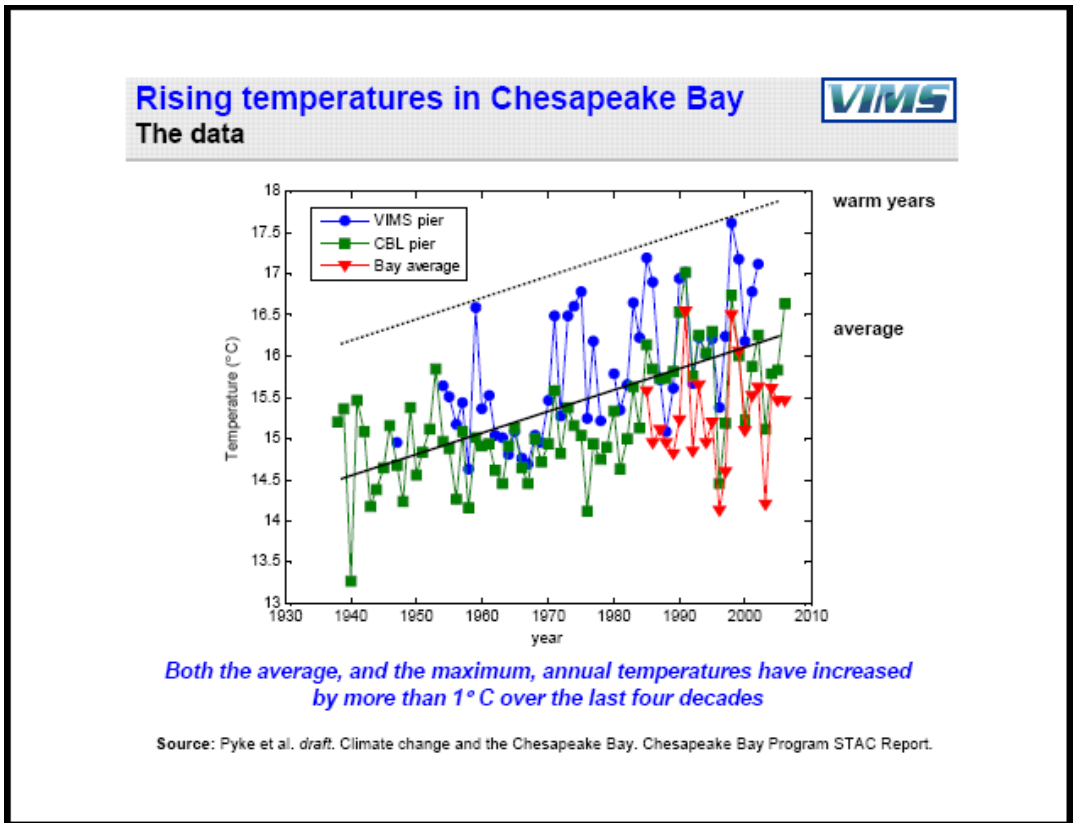
Coastal flooding is a function of water height, adjacent land elevation, and land relief. With rising sea levels, additional flooding from storm surge effects will be greater than have been previously seen, such that smaller storms may have equivalent damage potential as did larger storms prior to increases in sea level. This will affect human populations and living resources along the coastline.



Further, according to Dr. Bauer, oxygen levels in the Chesapeake Bay are expected to decrease due to increasing temperatures (warmer water holds less dissolved oxygen), and increasing stratification due to increased nutrient inputs and temperature increases. This will have negative impacts on Bay species like striped bass, blue crabs, and oysters that require certain levels of dissolved oxygen for survival. Another impact of concern for the Chesapeake Bay is ocean (and Bay) acidification. As atmospheric CO_2 levels increase, the oceans absorb more CO_2, increasing ocean acidity. In the pre-Industrial era, the oceans had an average pH level around 8.2. Currently ocean pH levels are less than 8.1. Acidification causes problems with shell formation and physiology of many oceanic organisms, like some phytoplankton, shellfish, and corals. Because phytoplankton is a keystone of the Chesapeake Bay food-web, acidification of Chesapeake Bay waters could have severe ramifications for other Bay species.

Further information on impacts to the Chesapeake Bay and its living resources was provided by J. Emmett Duffy, Ph.D., of the Virginia Institute of Marine Science. The Bay's ecosystem and its living resources are already being impacted by increasing water temperatures, sea level rise, and salinity changes. Many "foundation species," such as underwater grass beds, zooplankton, and oyster reefs, could decline or disappear altogether as salinity and temperatures continue to increase. Foundation species support many other species, so these impacts would be felt throughout the ecosystem.

The average and the maximum annual temperatures of the Chesapeake Bay, according to Dr. Duffy, have increased by more than 1° C over the last four decades.



The life cycles of animals and plants are closely tied to temperature cues. For example, many Chesapeake Bay fish are triggered to spawn when water temperatures reach about 15º C in the spring. Since 1960, springtime has advanced by three weeks, causing fish to spawn much earlier in the year. Similar shifts also have been documented in many other types of plants and animals, causing changes to typical predator/prey relationships. One such shift has been observed in jellyfish within the Bay. Jellyfish have been blooming earlier in the year, consuming zooplankton and potentially depriving later arrivals of juvenile fish of this food source.

According to a National Wildlife Federation report, 50 percent of the nation's annual blue crab harvest comes from the Chesapeake Bay. Warmer winters may extend their growing season and lead to population increases; however, eelgrass, an underwater grass that provides essential refuge habitat for young blue crabs, already has seen marked decreases following slight temperature increases. In 2005, Virginia waters lost about 15,000 acres of eelgrass following a heat wave that increased average water temperatures 2.5-3.0º F, and much of this acreage has yet to return. Because eelgrass, which also is suffering the effects of nutrient pollution, is at its southern extent in the Bay, warming waters may mean that this species could no longer thrive here. Underwater grassbeds are essential habitat and food sources for many fish, shellfish, and waterfowl populations. They also are important because they can offer erosion protection to adjacent shorelines.

Coastal wetlands, a critical habitat for many of the Chesapeake Bay's plants and animals, also are being lost as sea levels rise. Wetlands can migrate upland, assuming there are no impediments and the rate of sea level rise is slow enough. When the rate of sea level rise outpaces the rate of upland migration, wetlands can drown in place. Sea level rise, subsidence, erosion, saltwater intrusion, and grazing by nutria have all led to the loss of approximately 8,000 acres of tidal marsh within Blackwater Wildlife Refuge on Maryland's Eastern Shore since the late 1930s.

The native oyster, another foundation species, could be threatened by climate change. The oyster diseases, MSX and Dermo, thrive in high water temperatures and high salinities. As water temperatures and salinities continue to increase, oysters likely will experience more frequent and intense disease outbreaks. Given the combined pressures of harvest, disease, and already low abundances, the native oyster may cross a "tipping point" from which populations could not recover.

Human health impacts of climate change were addressed by Kristie L. Ebi, Ph.D., M.P.H. The impacts of climate change on human health may be direct or indirect and include increases in heat-related illnesses; injuries, or deaths from extreme weather events; cases and outbreaks of infectious diseases, specifically vector-borne diseases spread by mosquitoes or ticks and rodent-borne diseases; cases of skin cancer; cardio-respiratory diseases and deaths from changes in air quality; cases and outbreaks of waterborne and food-borne diseases; health effects from food and water shortages; and mental, nutritional, and other health effects.

Health impacts, according to Dr. Ebi, depend on and may be mitigated by a number of factors including geography, such as baseline climate; an abundance of natural resources, such as

soil and fresh water supplies; biology, such as age, genetics, immunity, or pre-existing medical conditions; and socioeconomic factors that affect an individual's ability to respond or adapt.

The Intergovernmental Panel on Climate Change has noted that health impacts are occurring now and will continue to occur for decades, even after control and reduction of greenhouse gases. The extent of health impacts over the next few decades will depend on the design and effectiveness of adaptation measures implemented now.

Dr. Ebi believes there is a need to identify and assess health risks associated with climate change, especially vulnerable populations and regions. Assessment should include an understanding of the vulnerability of a population as well as its capacity to respond to new and changing conditions. Those at greatest risk include the urban poor, the elderly, children, traditional societies, and coastal populations. Raising awareness and strengthening health systems to adapt and respond to impacts of climate change will reduce the health risks faced by the Commonwealth and the world.

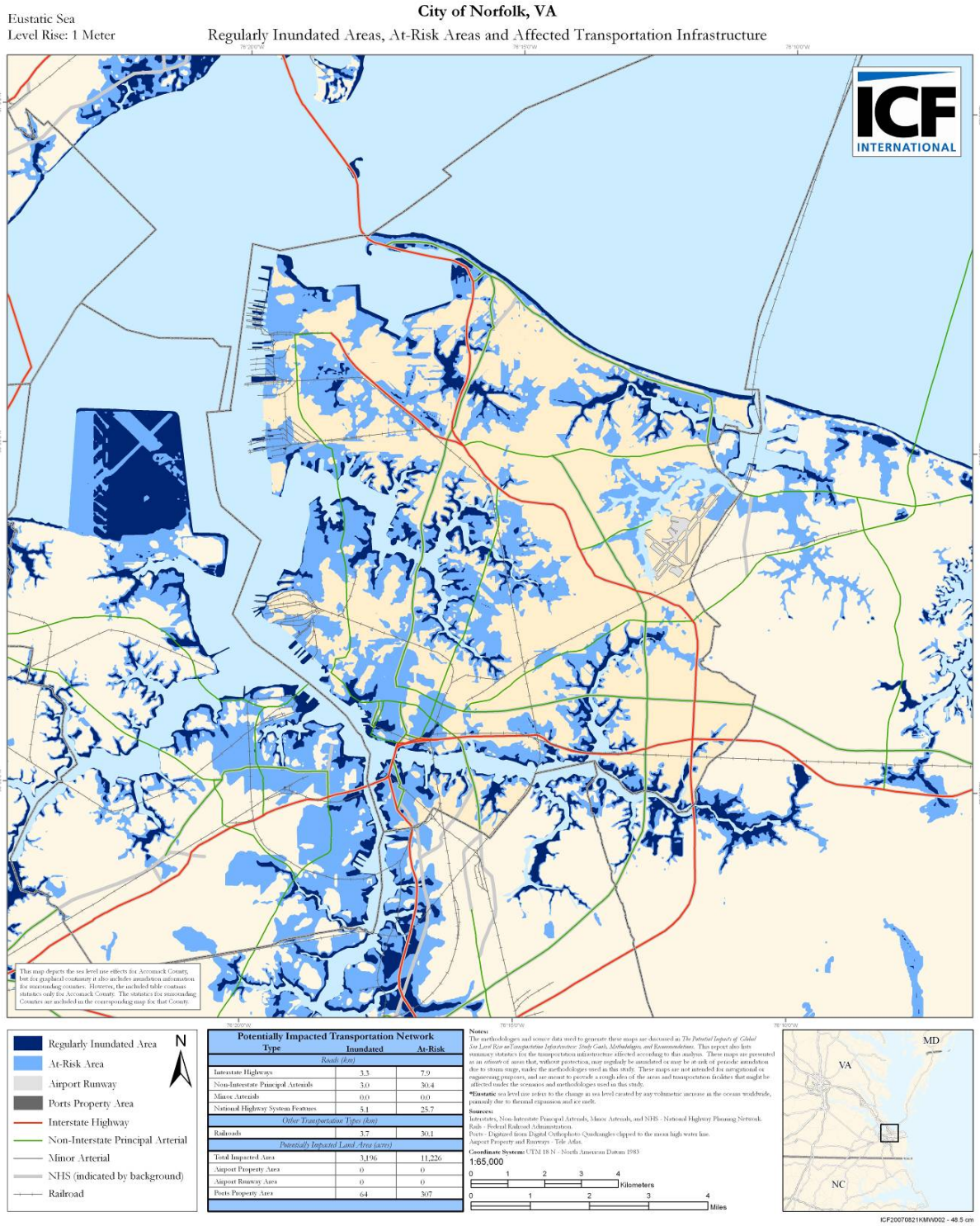
Effective public health adaptation to climate change includes disease surveillance and monitoring, vector control programs, and public education and outreach to reduce and prevent adverse health outcomes; and early warning systems, coupled with effective response capabilities (e.g., medical training and awareness), to reduce current and future vulnerability.

B. Impacts on the Built Environment and Insurance

Not only will climate change have effects on Virginia's natural assets, but also buildings and infrastructure will be affected by rising sea levels, severe storms, and other consequences of climate change. The Commission received presentations that addressed projected impacts to transportation infrastructure, military installations, and coastal communities. All of these changes will affect the ability of the insurance industry to help its customers manage risk in an affordable way, so the Commission also heard a presentation on the impact of climate change on insurance.

Recently, ICF International prepared a study for the U.S. Department of Transportation on the potential impacts of global sea level rise on transportation infrastructure. The study, which was presented to the Commission by Mr. Chris Munson, provides estimates of how future climate change, specifically sea level rise and storm surge, could affect transportation infrastructure on the East Coast of the United States. This study explored how the predictions of future global sea level elevations from the United Nations Intergovernmental Panel on Climate Change (IPCC) may affect the coastal transportation infrastructure.

According to Mr. Munson, it is important, for the stability of commerce and the safety of the population, to have a broad picture of the land and infrastructure that may be affected by the change in coastline and resulting periodic flooding. An estimate of the impact must be quantified in order to create a plan to address the potential impacts of sea level rise. The study's major purpose is to aid policy makers by providing estimates of these effects as they relate to roads, rails, airports, and ports. The resulting maps and statistics demonstrate the location and quantity of infrastructure that could be affected under the sea level rise scenarios.



Another recent study has been completed by the Transportation Research Board (TRB) of the National Academy of Sciences. Released in March of this year, the report was entitled *Potential Impacts of Climate Change on U.S. Transportation* and was described to the

Commission by Ms. Nan Humphrey, Senior Staff Officer of the TRB. The primary focus of the report was on the consequences of climate change for transportation infrastructure and operations. The report identified potential impacts on U.S. transportation and adaptation options and offered recommendations for both research and actions that could be taken to prepare for climate change.

The study's main findings included:

- Climate change will affect transportation primarily through increases in weather and climate extremes. The impacts will vary by mode of transportation and region of the country, but they will be widespread and costly in both human and economic terms and will require significant changes in the planning, design, construction, operation, and maintenance of transportation systems.
- We currently are feeling the results of greenhouse gases that were emitted into the atmosphere over the last 100 years.
- Potentially, the greatest impact will be flooding of coastal roads, railways, transit systems, and runways because of global rising sea levels coupled with storm surges and exacerbated in some locations by land subsidence.
- The Atlantic and Gulf Coasts are particularly vulnerable and seven of the 10 largest ports as well as significant oil and gas production facilities are exposed to disruption and damage.
- The significant costs of redesigning and retrofitting infrastructure to adapt to impacts suggest the need for more strategic risk-based approaches to investment.
- Increases in extreme weather underscore the importance of emergency response plans and the need for better communication.
- In the short term, infrastructure rehabilitation projects in highly vulnerable locations should be rebuilt to higher standards, and greater attention should be paid to the provision of redundant power and communications systems to ensure rapid restoration of transportation services in the event of failure.
- Governments, owners, and operators of transportation infrastructure should incorporate climate change into their long-term capital improvement plans, design, maintenance practice, operations, and emergency response plans.

At its April meeting, the Commission was shown simulations of extensive flooding in the coastal areas, particularly in Norfolk and Hampton, due to sea level rise and storm surges. Such simulation tools provide a dramatic visual picture of the effects of sea level rise and storm-based water flows on land, buildings, and infrastructure.

Expanding the capacity and availability of modeling and simulation tools would provide Virginians with multiple benefits as the Commonwealth looks to manage the impacts of climate change. Sea level increase models are being developed by teams, such as an effort in Virginia by the Virginia Institute of Marine Science, Old Dominion University, and the National Oceanographic and Atmospheric Administration. Additional modeling for emergency

management is being completed by Noblis, a non-profit science, technology, and strategy organization whose clients include both government agencies and private-sector companies. These tools include two-dimensional views. Lockheed Martin is developing three-dimensional modeling using LIDAR (Light Detection and Ranging) data of coastal areas.

The accuracy of these tools can be improved with better land elevation data available from LIDAR and additional research on water flows in Virginia coastal areas during storm events. LIDAR data is available today for only a small part of Virginia.

These tools can help emergency managers predict flooding and plan for actions needed during storms. The tools also can assist with long-term planning of infrastructure improvements. Long-term investments will need to be designed to manage the impacts of long-term sea level rise so that the investments will not be lost. This ranges from coastal infrastructure such as highways, transit, buildings and utilities, to natural areas such as constructed wetlands.

Sea level rise attributable to climate change is caused by two effects, expanding water volume as water temperatures increase and ice melt. Historic records of sea level change show a steady increase of global average sea level of approximately 75 millimeters from the late 19th century through today.

Virginia is at particular risk from sea level rise. The Commonwealth has a much longer coastline than most states with Atlantic, Chesapeake Bay, and tidal river coastal areas. The Hampton Roads region is considered to be the second most populated region at risk from sea level and related storm damage after the New Orleans region. Other populated areas such as Alexandria have seen flooding damage from water inundation and are at greater risk due to sea level rise. Rising sea levels also will affect the availability of fresh water resources in the coastal areas. As the sea level rises, salt water will intrude further into both surface and groundwater sources.

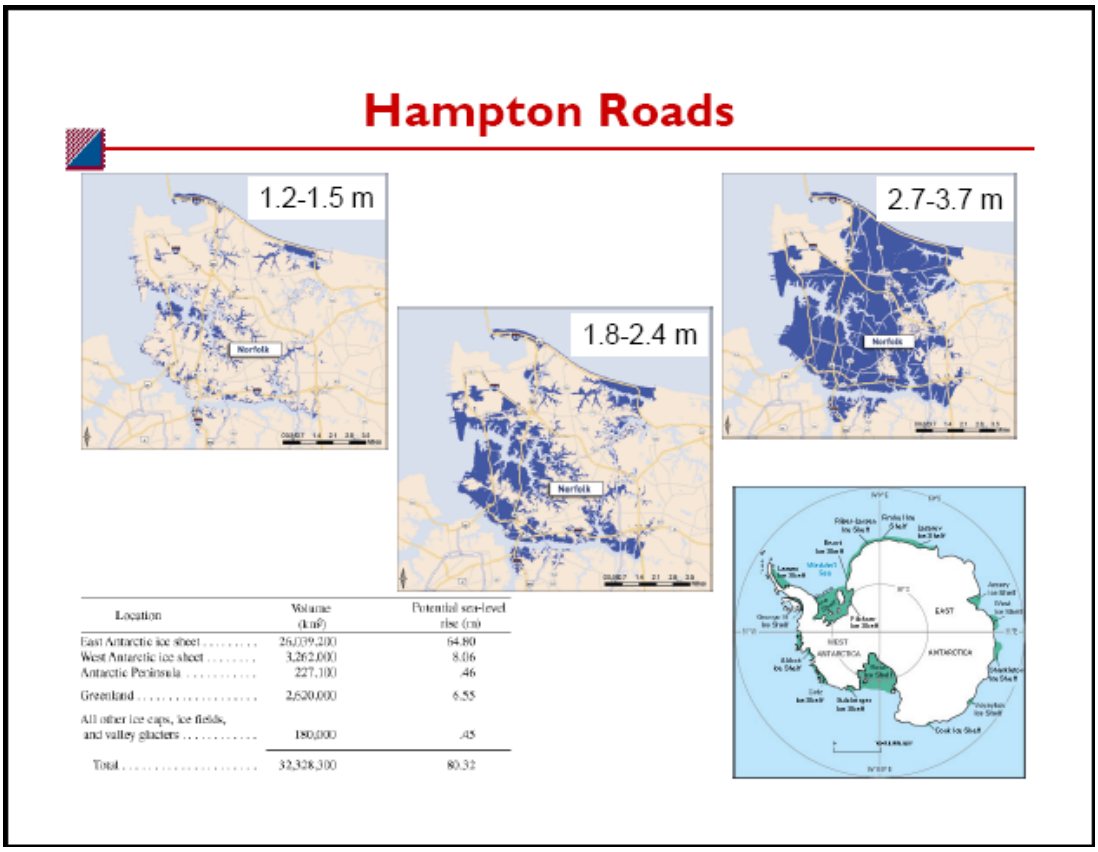
In 2007, CNA Corporation convened a panel of senior military leaders to examine the national security consequences of climate change. The results of that study are reported in *National Security and the Threat of Climate Change*, which was presented to the Commission by Mr. Edward T. (Tom) Morehouse, Jr.

The CNA study concluded that climate change poses a serious threat to national security. The predicted impacts of climate change in coming years include extreme weather events, drought, flooding, sea level rise, retreating glaciers, shifting habitats, and the increased spread of disease. The impacts of climate change provide additional and exacerbating mechanisms for instability and conflict around the world. Projected climate change may threaten already marginal living conditions in some areas causing widespread political instability. Cross-border conflicts may arise as resources, such as clean water, become scarce. The world may experience mass population migrations due to resource shortfalls and land loss (from sea level rise). Additionally, the impacts of climate change have the potential to create sustained natural and humanitarian disasters on a scale far beyond those experienced today. All of these impacts may lead to a number of U.S. agencies, including military forces, having to take on a greater number of more diverse missions around the world.

The impacts of climate change will act as a threat multiplier for instability in some of the most volatile regions of the world. In Africa, climate change will facilitate weakened governance, economic collapse, human migrations, and potential conflicts, which may lead to increased stability operations and human missions for the United States. In the Middle East, water security will be threatened. Two-thirds of the Arab world already depends on water sources external to their borders. Loss of food and water security will increase pressure to emigrate across borders.

Projected climate change will add to tensions even in stable regions of the world. In Europe, tensions may rise as climate change increases immigration from Africa and the Middle East. In Asia, almost 40 percent of Asia's four billion people live within 45 miles of the coast. Reduced agricultural productivity, threats to water supply, and increased spread of infectious disease will stress the region. In the Western Hemisphere, coastal areas already vulnerable to sea level rise also will face more intense hurricanes. The loss of glaciers will strain water supplies in the Andean regions of South America, and migration to the United States may increase.

Virginia is home to the world's largest naval station in Norfolk. Thus, the impacts of climate change and its threat to national security will be realized in the Commonwealth as sea level rise affects military installations in and around Hampton Roads and increasing security issues stretch our military resources.



Location	Volume (km³)	Potential sea-level rise (m)
East Antarctic ice sheet	26,039,200	64.80
West Antarctic ice sheet	3,262,000	8.06
Antarctic Peninsula	227,100	.46
Greenland	2,620,000	6.55
All other ice caps, ice fields, and valley glaciers	180,000	.45
Total	32,328,300	80.32

Climate change impacts on insurance were discussed by Ms. Elizabeth Costle, former Vermont Commissioner of Banking, Insurance, Securities and Health Care Administration. Ms. Costle explained that insurance is a key part of the nation's economy because it keeps risk within reasonable limits so businesses can invest and grow and individuals can recover their losses. Insurers are investors in government, private bonds, business financing, and home mortgages. A survey by Ernst & Young of global leaders on strategic business risk identified climate change as the top insurance risk in 2008. Climate change is a concern to insurers (and the insured) because the predicted increase in the number of severe weather events is likely to result in more claims and because these events are likely to increase catastrophic losses. Because insurers fear that the past may no longer predict the future, the cost of insurance is likely to include a premium for uncertainty.

The potential impacts of climate change on the insurance industry have been illustrated by recent severe weather events. The hurricanes experienced in the United States in 2005 likely cost private insurers $60-70 billion. Multiple storms in 2004 cost $22.5 billion. In addition to increasing the number and intensity of hurricanes and severe storms, climate change is expected to increase the number of floods and droughts. Insurers and reinsurers fear occurrence of these multiple events in a single year. The expected impacts of climate change to the insurance industry are far-reaching and go well beyond impacts to property-related insurance and premiums. The increasing potential for climate-related litigation will increase claims against, and affect premiums for, liability and Director & Officer insurance. Health and life insurance claims and premiums also will be affected by expected increasing heat waves, pollution, and vector borne diseases.

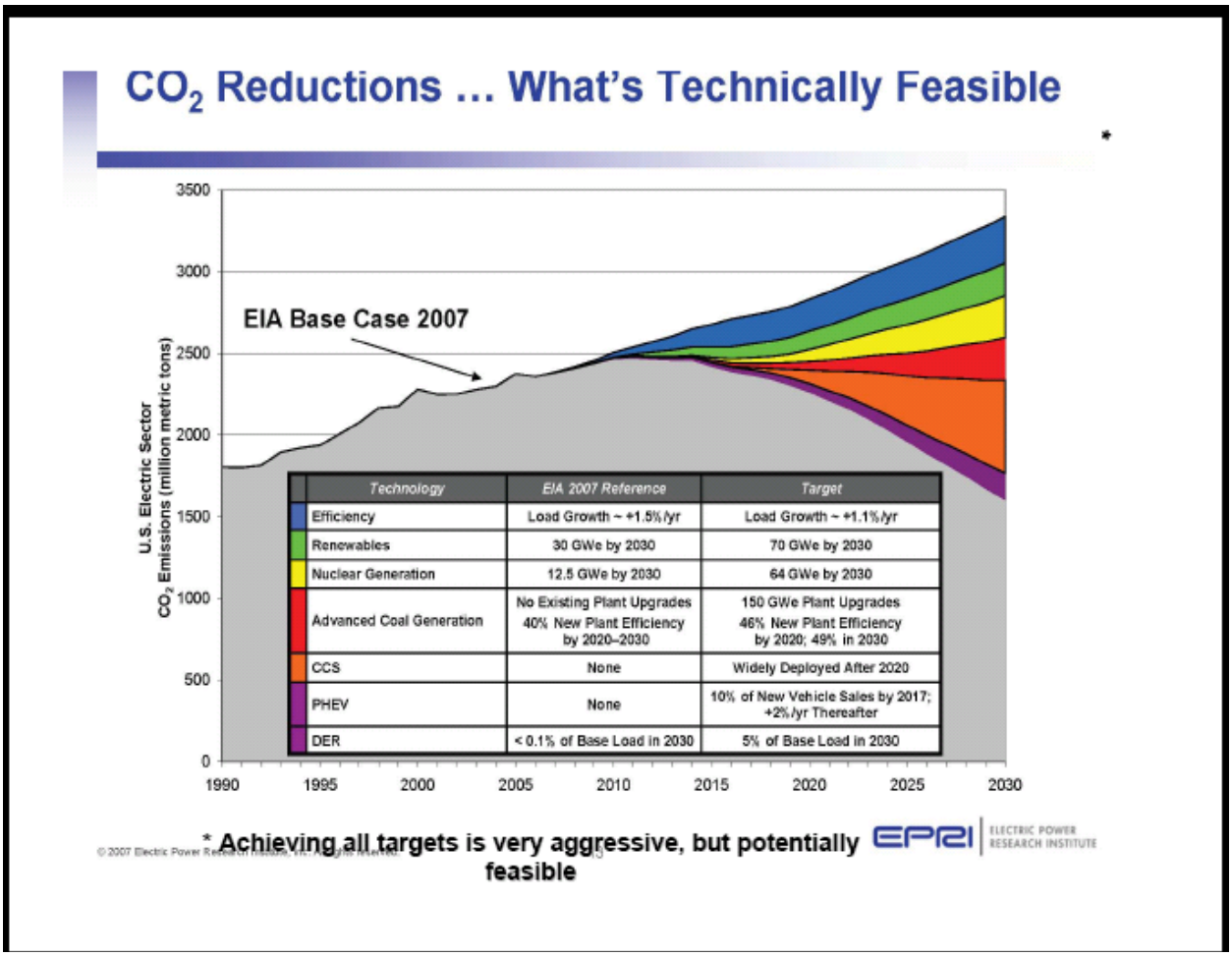
In Virginia, homeowner premiums have increased 67.2 percent between 2001 and 2006, compared to a nationwide increase of 46.3%. Based on an analysis by RMS (a catastrophe modeling company), Virginia Beach is the 10th largest coastal city in the world in terms of assets exposed to increased flooding from sea level rise. Future hurricanes could cause more serious damage and future problems with insurance affordability and availability for Virginians.

The insurance industry also may provide tools to help mitigate climate change as it looks for opportunities to impact public policy to protect the industry, including pricing to encourage the reduction of GHG emissions. For example, insurers are developing pay-as-you-drive insurance, discounts on green buildings, and discounts and financing for policyholder investments to prevent damage (e.g., hurricane shutters).

C. New Technologies and Economic Opportunities

While most of the impacts of climate change of which the Commission has learned are negative, some opportunities are being brought about as a result of efforts to limit GHG emissions. As the world moves toward a carbon-constrained economy, the need to accelerate the advancement of emerging technologies provides opportunities for researchers, inventors, and investors. The Commission heard presentations on opportunities associated with energy efficiency, green investing, solar energy, algal biofuel, biodiesel, geoengineering, and carbon capture and storage.

Ms. Diane Munns, Executive Director, Retail Energy Services for the Edison Electric Institute, provided information about the potential for energy efficiency to reduce electric use and indirectly reduce GHG emissions. A study by Edison Electric Institute and the Electric Power Research Institute analyzed potential United States electric efficiency savings between 2008 and 2030. It found that market driven savings should reduce electric consumption by approximately 5% and implementation of advanced energy codes and standards should reduce electric consumption by as much as 15% below the base case consumption estimates without these efforts. The study also found that the "achievable potential electrical savings" of energy efficiency programs, including efforts such as rebates, tax incentives, and innovative rates, is estimated to be 7% of consumption by 2030. An aggressive program could possibly reduce consumption by 11%. These savings strategies would be part of a larger set of wedges used to reduce greenhouse gas emissions.



There may be additional savings from use of smart electronic devices and hyper-efficient technologies. However, these may be offset if consumers use more or greater energy-consuming appliances. Smart electronic devices include smart thermostats, direct energy-cost feedback devices, and next generation lighting such as LED's. Hyper-efficient technologies might include variable refrigerant flow air conditioning, low-energy use data centers, and hyper-efficient appliances. A good example of how these savings may be offset is to look at changes in the

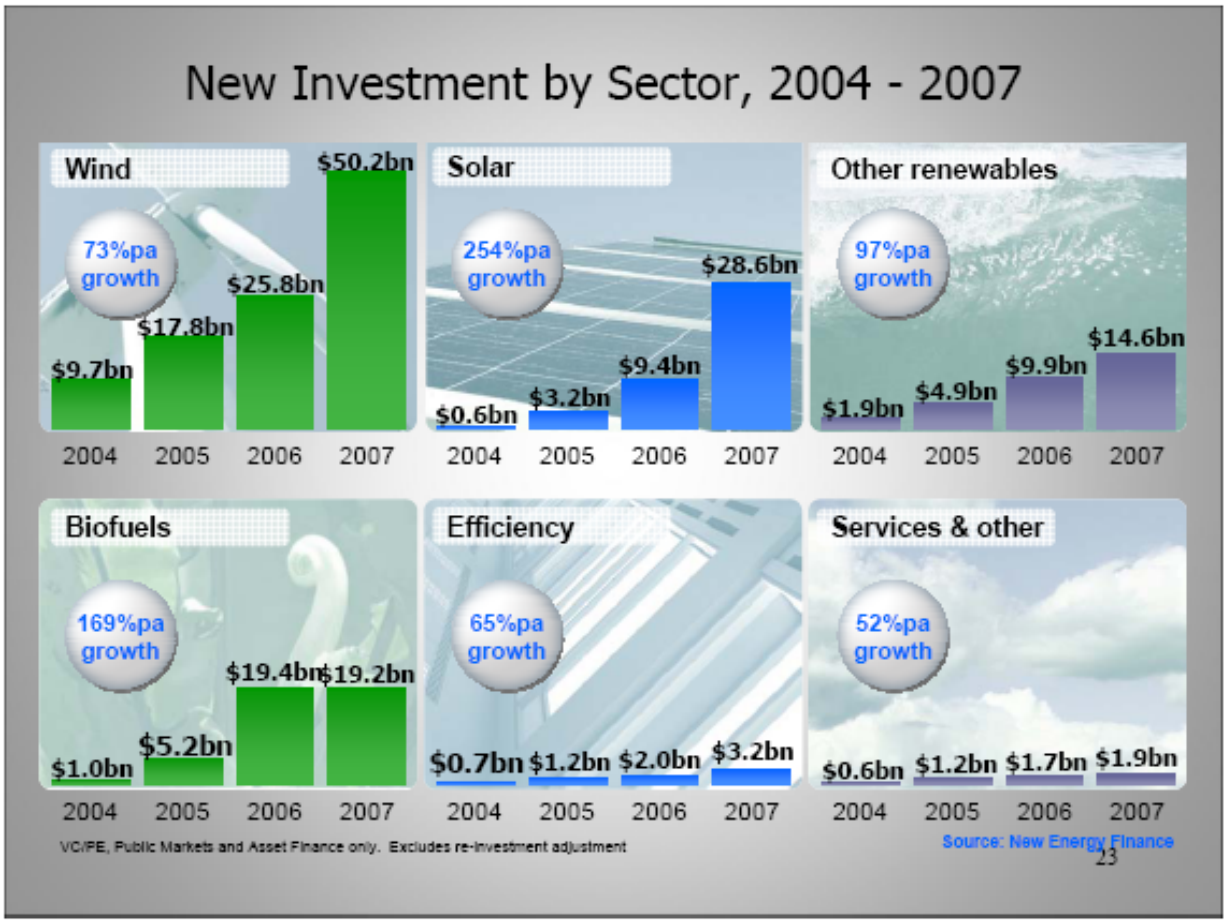
television market. A conventional 27-inch television is typically rated at 100 watts. A 42-inch plasma television is rated at 250 watts, 2 ½ times more. Just two 30 watt set-top digital-to-analog converter boxes at 30 watts each could consume as much energy as an efficient refrigerator.

According to Ms. Munns, electric energy efficiency targets will not be reached unless barriers to investment in energy efficiency are addressed. These barriers can be placed in the following categories: market, consumer, public policy, utility, state and regional planning, and program, product and service. Actions to aid in overcoming these barriers include having states and utilities formally recognize energy efficiency as an energy resource; increasing consumer education; adopting and enforcing aggressive building codes and appliance standards; and promoting utility rates that more accurately reflect costs to provide electricity.

Mr. Roger Ballentine, President, Green Strategies, Inc., discussed a number of investment opportunities that are related to the need to abate climate change. According to Mr. Ballentine, the energy marketplace of the future will be defined by two "mega" trends: (i) unprecedented global demand for oil, particularly from China and India, while the supply remains relatively fixed, and (ii) a sustained political response to climate change and security concerns. Investors view the challenges of responding to these trends as investment opportunities. Investors are more likely to be concerned with growth potential in emerging markets than the science or debates surrounding climate change.

Mr. Ballentine cited a recent McKinsey & Company report in stating that approximately half of the available tools to stabilize GHG emissions are already available and can be profitable. These include methods of improving energy efficiency in buildings, appliances, and vehicles and the use of combined heat and power. Many capital investments are now being directed toward developing renewable energy technologies, such as wind power, solar power, geothermal energy, hydropower, biomass energy, and ethanol. Worldwide, clean energy investments have increased rapidly since around 2000. Europe has been a major leader in these expansions, although the United States is making gains. Within the United States, according to Mr. Ballentine, the key issues for expansion of renewable energy sources include government incentives, transmission access, and further research and development to increase performance and reliability. Biofuels, ethanol in particular, have seen particularly rapid increases in the United States since 2000. Ethanol (E85), offers an opportunity for major increases in fuel efficiency. Hybrid engines typically get approximately 50-100 miles per gallon (mpg), whereas engines using E85 can get between 300-600 mpg.

Total global investments in clean energy between 2004 and 2007 have increased 58-76% annually. The outlook for investment opportunities in renewable energy sectors is good, based on the increasing amount of new investments since 2004.



Venture capital and private equity are moving into the clean energy sector, and public equity funds are growing. Carbon finance also is growing as a result of carbon becoming a commodity of its own. Mr. Ballentine suggested that once there was a price on carbon emissions, market economics would take it from there.

Mr. Travis Bradford of the Prometheus Institute for Sustainable Development and author of *Solar Revolution* provided information on the world photovoltaic (PV) market. Mr. Bradford believes that solar is a powerful driver of world electricity and represents a tremendous business opportunity. PV production reflects a strong annual global growth rate, 50% from 2006 to 2007. Currently, a great deal of PV production is going to Asia (China and Taiwan) and to the U.S. The U.S. growth in PV production is expected to rapidly increase.

US Producers - 2007

Company	2001	2002	2003	2004	2005	2006	2007	06 to 07 Growth	Capacity YE07	Capacity YE08
First Solar	-	-	3.0	6.0	20.0	60.0	120.0	100%	135.0	150.0
United Solar OVONICS	3.8	4.0	7.0	14.0	22.0	28.0	48.0	71%	60.0	120.0
Solarworld CA (Shell Solar)	39.0	46.5	52.0	62.0	42.0	35.0	35.0	0%	45.0	100.0
BP Solar	25.2	31.0	13.4	14.2	22.6	25.6	27.7	8%	40.0	40.0
Evergreen Solar	-	1.9	2.8	6.0	14.0	13.0	16.4	26%	16.0	86.0
Schott Solar	5.0	5.0	4.0	10.0	13.0	13.0	10.0	-23%	15.0	15.0
Global Solar	-	-	2.0	1.0	1.0	2.5	4.0	60%	5.0	40.0
Other	27.3	32.2	18.8	25.5	18.5	2.5	5.0	100%	2.0	65.0
Total	100.3	120.6	103.0	138.7	153.1	179.6	266.1	48%	318.0	616.0
w/o First Solar					*133.1*	*119.6*	*146.1*	*22%*	*183.0*	*466.0*

All figures in MW-dc of Cells

- US production growth almost completely driven by First Solar - $2.45 per Watt selling price
- Polysilicon shortage pinched majors

Day of Data, Bradford, Page 6

Prometheus Institute

As large manufacturing plants go online in the next few years and PV production increases, costs for average modules are expected to go down from the 2006 average of $3.75 to an average $2.20 in 2010.

With respect to policy and state legislation, according to Mr. Bradford, a number of states are enacting policies to increase their solar generation, particularly California at 3,000 megawatts (MWs). Renewable portfolio standards (RPSs) in many states are adding to demand. Federal legislation for solar energy tax credits from the Energy Policy Act of 2005 was the first tax credit in 20 years, although it was only available for two years. Proposed federal legislation (HR 550, S 590) revises and extends these credits for 10 years retroactive to January 1, 2008.

Patrick G. Hatcher, Ph.D., of Old Dominion University (ODU) and Executive Director of the Virginia Coastal Energy Research Consortium (VCERC), discussed work being carried out by ODU and VCERC on biodiesel production from algae. The specific focus on algae-to-diesel is attractive because the quality of oil production from algae is high, reproduction occurs rapidly, the ensuing biodiesel can be coupled with numerous industrial processes, and it is clean-burning. Algae production also does not require agricultural land. Biodiesel produced from algae can be grown on municipal wastewater. The process is carbon-neutral and avoids reliance upon fossil fuels.

Algal biofuel production is attractive for Virginia, according to Dr. Hatcher, because Virginia has plenty of sunshine and has many coastal areas, often choked with algae, that are amenable to locating algal production. Virginia also hosts many federal and state government vehicles, military needs, and high energy demand coastal cities.

VCERC's strategy for production of biodiesel from algal wastewater has led to the development of a "one step process" chemo-reactor to convert algal biomass to liquid biodiesel. A functional small-scale test facility and biofuel chemo-reactor is installed in the Virginia Initiative Plant of the Hampton Roads Sanitation District. At this time, processing costs place this biodiesel at around $4.00 a gallon, although carbon and nitrogen credits or further reduction in waste disposal costs could offset these costs in the future.

David W. Schnare, Ph.D., of the Center for Environmental Stewardship, Thomas Jefferson Institute for Public Policy, made a presentation to the Commission on geoengineering. Geoengineering is defined as the deliberate, large-scale modification of the Earth's environment. It was the view of Dr. Schnare that geoengineering is at present the only economically competitive technology to offset global warming.

There are five large-scale geoengineering approaches that have been considered to cool the planet to combat global warming effects: whitening 30% of the Earth's surface, shading the Earth with 70 square km (27 square miles) of mirrors; using iron fertilization to sequester carbon in the ocean; shading the Earth with volcano-mimicking aerosols to provide more time to implement reductions; and shading the Earth with whiter clouds by spraying seawater into the atmosphere. Of the five approaches, according to Dr. Schnare, launching stratospheric aerosols (mimicking volcanic eruptions) and whitening clouds (utilizing natural cloud reflectivity) offer the ability to be easily turned off and on.

Mr. Dean Price of Red Birch Energy told the Commission about the Red Birch Country Market biodiesel project, which offers a small closed-loop biodiesel feedstock growth, refinery, and distribution system. The process includes growing canola in Southside Virginia near an interstate truck stop, producing biodiesel from the canola at the nearby small-scale Bassett biodiesel facility, and selling the biodiesel at the Basset truck stop.

This project encourages farmers to grow canola, a winter crop, and deliver the canola to the Bassett facility. Farmers, in turn, could purchase the biodiesel produced from their canola at the local truck stop. The project goal is to have farmers involved in all the value-added steps of biodiesel production. To make similar projects successful, it is important to identify a strategic location where traffic and population are near compatible farm sites.

Emissions from biodiesel are much cleaner than from #2 petroleum-based diesel. Biodiesel is less toxic and biodegrades quickly. Mr. Price argued that from an economics perspective, local enterprises can significantly stimulate local economies. Canola cultivation has nutrient demands that are similar to that of wheat with the exception that more nitrogen and sulfur are needed. No pesticides, fungicides, or herbicides are used.

Michael E. Karmis, Ph.D., Director of the Virginia Center for Coal and Energy Research at Virginia Tech, made a presentation on carbon capture and storage (CCS), which is a potential mitigation tool for CO_2 capture from large point sources, such as coal-fired power plants, and sequestered underground. Carbon can be stored in unmineable coal seams, depleted oil/natural gas reservoirs, or saline aquifers.

Dr. Karmis' presentation focused on addressing whether CCS technology offers a realistic mitigation approach that Virginia could consider. If this technology can be proven reliable, it could play a substantial role in future carbon reduction policies by reducing carbon emissions from power plants by as much as 90% compared to facilities without CCS. However, the state of the science on exploring CCS options is still in its relative infancy. There are three main steps in the process: capture, transport, and ultimate geologic storage. More research is needed on all steps of the process to better understand the potential for broad application of CCS as a mitigation strategy.

The U.S. Department of Energy and energy industry representatives have developed seven regional carbon sequestration partnerships, including one in the Southeast U.S. that run from Virginia to Texas. These partnerships are beginning pilot CCS projects to research the various phases involved with this technology. Some of this work is slated to occur in the Central Appalachian Basin in Virginia. These pilots are scheduled to run through 2017 or beyond.

Dr. Karmis believes that CCS is essential if the world is to stabilize atmospheric concentrations of GHGs. Commercial deployment of CCS requires large-scale tests to develop, demonstrate and confirm geologic storage. Demonstration of CCS requires significant funding, and Dr. Karmis argued that Central Appalachian states should contribute financial resources to support CCS research and development.

V. Climate Change Approaches Being Pursued by Other Governments

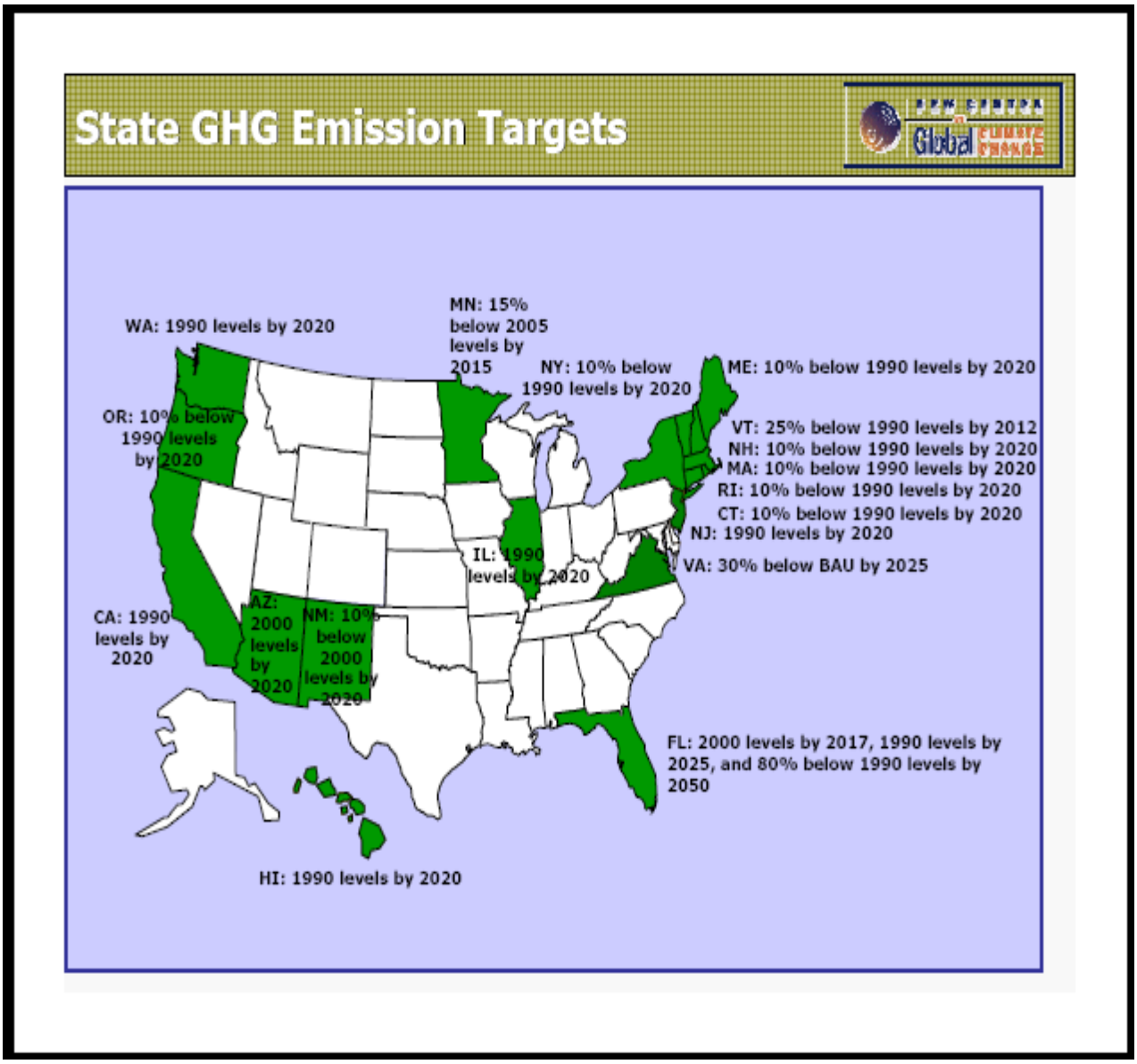
Virginia is not acting alone in seeking ways to reduce greenhouse gas emissions and adapt to climate change. States throughout the nation are preparing climate actions plans, enacting greenhouse gas reduction policies and cooperating in regional efforts. The U.S. Senate has debated one climate change bill, and many other pieces of legislation are currently under consideration in Congress. Many local governments in Virginia and elsewhere are taking actions to conserve energy, increase use of renewable energy and reduce greenhouse gas emissions. The Commission received presentations that provided examples of actions at all levels of government. For comparison purposes, the Commission also heard one presentation on actions being taken in a different part of the world, the European Union.

A. Other States and Regions

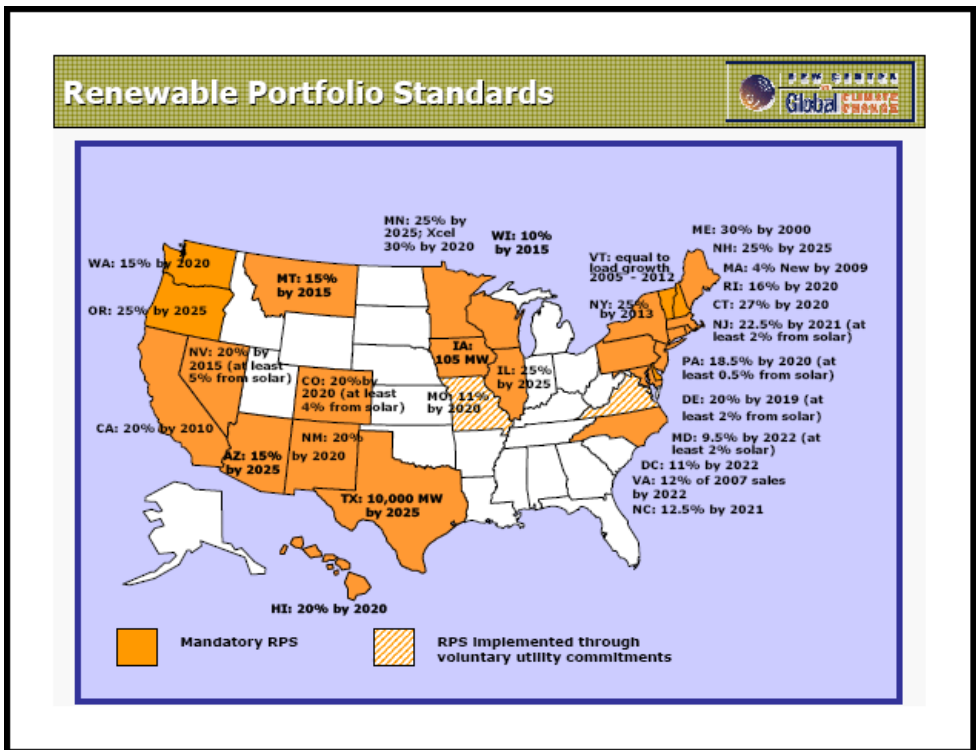
Mr. Patrick Hogan with the Pew Center on Global Climate Change provided a summary of state and regional actions that are underway to address climate change. Founded in May 1998, the Pew Center is an independent, non-profit, non-partisan organization that conducts research, engages in education and outreach, and facilitates the Business Environmental

Leadership Council (BELC). The BELC is a business association focused on climate change issues that consists of 42 large corporations (mostly Fortune 500 multinationals that together employ over 3.8 million people). The Pew Center works with these companies to reduce their GHG emissions; develop technologies, products, and services that reduce GHG emissions; and help policymakers design effective policies that also work for business.

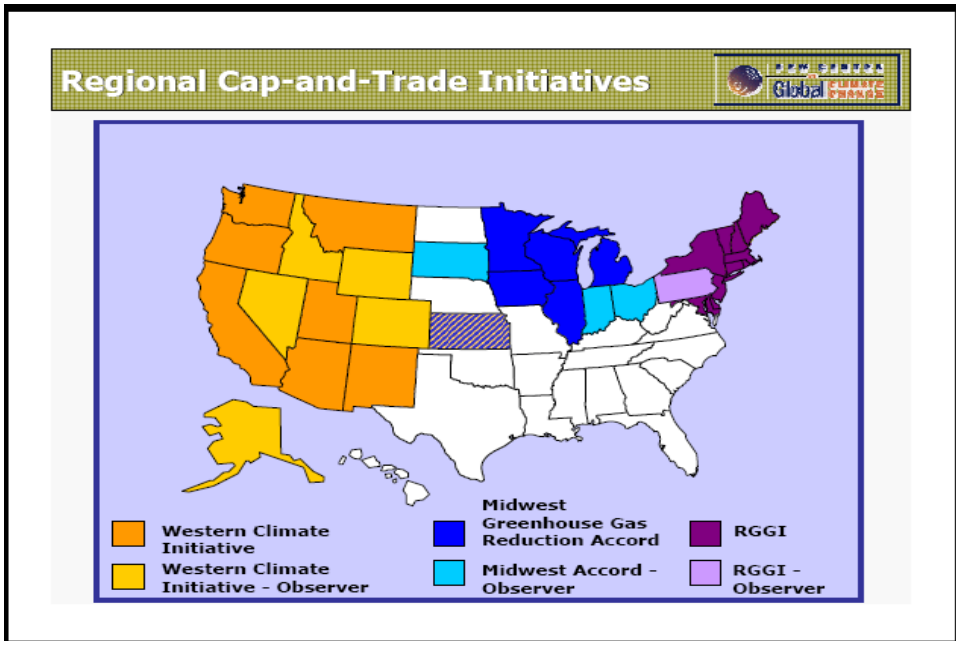
Just within the past year (since October 2006), seven states – Washington, Illinois, New Jersey, Minnesota, Hawaii, Florida, and Oregon – have adopted GHG reduction targets. A total of 18 states now have established such targets. This map shows only mid-term targets; most states also have long-term targets:



More than half of the states have adopted renewable energy portfolio standards.



Regional cap-and-trade programs are under development across the country. Under cap-and-trade programs, the government imposes a mandatory limit on the total emissions that can be released in a given period from sources – the "cap" – covered by the program. These sources receive "allowances," or permission, that entitle the holder to emit a specified quantity. Such allowances can be bought and sold, which is the "trading" part of the program.



To date, 37 states have addressed climate change through the development of a climate action plan. Specific information about climate change planning activities underway in mid-Atlantic states was provided by Ms. Paula Jasinski of the National Oceanic and Atmospheric Administration's Chesapeake Bay Office. The mid-Atlantic states of Pennsylvania, Maryland, North Carolina, South Carolina, and Virginia are all taking similar steps in their initial efforts to combat climate change: developing climate action plans; joining The Climate Registry for voluntary greenhouse gas emissions reporting; offering renewable energy portfolio incentives; and establishing building codes that improve energy efficiency.

Pennsylvania is currently focused on developing an energy independence strategy to increase its reliance on domestic energy sources, including renewable energy sources. Mitigation, or strategies to reduce the emission of greenhouse gas emissions, is a significant component of this energy strategy. Although the state has not developed or adopted a climate action plan, the "Climate Change Roadmap" was developed by a non-profit, the Pennsylvania Environmental Council in 2007.

Maryland has recently finalized a Climate Action Plan that includes both mitigation and adaptation strategies. Within the mitigation arena, the Maryland plan proposes that the state adopt legislation to reduce GHG emissions by 25% by 2020 and 90% by 2050. Other Maryland recommendations include the development of legislation to increase energy efficiency in new development and legislation that would provide enhanced incentives for renewable energy sources. Maryland's draft adaptation strategies largely focus on the projected impacts of sea level rise to its coastline, including mandating regular shoreline condition reports for localities, adopting a unified shoreline management approach across all coastal counties, and increasing public awareness on the impacts expected from climate change and sea level rise.

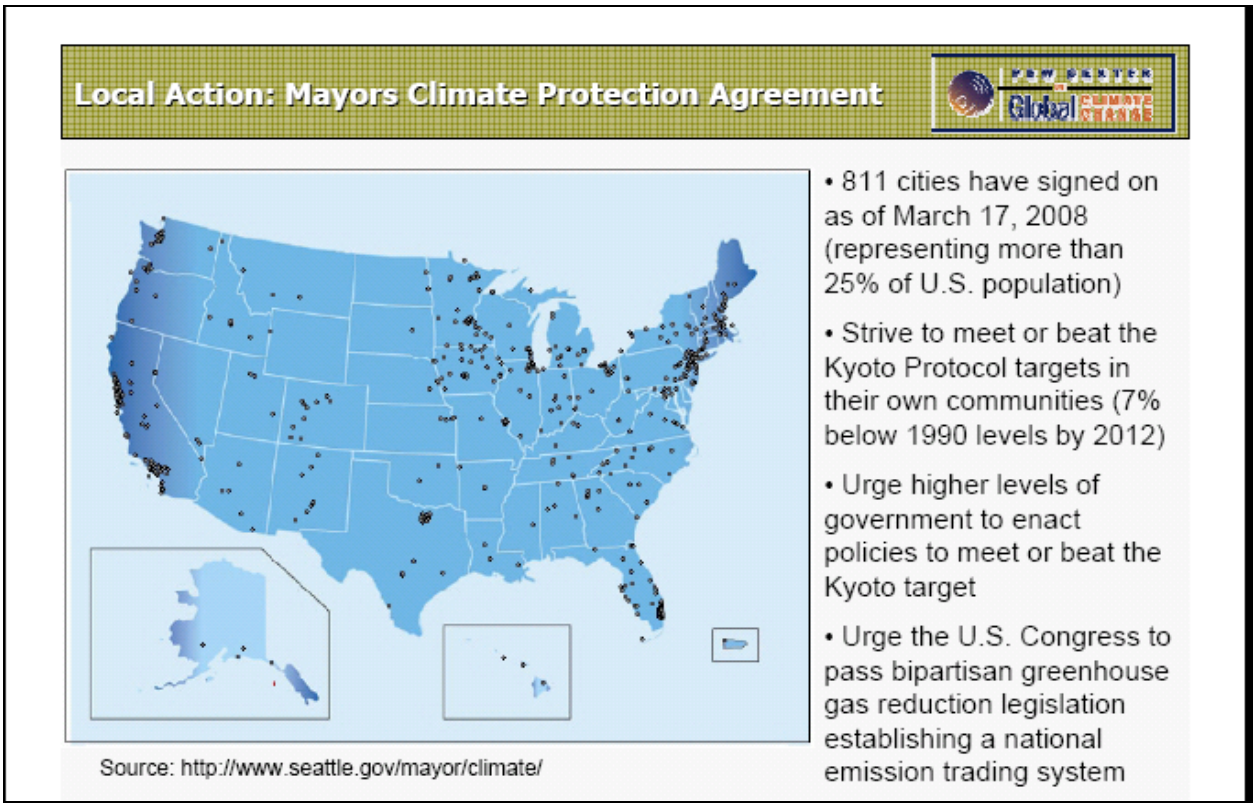
North Carolina has two complimentary groups addressing climate change planning. One is the North Carolina Legislative Commission on Global Climate Change that was established in 2005. The second is the Climate Action Plan Advisory Group (CAPAG) established in 2006. CAPAG is developing a Climate Action Plan for the state that is due in late summer 2008. Draft recommendations from this report include establishing a Blue Ribbon Commission to address adaptation responses, calling for land development plans that take climate change and natural resource protection into account, and providing financial disincentives for lower efficiency vehicles.

South Carolina released its Climate Action Plan in early June 2008. Recommendations in the plan include encouraging local governments to develop their own climate action plans, establishing a Commission for a Sustainable South Carolina, improving vehicle emissions standards, and increasing in-state production of bio-fuels.

B. Local Governments

Across the United States, many local governments are acting to combat climate change. One coordinated effort is the U.S. Mayors Climate Protection Agreement, under which localities strive to achieve reductions in GHG emissions of seven percent below 1990 levels by 2012.

More than 850 mayors to date across the United States, including nine in Virginia, have signed onto this agreement.



In Virginia, the Virginia Municipal League (VML), has taken the lead in encouraging local governments to consider actions that can reduce greenhouse gas emissions and save energy. Mr. Jay Fisette, President of VML, made a presentation to the Commission in which he detailed the efforts of the VML's Go Green Initiative, a program largely created to increase awareness among localities regarding climate change. The program launched a website, www.GoGreenVA.org, in February 2008 to provide information resources for local governments, as well as details on the Green Government Challenge. Thus far, 47 localities have registered for the challenge with the incentive of possible VML certification and cash awards for top jurisdictions.

The Green Government Challenge is intended to be a friendly competition between localities that encourages the implementation of 30 policies and practical actions under 11 categories, including government policy adoption, energy efficiency, green buildings, waste management, vehicles, land use and transportation, water and air quality, employee incentives, education and community participation, schools, and innovation. For example, a specific policy under the energy efficiency category is conducting an energy audit of two or more government facilities and implementing at least one recommendation of the audit. For waste management, a specific goal would be establishing a procurement policy for a minimum of 30 percent post-consumer recycled content for everyday paper use. Providing employee benefits for ride sharing, walking, biking, or taking transit to work is an approved practice under employee incentives. For land use and transportation, a locality could adopt a land use or development tool

that preserves open space, farmland, and forests, such as Purchase of Development Rights or Transfer of Development Rights.

Efforts in the City of Roanoke where highlighted in a presentation by Mr. Kenneth Cronin, Director of General Services. Roanoke has joined ICLEI-Local Governments for Sustainability, which is a membership association of local governments committed to advancing climate protection and sustainable development. Roanoke has followed the ICLEI model that identifies five milestones for establishing a green government program, which include: conducting a baseline emissions inventory and forecast (commonly called a "carbon footprint"), adopting an emissions-reduction target for the forecast year, developing a Local Action Plan, implementing policies and procedures and monitoring and verifying results. Roanoke utilizes a software program to determine its carbon footprint. The cost to the city for the software was approximately $1,600.

Roanoke's other efforts have included building its first LEED building (a fire station) and implementing a number of practices in its other buildings, including replacing incandescent lights with compact fluorescent lights (CFLs), replacing T12 lamps with T8 lamps in municipal buildings, replacing incandescent traffic lights with compact fluorescent lights (CFLs) and using products that have the EPA/U.S. Department of Energy (DOE) Energy Star Energy Star rating. The locality is the first in Southwest Virginia to use biodiesel and ethanol.

Roanoke Municipal Measures - Implemented

Measure	CO_2 (eq. tons)
1. Municipal South Building Upgrade	
• *HVAC upgrade (~50% energy reduction)*	-217
• *694 40W T-12 lights changed to 32W T-8 lights (~20% energy reduction)*	-135
2. Eureka Park Recreational Center Boiler Upgrade	
• *40-yr old boiler replaced with new, efficient boiler (~10% energy reduction)*	-5
3. Light Bulbs	
• *460 - 60 W incandescent light bulbs replaced with 14 W CFL bulbs*	-86
• *300 - 90 W exterior halogen lights replaced with 23 W CFL bulbs*	-82
4. Vehicles	
• *Low-sulfur diesel (LSD) fuel replaced by ultra-low sulfur diesel (ULSD)*	
• *Biodiesel blend increased first to 2% (B-2) and then to 5% (B-5)*	-303
• *Ford Escape hybrid SUV's purchased to replace standard gasoline sedans*	-5
TOTALS	-833
Emission Reduction Relative to 2005 Baseline	-1.5%

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The city also participates in the Safe Route to Schools Program, which is an initiative to educate children about bike safety and increase the use of alternate transportation to school.

As a result of all these efforts, the City of Roanoke has reduced its GHG emissions, its carbon footprint, and its overall energy consumption. The city continues to explore opportunities to do more.

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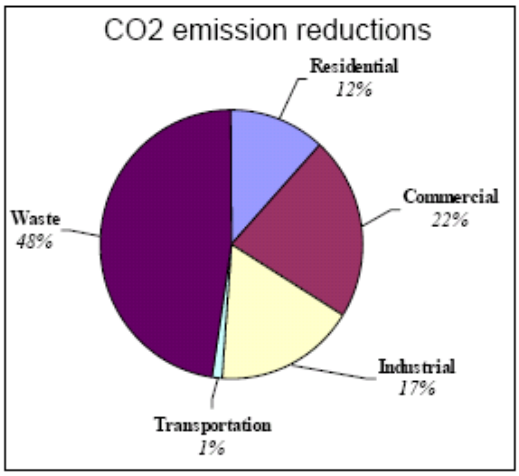
Given that municipal emissions are only a small contributor to a community's overall emissions (1.9% in Roanoke), the city also is working with citizens and businesses to identify initiatives in which everyone can take part. For example, Roanoke has analyzed the following options in the waste, residential, commercial, industrial, and transportation sectors and has found that significant emissions reductions are possible:

- Increase total recycling of municipal solid waste (paper, glass, metal, plastic) by 1% (weight) each year (2008 – 2012).
- Replace one 75 W incandescent bulb with an equivalent 20 W CFL in each Roanoke household each year (2008 – 2012).
- Reduce total commercial and industrial electricity usage by 1% each year (2008 – 2012).
- Replace one automobile trip with one public transportation trip per week for 1% of Roanoke's population each year (2008 – 2012).

Roanoke Potential Measures Results



Sector	Equiv. CO2 (tons)
Residential	-15,656
Commercial	-28,595
Industrial	-22,653
Transportation	- 1,347
Waste	-62,475
TOTALS	***- 130,726***
Community Total	2,876,827
5 yr. Reduction (%)	-4.5%

- **These are simple examples of potential measures that the community could undertake to reduce emissions and energy use - *and save money at the same time.***
- **Further analysis and discussion with city staff is required to determine best use of money and resources (ICLEI steps 3 and 4).**

Roanoke City Council also has launched a Clean and Green Campaign to encourage the adoption of such practices in the community. This effort inspired the creation of the Roanoke Business Environmental Leadership Coalition. As a part of the Campaign, some of Roanoke's largest businesses have said they would calculate their carbon footprint.

Several of the Commission's members shared information about efforts to combat climate change in their communities.

The Honorable Penelope A. Gross of the Fairfax County Board of Supervisors discussed Fairfax County's actions to combat climate change, which include: purchasing hybrid vehicles; entering into a three-year wind energy contract; establishing a transit program that includes providing subsidies for mass transit systems and supporting metro-check and teleworking; being a leader in tree planting and tree preservation; developing green building policies; retrofitting municipal lighting; and investigating means by which to transition the largest school bus fleet in the country to a greener system. Ms. Gross emphasized that for many actions like these, local government is "where the action is."

Mr. Stuart Freudberg reviewed highlights of the Metropolitan Washington Council of Governments (COG) Climate Change Initiative. The COG Climate Change Initiative began a year ago and established best practices, a greenhouse gas emissions inventory and forecast, regional reduction goals, advocacy positions, and a number of recommended actions. COG's business as usual (BAU) projections of regional greenhouse gas emissions are expected to reflect a 43 percent increase by 2050. Using 2005 as the baseline, COG's goals include a 10 percent reduction below BAU by 2012 (back to 2005 levels), 20 percent below 2005 BAU levels by

2020, and 80% below 2005 BAU by 2050. To achieve particularly the shorter-term goals, actions must be taken by individuals and businesses; utilization of new technology will be essential for meeting the 2050 goal. COG is supporting a 20% renewable portfolio standard and a commitment by local governments to reduce its energy use by 15 percent by 2012. The draft report contains a number of other initiatives in the areas of energy efficiency and conservation, transportation and land use, and outreach and education. COG plans to partner with George Mason University on an outreach program and to establish a permanent climate and energy policy committee. The report is now circulating for COG-member, stakeholder, and public review through September 30, 2008.

Finally, the Honorable Ron Rordam, Mayor of the Town of Blacksburg, discussed what is being done in Blacksburg and referred Commission members to the Public Works webpage found under the Government tab on www.Blacksburg.gov/. Mayor Rordam posed a series of questions: How do we encourage in-fill and transportation efficiencies? How do we encourage reducing vehicle miles traveled? How do we bring developers on board to plan for workforce housing that is close to town? To address these concerns, the Blacksburg Planning Commission is coordinating zoning efforts in localities in the New River Valley to encourage green development. Blacksburg also is endeavoring to get the community involved by devising Sustainable Blacksburg, which is comprised of the Town of Blacksburg, representatives from Virginia Tech, and community leaders. Each year, Sustainable Blacksburg sponsors a week-long program that offers educational opportunities and discussions.

C. Federal Approaches

Information regarding the U.S. government's current approach to climate change was provided by representatives of the U.S. Environmental Protection Agency (EPA). Pending federal legislation was discussed by staff from the office of Senator John Warner and by Representative Rick Boucher. An analysis of the economic impacts of federal legislation that would cap GHG emissions was presented by the Environmental Defense Fund. (The next section of this report also contains views on economic impacts presented by Mr. Edward T. (Tom) Morehouse, Jr., that were included in presentations by representatives of private industry.)

1. Current Approach

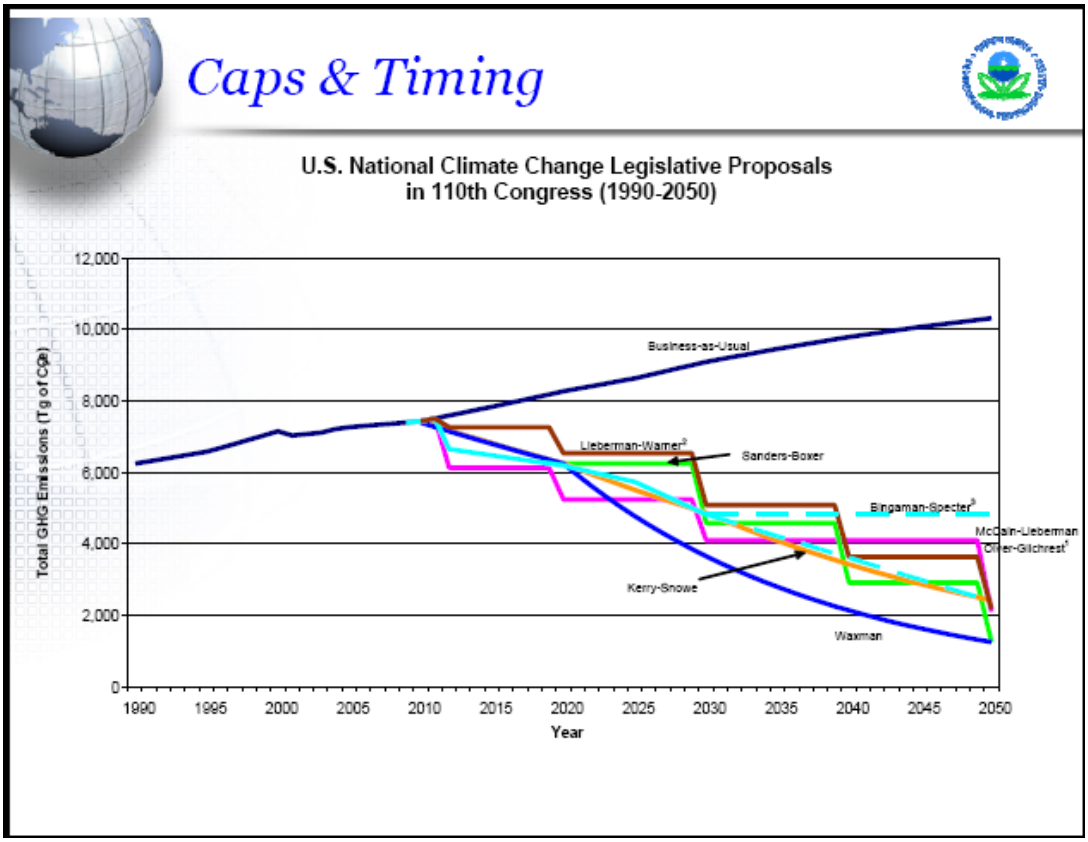
Mr. Bill Irving and Ms. Rebecca White of EPA's Office of Air and Radiation made a presentation to the Commission on U.S. Climate Policy and Programs. According to Mr. Irving and Ms. White, federal policy relating to climate change has focused on slowing the growth of emissions, strengthening science, technology and institutions, and enhancing international cooperation. The United States has a national goal to reduce the GHG intensity of the American economy by 18 percent over the 10-year period from 2002-2012. To achieve this goal, the federal government has tried to promote near-term opportunities, through voluntary programs and partnerships, to conserve fossil fuel, recover methane, and sequester carbon. Programs like EPA's Climate Leaders and Methane Outreach programs, DOE's Climate VISION program and the EPA/DOE Energy Star program, are designed to promote these near-term reductions.

Federal policy also is intended to encourage the adoption of existing technologies, energy efficiency improvements and renewable resources to reduce emissions cost-effectively. In the longer term, development and deployment of breakthrough technologies, through the Climate Change Technology Program and the Climate Change Science Program, are expected to provide safe and reliable energy to fuel the United States economy with reduced or no GHG emissions. Other administration activities include EPA's proposed rulemaking for geologic sequestration of CO_2 and the SmartWay Transport Partnership, a collaboration with the freight industry to increase energy efficiency while reducing GHG emissions and air pollution.

As part of its Omnibus FY 2008 Appropriations Bill, Congress has mandated that EPA implement a mandatory GHG reporting program for all sectors of the economy. Congress also passed the Energy Independence and Security Act of 2007, which establishes new fuel economy standards and requires fuel producers to supply at least 36 billion gallons of renewable fuel by 2022. Congress also has required EPA to conduct a lifecycle GHG analysis, including indirect land-use changes of various fuels, including evaluation of the implications of growing increased amounts of food grains for ethanol production.

2. Proposed Legislation

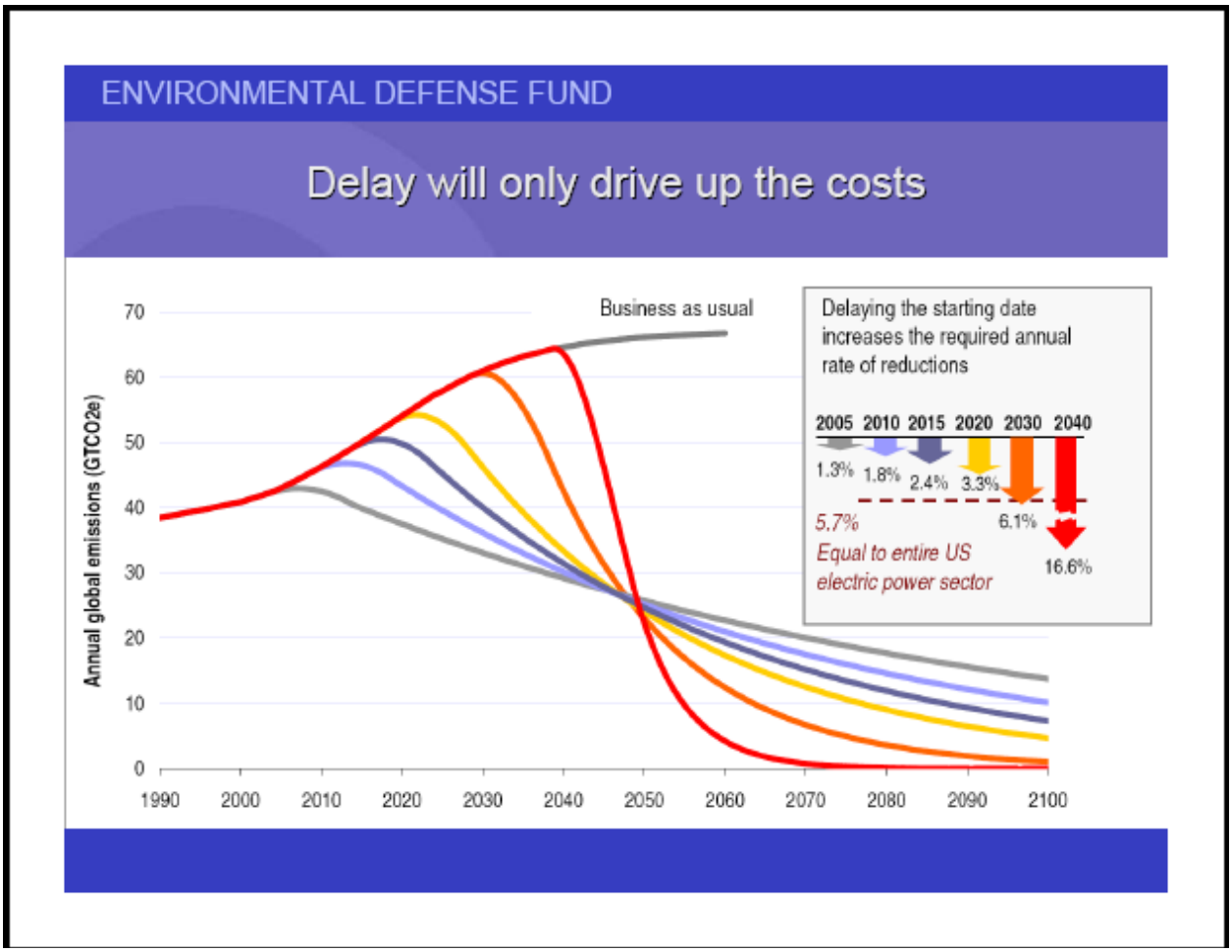
EPA has performed analyses of all of the GHG reduction legislation that has been introduced in the 110th Congress and provides the following depiction of the reductions that would be achieved by each bill:

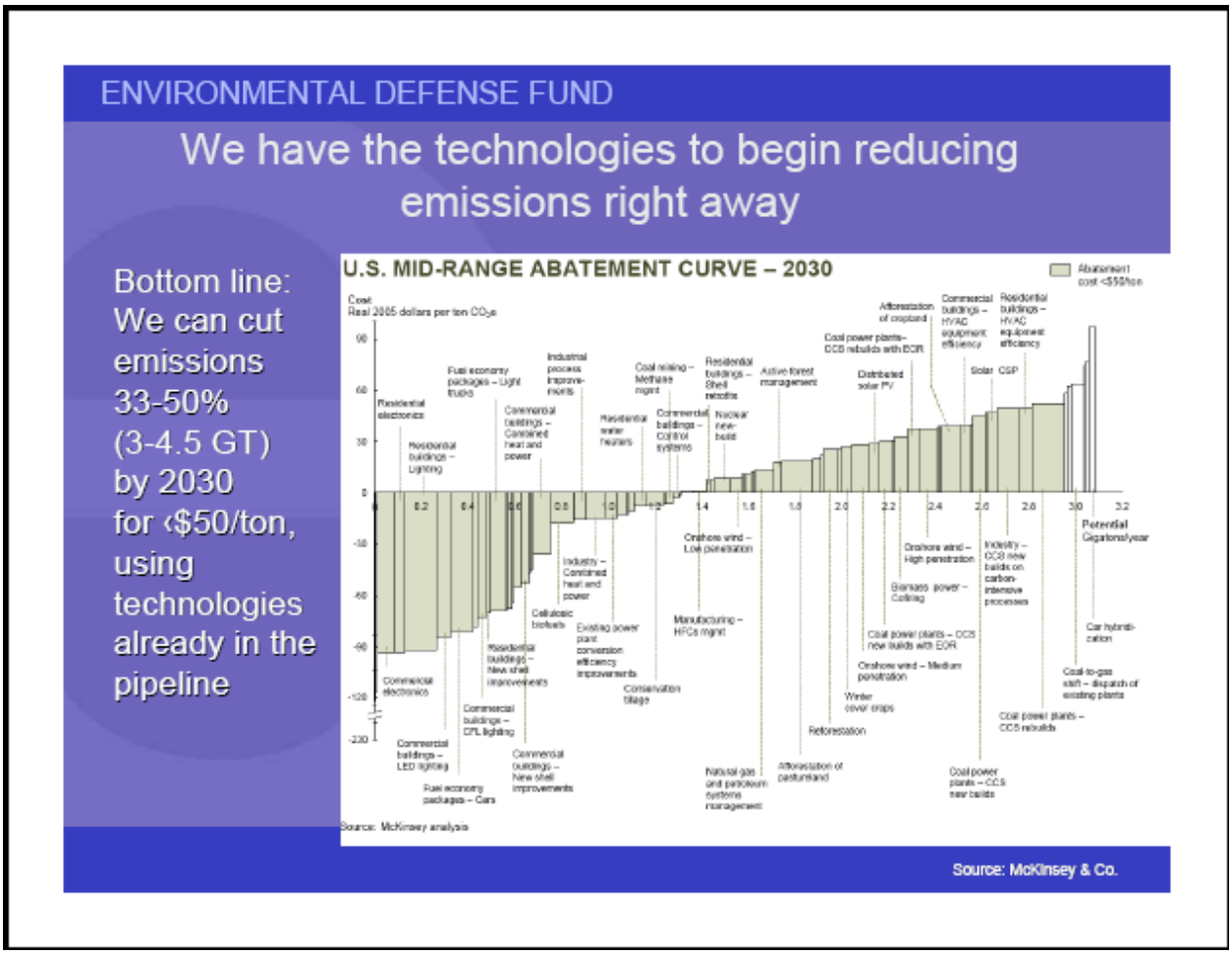


Carter Cornick, Chief of Staff, and Chelsea Maxwell, Senior Policy Advisor, in the Office of U.S. Senator John Warner provided an update on congressional action at the Commission's May meeting. The Climate Security Act, legislation sponsored by Senators Warner and Lieberman, is the first climate change bill to have emerged from a committee to the Senate floor. Subsequent to the presentation made at the May meeting, the Warner-Lieberman bill was debated in the Senate for several days, but a final vote was not taken.

Congressman Rick Boucher spoke to the Commission at its June meeting. Congressman Boucher cautioned the Commission not to take the defeat of Senator Warner's bill as an indication that Congress will not act on climate change. He predicted that there is an 80% chance that a cap-and-trade bill will pass Congress in the next two years, and a 100% chance that a bill will pass in the next four years.

Mark MacLeod, Director for Special Projects, Environmental Defense Fund (EDF), talked to the Commission about the economic ramifications of national cap-and-trade legislation. It is the view of EDF that the most expensive action is to do nothing to address climate change. He also argued that delay drives up the costs of climate change abatement, that technology to begin moving to a low-carbon economy is already available, and that public policy can effectively advance the development of new technology.

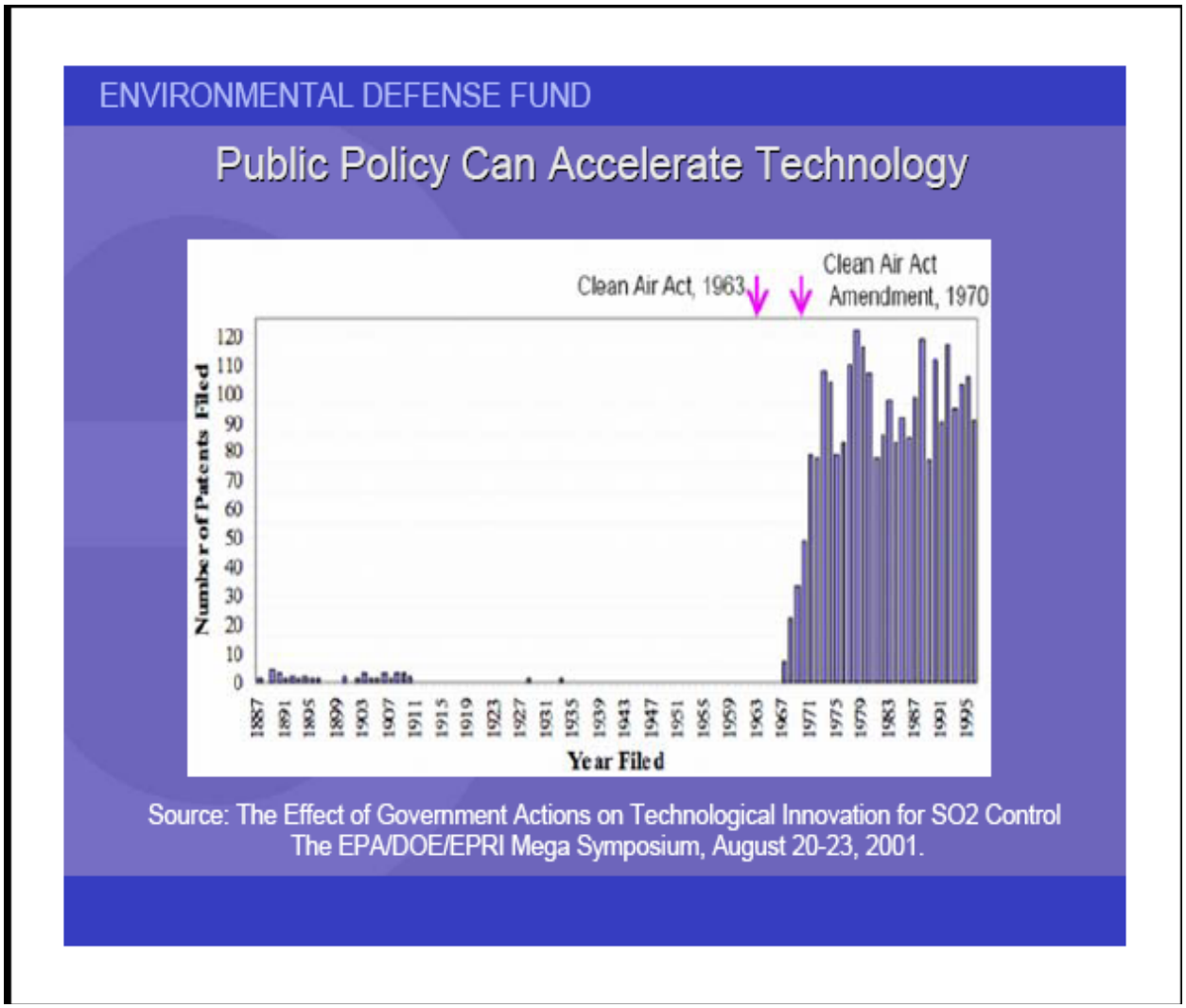




Mr. MacLeod indicated that most economic models that address climate change consider only the costs associated with abatement actions and fail to address the benefits of avoiding catastrophic climate change. They also have difficulty predicting the rate of technological change.

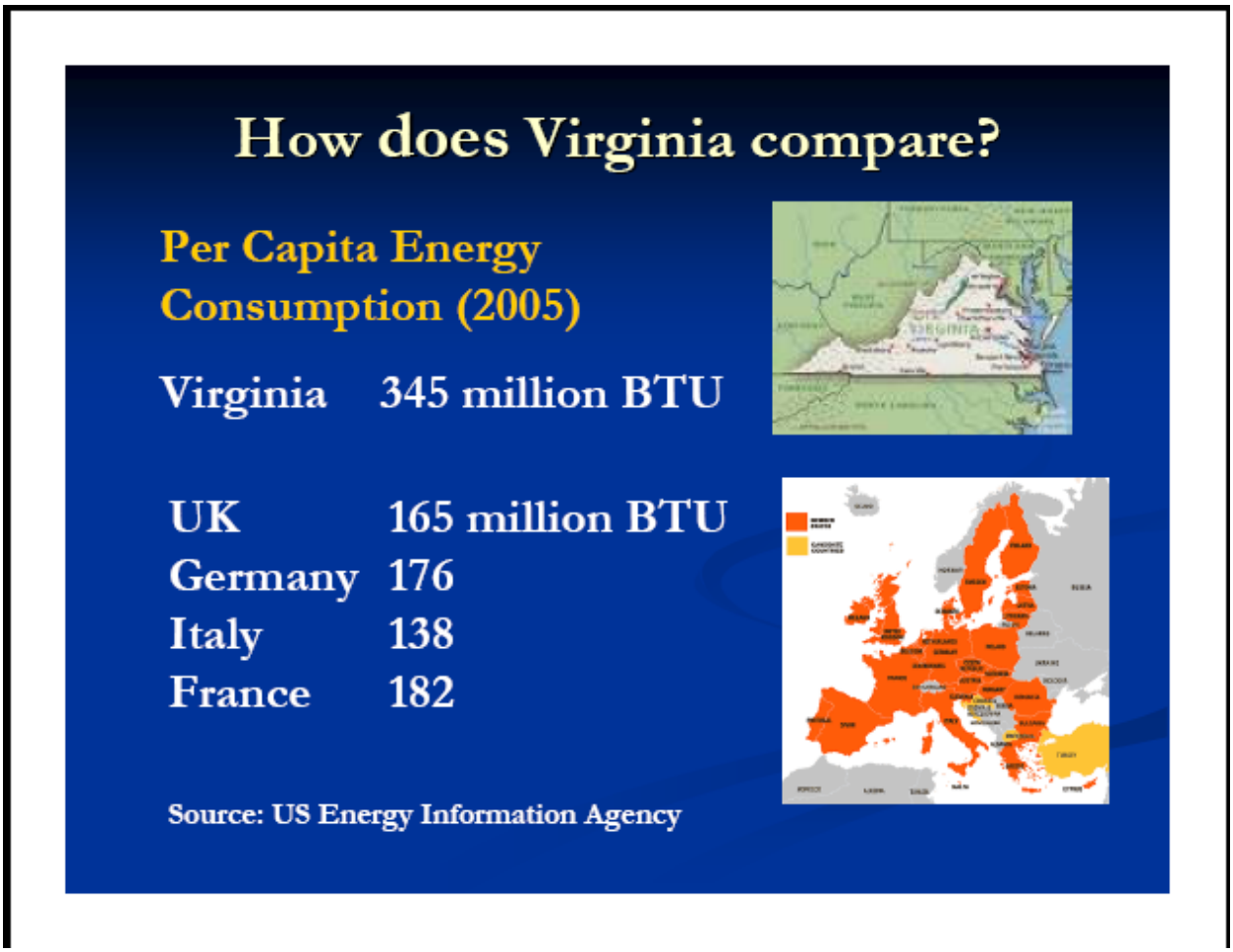
According to EDF's analysis of five economic models, the impact of a national cap-and trade program on the economy (measured as gross domestic product) will be small. Under a business as usual analysis, the total output of the U.S. economy is projected to reach $26 trillion in January 2030. With a cap on greenhouse gases, the economy will reach this amount just four months later. (It should be noted that the EDF economic analysis of certain climate change laws proposed at the federal level differs from analyses prepared by some industry analysts. See, for example, Section F below, "Industry View of Federal Legislation.")

Public policy can accelerate technology. An example is the acid rain program. After a cap on sulfur dioxide (SO_2) emissions was imposed, technology to limit emissions developed rapidly. The result has been very successful reductions in acid rain pollution.



D. The European Union

Professor Noah M. Sachs, Assistant Professor of Law, University of Richmond, made a presentation to the Commission on the European Union's (EU) Climate Change Strategy, and the lessons Virginia can learn from the EU experience. The EU is different from the United States in many ways, not the least of which is energy consumption patterns. Europe may serve as a model of what can be accomplished when additional conservation and efficiency measures are implemented in the United States.



The EU is on track to meet the EU-wide commitment of reducing GHG emissions by 8% below 1990 levels by 2012. The EU has developed policies in the following areas to reach this cap: emissions trading, fuel pricing, mass transit, renewable energy sources, biofuels, energy efficiency, and waste management. The centerpiece of these policies is the emissions trading system (ETS), which is a cap-and-trade system for power plants and major emitting industries. The trading system was designed for two phases: Phase I (2005-2007, "warm up") and Phase II (2008-2012). Under the initial phase of the EU's trading program, most allowances were distributed for free to emissions sources by EU member states under the supervision of the European Commission. Phase I of the EU ETS has been criticized because caps for individual member states turned out to be too high (due to a lack of monitoring and reporting data) and too many allocations were distributed. Additionally, because of the absence of a transition to the second phase of the program, the allowance market has experienced price volatility making planning difficult for regulated facilities.

Despite these setbacks, however, the concerns during this "warm up" phase are being addressed and provide lessons about the creation of a carbon trading scheme. The system has worked much as it was envisioned by establishing a European-wide carbon price for businesses to incorporate into their decision-making and developing a multi-national trading program.

Additionally, even in the "warm up" phase, emission reductions were realized in some of the covered sectors, which put the EU on track to meet its initial goal.

In 2007, the EU Heads of State developed the 20/20/20 plan by committing to achieve the following by 2020:

- 20% GHG reduction below 1990 levels;
- 20% improvement in energy efficiency; and
- 20% renewables in energy mix (up from 8.5% today).

To help achieve these goals, the ETS after 2012 will include an EU-wide cap with no national allocation plans. The EU will move toward full auctioning of allowances, with 20% of auction revenues to be devoted to combating climate change. The EU plans to increase the scope of the cap to include more sectors of the economy and more GHG gases, and the total cap in 2020 will be 21% lower than CO_2 allowances available in 2005.

According to Professor Sachs, the lessons learned for Virginia include: (i) markets do work, but cap-and-trade is only as good as the tightness of the cap; and (ii) climate change strategies need to be wide (all sectors of the economy), deep (not just industry, but agriculture, suburban areas, and the transportation sector, the building sector, and the land use sector must all bear the burden), and long (long-term, 2020 or beyond).

E. Industry Perspective on Voluntary Actions and Experience with Government Programs

A number of representatives of electric utilities and industries whose products, processes, or use of energy result in GHG emissions were asked to speak to the Commission about ways in which their businesses are voluntarily reducing emissions or helping consumers to do so. Presentations from industry also enabled the Commission to learn how existing climate change policies at different levels of government are affecting businesses.

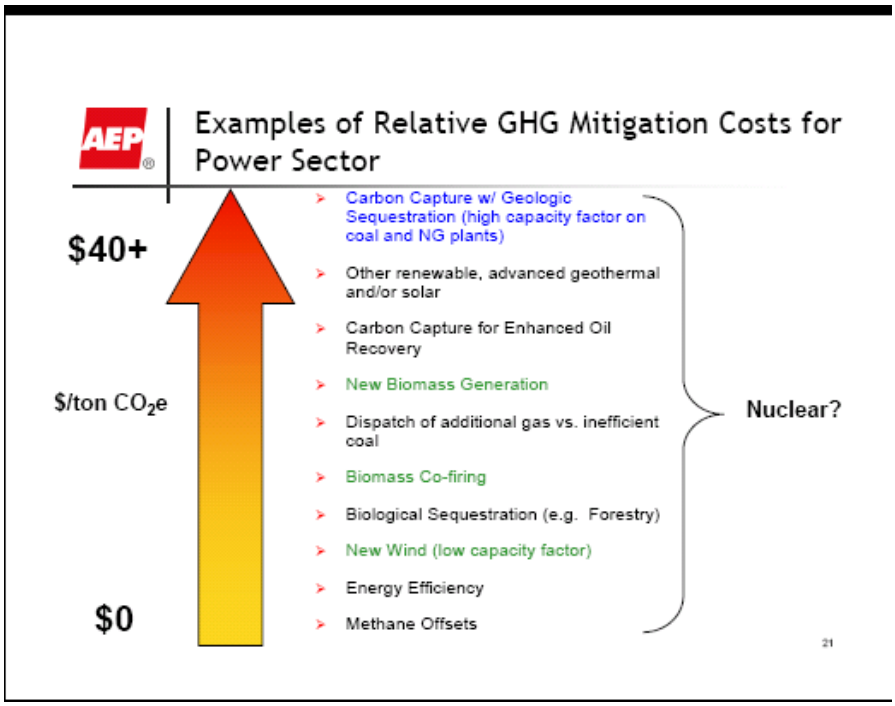
Mr. Paul Loeffelman, Director of Environmental Public Policy for American Electric Power (AEP), explained how his company has voluntarily developed a corporate climate change strategy. AEP is one of the largest United States electricity generators with a capacity of 38,000 megawatts (MW). Currently, AEP uses 76 million tons of coal per year. In 2007, 150 million metric (MM) tons of CO_2 equivalent were emitted. The electricity generated by AEP is used by 5.2 million customers in 11 states.

.Measures that are part of AEP's voluntary strategy include being politically engaged in the development of climate change policy, investing in science and technology research and development, and participation in the EPA Climate Leaders Program and Chicago Climate Exchange. Also, through the Electric Power Research Institute, AEP is investing in long-term technological solutions such as carbon capture and storage.

AEP initiatives to reduce CO_2 emissions include improving plant efficiencies, utilizing renewables such as wind (800 MW) and hydro (300 MW), and using forestry projects to help offset emissions. The current $500,000 per year investment in forestry projects offsets .35MM tons of CO_2 emissions.

AEP believes that the path forward to reducing emissions is dependent on several factors. There must be technology financing policies that encourage investment and reduce costs. Reduction targets and timelines need to allow for commercial technology to be developed and deployed. AEP feels that a cap-and-trade program with allocated carbon credits will support the development of emissions reduction technologies, while the cost of emission reductions would be much higher if carbon allowances are auctioned rather than allocated to emitters.

The choices available to the power sector to mitigate GHG emissions can range greatly in cost. For example, the cost associated with utilizing methane offsets or increasing energy efficiencies may be relatively low while the costs associated with carbon capture and storage may be quite high ($40 or more per ton of CO_2 equivalent). AEP estimates the costs associated with different strategies as follows:

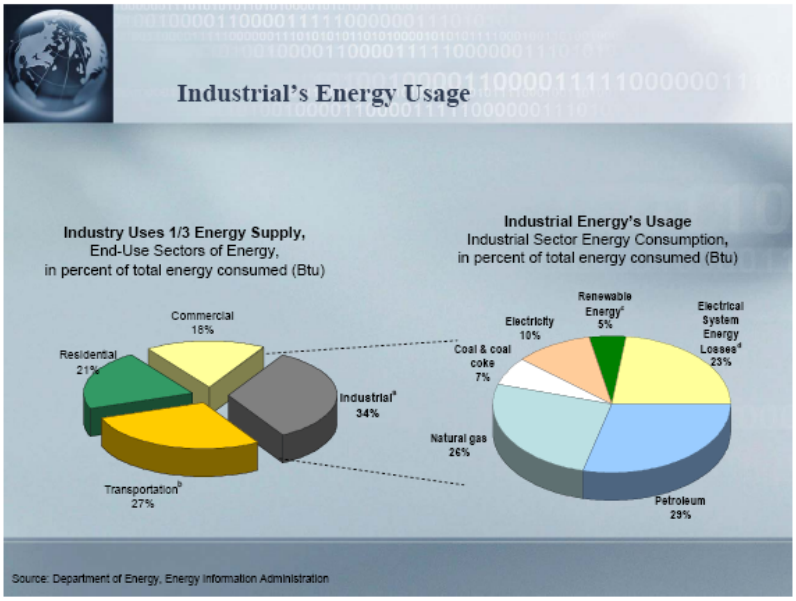


Reducing GHG emissions will be particularly challenging given increasing demands for electricity which result in a need for new generating capacity. According to the Energy Information Administration (EIA) *2004 Annual Energy Outlook* report, it is expected that 335 gigawatts of electricity will need to be added between 2002 and 2025.

The National Association of Manufacturers (NAM) is an advocacy organization that seeks to influence legislation and regulatory policy that is favorable to manufacturers and economic growth. Mr. Keith McCoy, Vice President of Energy and Resources Policy, made a

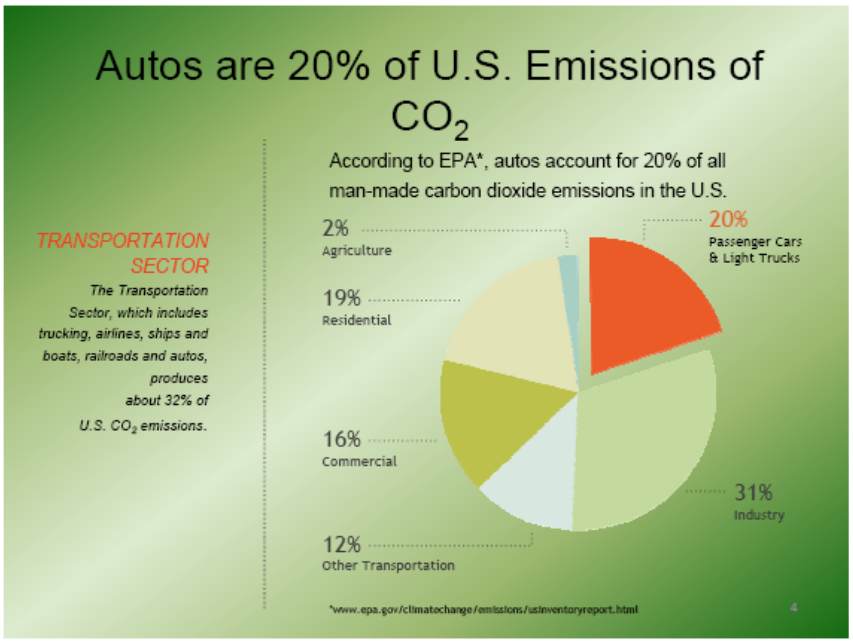
presentation to the Commission on behalf of NAM. Currently, NAM represents approximately 11,000 companies with a workforce of 14.1 million employees.

According to NAM, manufacturing is responsible for the largest portion of U.S. economic growth during the past decade. Manufacturing alone contributed 14% to Gross Domestic Product (GDP) growth between 1996 and 2006. Energy consumption in the nation, according to the U.S. Department of Energy, will increase by 30% between 2005 and 2030, even after factoring in an expected 35% gain in efficiencies, and the industrial sector utilizes 34% of the nation's energy supply. Petroleum and natural gas make up the largest portion (55% combined) of this energy usage.



NAM's recommended strategies for reducing global GHG growth include making improvements to the tax code that reduce the cost of energy investments and provides incentives; removing barriers to the developing world's access to more energy and cleaner technology by promoting economic freedom and market reforms; increasing research and development for new technologies to reduce energy intensity, capture and store carbon, and develop new energy sources; and promoting nuclear power for electricity. NAM also advocates using a cost/benefit analysis when considering adopting new GHG-reduction policies.

To share the automobile industry's views, Mr. Michael Stanton, President and CEO of the American Automobile Manufacturers Association, delivered a presentation to the Commission. Twenty percent of total CO_2 emissions nationwide come from cars and light trucks.



According to Mr. Stanton, the automobile industry recognizes its role in climate change issues and its obligation to be part of the solution. The primary means for the auto industry to mitigate CO_2 emissions is to make quick and ongoing improvements in vehicle fuel economy. In the short term, the industry is focusing on improving the operation of engines and transmissions, reducing the weight of vehicles, improving aerodynamics and finding alternate fuels. The longer term objective will require a shift to low-carbon or no-carbon fuels by switching entirely to electric vehicles, hybrid-electric vehicles, or hydrogen fuel cell electric vehicles.

In addition to the engineering challenges faced in pursuing greater fuel economy, there are additional factors that will further complicate the industry's progress toward a smaller carbon footprint, including a growing population; an increase in the number of vehicles and miles driven; continued efforts to increase occupant safety; performance that will suit the needs of customers; how to properly recycle batteries to minimize environmental damage; and how to ensure that the infrastructure needed to support the new technologies is available.

Challenges faced by the auto industry include putting new technologies on the road in sufficient numbers and at affordable prices quickly, given the long lead times and heavy spending the industry requires to engineer, design, and build next-generation products. Maintaining customer satisfaction while employing new and different technologies also is a challenge. As the price of fuel has increased, customers have reacted by shifting their buying preferences to smaller, more fuel-efficient vehicles, putting even more pressure on manufacturers to shift as quickly as possible to "next generation" products.

Hybrid Sales

U.S. HEV Sales

2000	9,000
2001	20,000
2002	36,000
2003	48,000
2004	84,000
2005	210,000
2006	253,000
2007	374,000

Market Segment

SHARES (%)						
	2007			2008		
	March	YTD		March	YTD	Δ
Small Car	15.2%	14.7%		17.4%	16.5%	1.8%
Middle Car	20.1%	19.8%		22.0%	21.2%	1.4%
Large Car	4.5%	4.6%		3.6%	3.9%	-0.7%
Luxury Car	7.4%	7.4%		7.5%	7.3%	-0.1%
CUVs	16.7%	16.5%		18.5%	18.8%	2.3%
SUVs	12.2%	12.7%		9.4%	10.2%	-2.5%
Vans	7.1%	7.5%		6.7%	6.6%	-0.9%
Pickups	16.9%	16.9%		14.9%	15.4%	-1.5%

The industry also is revamping its manufacturing operations to reduce GHG emissions from stationary sources (its factories), with improvements reaching as high as 30% in some instances. Additional efforts, such as operating zero landfill plants and high use of recyclable materials, also are well underway.

The industry feels it is important to recognize that, in addition to improving vehicles and the factories where they are made, changes in personal behavior also can help reduce society's carbon footprint, including more fuel-efficient driving practices, taking fewer trips by car, increasing use of mass transit, joining rideshare programs, and telecommuting.

F. Industry View of Federal Legislation

Mr. Loeffelman and Mr. McCoy presented an analysis of the Lieberman-Warner legislation's economic impact that differed markedly from that presented by the Environmental Defense Fund. Mr. Loeffelman cited an analysis by the American Council for Capital Formation

(ACCF) and the National Association of Manufacturers (NAM). In this analysis, Gross Domestic Product will experience losses up to $669 billion in 2030. Other concerns cited were: employment losses approaching 4 million jobs by 2030, electricity prices increasing between 101% and129% by 2030, and gasoline prices increasing by as much as 145% by 2030. Mr. McCoy presented numbers for GDP, job loss, and loss of household income that were similar to those presented by Paul Loeffelman in the AEP presentation. He correlated carbon allowance prices with increases in gasoline, residential electricity, industrial electricity, and industrial natural gas prices. Based on the particular carbon allowance scenario used, estimates of price increases nationally for gasoline, residential electricity, industrial electricity, and industrial gas could be as high as 145%, 129%, 185%, and 244% respectively by 2030.

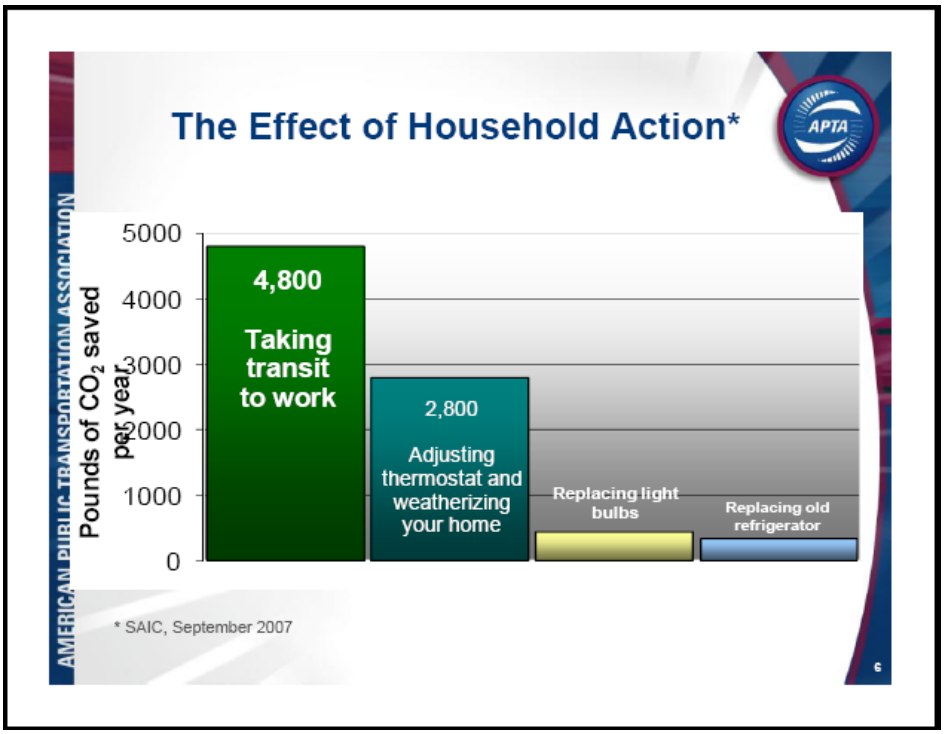
Ms. Pamela Faggert, Chief Environmental Officer for Dominion, told the Commission that Dominion supports federal legislation that: regulates greenhouse gas emissions economy-wide, establishes a cap and trade regulatory approach, sets a realistic baseline year and schedule of compliance, promotes technology development, and includes a safety valve to protect customers. Dominion's strategy for reducing GHG emissions while also meeting increasing demands for electricity is to use three major tools: conservation and efficiency, renewable generation, baseload and intermediate generation and other infrastructure improvements. Climate change is a global issue and requires a consistent national approach as well as international efforts. Dominion believes that regional and state efforts should work in tandem with a consistent national approach.

VI. The Connections Between Climate Change, Transportation and Land Use

In order to better understand the interrelationships between climate change, transportation, and land use, the Commission received presentations from a representative of a group that promotes transit, an expert working to develop certification standards for sustainable neighborhood design, a planning professional from one of Virginia's planning district commissions, and a smart growth specialist from the U.S. Environmental Protection Agency.

Ms. Petra Mollet of the American Public Transportation Association (APTA) gave a presentation entitled *Providing Transportation Choices to Reduce Greenhouse Gas Emissions*. To put transportation's GHG contribution in perspective, the transportation sector contributes 32 % of total CO_2 emissions in the U.S. (with 85% coming from surface transportation). Viewed on a household scale, automobile use contributes 55% of all household carbon emissions.

Ms. Mollet concluded that CO_2 reduction targets cannot be met by relying solely on recently enacted fuel efficiency standards. APTA views public transportation as a "Net Carbon Reducer" in that it generates far less CO_2 than it offsets by reducing vehicle miles traveled and congestion. On a household scale, substituting public transit for driving an automobile to work reduces twice as many pounds of CO_2 than any other household energy conservation measure (e.g., adjusting thermostats, weatherizing, replacing light bulbs, replacing old refrigerators). A 30% savings in household carbon emissions can be achieved by switching one automobile to public transportation or other non auto-related modes.



In addition, increased public transportation infrastructure provides a "leverage effect" by supporting more efficient land use patterns that result in reduced growth in vehicle miles traveled and reduced congestion.

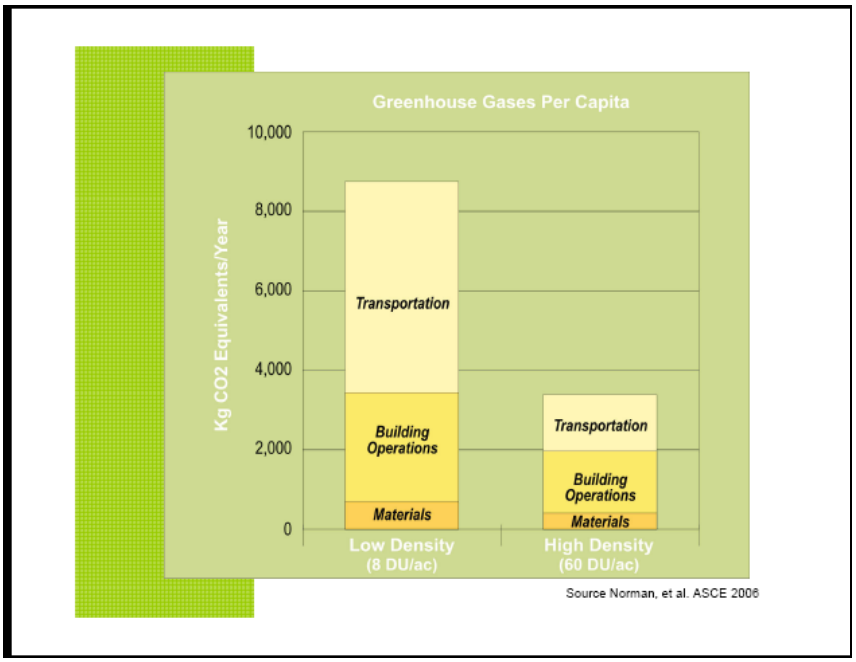
Higher density regions produce less carbon emissions per year from cars. Data was presented that showed that the average Richmond resident (relatively low density region) generates larger annual auto carbon emissions (1.335 tons) compared to the higher density regions of Virginia Beach (1.004 tons) and DC metro (0.984 tons).

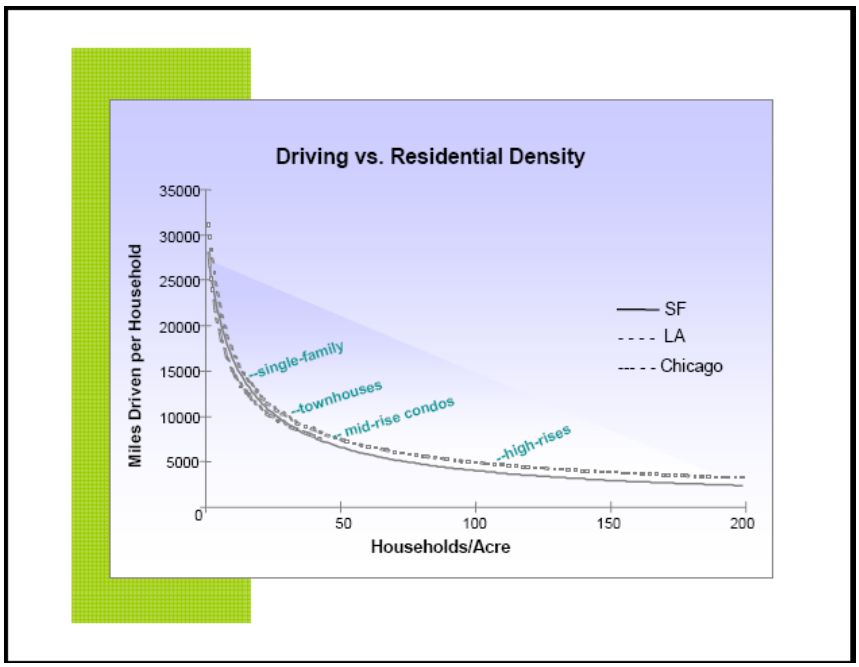
APTA's recommendations for policy makers include: (i) avoiding increases in public transportation fares, (ii) protecting existing public transportation assets and services, (iii) expanding public transportation coverage and frequency, (iv) recognizing transit's net benefits in carbon programs, and (v) promoting energy efficient transportation technologies. APTA believes that transportation investments could be made more effective by: (i) linking public transit investments to land use policies, (ii) increasing accessibility to public transit through improved park & ride, bike paths, and sidewalks, and (iii) using both carrot and stick-type approaches to increase public transit occupancy and decrease the GHG emissions per passenger.

.LEED (Leadership in Energy and Environmental Design) is a third-party certification program and the nationally accepted benchmark for the design, construction, and operation of high performance green buildings. LEED-ND (Neighborhood Development) is an effort, still in pilot phase, to move beyond construction of individual green buildings into the certification of holistic neighborhood development. Ms. Elizabeth Humphrey Schilling explained that, in addition to green construction and technology, LEED-ND certification will encompass additional factors related to smart location, linkages, and neighborhood pattern and design. A rating system will assign points allowing for neighborhoods to achieve silver, gold, or platinum status. The

LEED-ND certification process reduces the carbon footprint of a proposed development by assessing: (i) building energy performance, (ii) location efficiency, (iii) compact development and focus on existing disturbed sites, (iv) preservation of carbon sequestration sites, (v) accessibility of diverse uses (e.g., parks and schools), and (vi) reduced demand for power for storm and wastewater management, light, and other needs.

The following two figures illustrate the significant difference in greenhouse gas emissions per capita and miles driven per household for low density vs. high density neighborhood development.

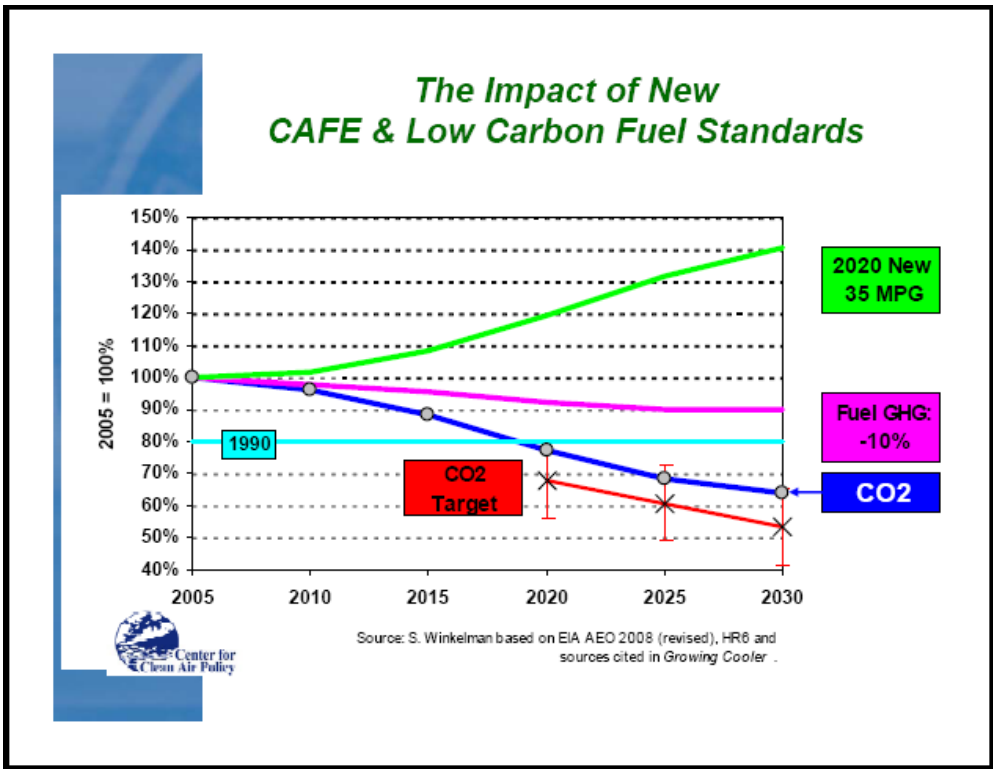


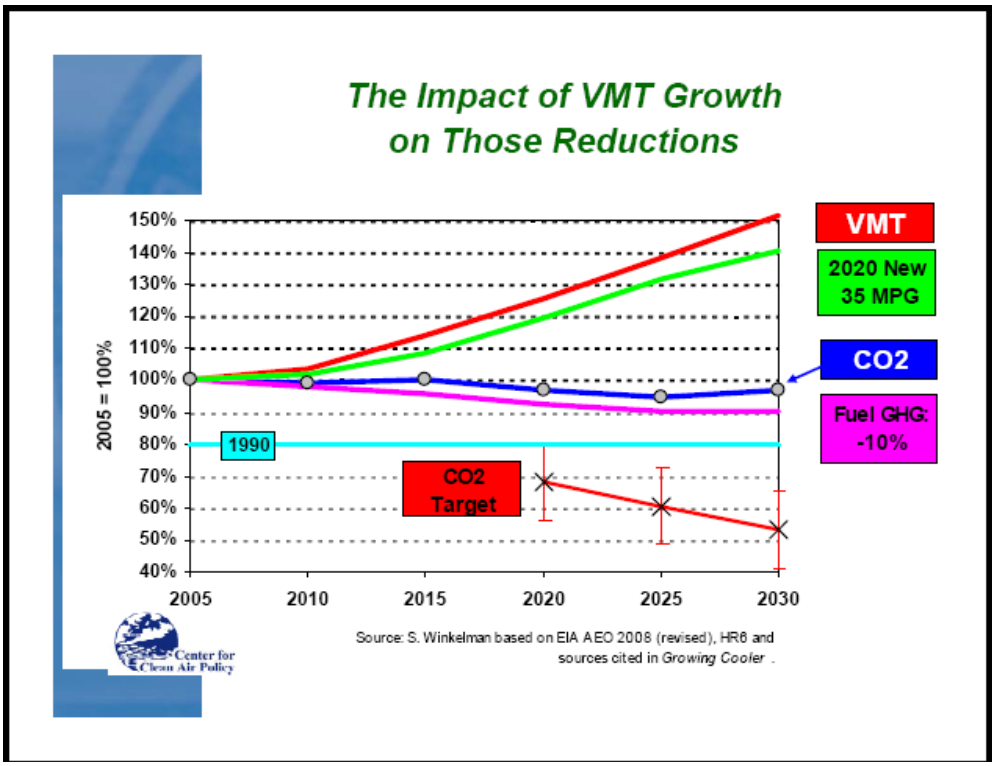


If the Commonwealth wished to use LEED-ND as a policy tool, Ms. Schilling suggested that it could provide incentives such as fast-track permitting or state support of certified projects. In addition, the certification evaluation process affords policy makers the opportunity to assess whether current codes and ordinances are creating barriers to energy-efficient growth.

Mr. Eric J. Walberg, Principal Planner, Hampton Roads Planning District Commission, spoke to the Commission about (i) linking strategic environmental planning and urban design, often referred to as green infrastructure and (ii) the emphasis on building quality communities that protect critical natural resources while having energy-efficient communities and multi-modal transportation. Mr. Walberg cited The Conservation Fund for a definition of green infrastructure: "a planned network of green spaces that benefits wildlife and people and links urban settings to rural ones." The focus of green infrastructure is on services provided by natural systems. Mr. Walberg argued that for coastal areas in particular, the concept of green infrastructure has much to offer in terms of how to deal with sea level rise and storm surges. The Virginia Department of Conservation and Recreation's Natural Heritage Program has provided a Virginia Conservation Lands Needs Assessment, which is relied upon as a valuable tool by the Hampton Roads Regional Planning District. The Assessment's forests economic model underscores the economic value of forestry based in Virginia.

John V. Thomas, Ph.D., of EPA's Office of Policy Economics and Innovation gave a presentation on urban development and climate change. Dr. Thomas argued that promoting smart growth is critical to climate change policy for two reasons. First, rapid growth, with an associated increase in vehicle miles traveled (VMT), undermines any gains achieved through improved fuel economy and low carbon fuels.





Second, rising gas prices have greatly increased public demand for high quality growth alternatives.

Vehicle miles traveled is shaped by where growth occurs (e.g., downtown areas vs. isolated subdivisions, public transit accessible suburban centers vs. auto-related town centers) and how growth occurs (e.g., better street design, mixed use development, compact neighborhood design).

According to Dr. Thomas, making smart growth work requires updating some rules and providing appropriate incentives. Rule changes could include: (i) more flexible land use regulations allowing for form-based or performance-based codes, (ii) updated parking requirements that allow for shared parking and context-specific standards, (iii) revised street design standards, and (iv) improved traffic impact assessments. Additional incentives could include: (i) support for infrastructure in key locations, (ii) streamlined development review process, (iii) public support for site planning, and (iv) density bonuses and other regulatory relief.

VII. Next Steps

The information contained in this interim report addresses three of the five tasks that comprise the Commission's charge: it provides an inventory of the amount of and contributors to Virginia's greenhouse gas emissions; it summarizes the expected impacts of climate change on

Virginia's citizens, natural resources and economy; and it identifies climate change approaches being pursued by other states, regions and the federal government.

In June, the Commission formed four workgroups to address the remaining two tasks. One workgroup is focusing on climate change adaptation – that is, identifying what Virginia needs to do to prepare for the likely consequences of climate change. The remaining three workgroups are identifying the actions that need to be taken to achieve the 30 percent greenhouse gas reduction goal. One workgroup is focusing on transportation and land use actions, a second workgroup is focusing on electricity generation and other sources, and a third workgroup is focusing on the built environment. The workgroups will provide recommendations to the Commission, and those accepted by the full Commission will be included in the Commission's final report, which will be issued in December, 2008. The Commission's final report also will contain key findings drawn from the information the Commission has received, as well as cross-cutting recommendations on issues that are broader than those assigned to the workgroups.

Throughout its work, information regarding the Commission and its workgroups will be available on the Commission's website: www.deq.virginia.gov/info/climatechange.html.