Part One

ODOT

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Ken Niles

Oregon Strategy for Greenhouse Gas Reductions

Report to the Governor

The Governor's Advisory Group on Global Warming — December 2004

"There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities." (*Intergovernmental Panel on Climate Change [IPCC], Climate Change 2001: The Scientific Basis, Summary for Policymakers*, p. 5)

"Greenhouse gas forcing in the 21st century could set in motion large scale, high-impact, non-linear, and potentially abrupt changes in physical and biological systems over the coming decades to millennia …." (*IPCC 2001, Summary for Policymakers*, p. 14)

"Here in Oregon we're putting together a battle plan to reduce greenhouse gases – the primary cause of global warming . . . We are not going to wait for federal leadership. We've got too much to lose if global warming continues unabated. And we've got too much to gain by being a leader in climate solutions."

Governor Ted Kulongoski
May 4, 2004

SECTION 1

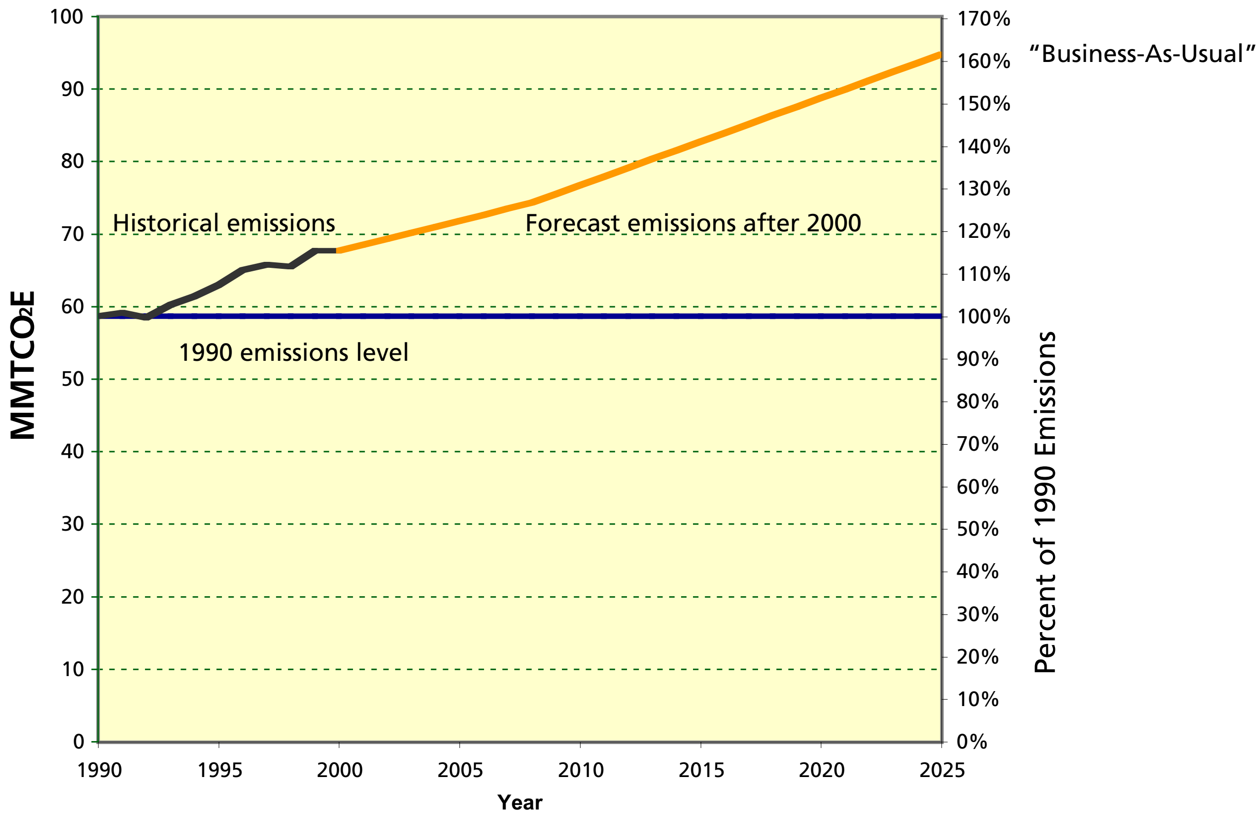
Introduction

Global warming is not just another environmental issue.

It's not "just another issue," period.

Absent decisive actions across the globe of the sort proposed in this report, the warming already underway is expected to lead to changes in the earth's physical and biological systems that would be extremely adverse to human beings, their communities, economies and cultures. These are changes that we would have unintentionally brought upon ourselves, but that are also in our power to reverse. Our failure to return atmospheric accumulations of greenhouse gases (GHG) back to levels that will sustain historic climate patterns may lead to an Earth that is dramatically altered and far less habitable within only a few generations. Figure 1 below shows historic and projected greenhouse gas emissions for Oregon.

FIGURE 1
Historic and Forecast Greenhouse Gas Emissions in Oregon



The black line that rises from 1990 to 2000 represents historical greenhouse gas emissions from Oregon. The orange line that continues beyond that represents a forecast of future emissions under a "business as usual" approach, which assumes we continue present activities (including many that now restrain greenhouse gas emissions), but take no additional special actions to reduce these emissions.

The vertical axis on the left is in million metric tons of carbon dioxide-equivalent ($MMTCO_2E$). "CO_2E" is the equivalent radiative impact of all the greenhouse gases expressed as tons of CO_2. It is larger than that of CO_2 alone, because it accounts for the radiative effects of other gases. The vertical axis on the right shows differences from 1990 levels, with 1990 representing 100 percent of emissions.

The impacts of such changes on Oregon citizens, businesses and environmental values are likely to be extensive and destructive. Coastal and river flooding, snowpack declines, lower summer river flows, impacts to farm and forest productivity, energy cost increases, public health effects, and increased pressures on many fish and wildlife species are some of the effects anticipated by scientists at Oregon and Washington universities.

The means to arrest and reverse these effects are at hand or within technological reach. Many of them carry co-benefits that would justify acting on them without the impetus of global warming:

positive economic returns on dollars invested in energy efficiency, energy price stability, and healthier air and water. Others will cost us something up front for insurance against the deeply disruptive and costly effects that we can expect absent any action. The earlier we take many of these actions, the less drastic they will have to be to achieve the same emissions reduction result.

But why is global warming an Oregon concern? We're one medium-sized state among 50 states and a world of nations, all emitting greenhouse gases. What can we do about it anyway? What do we stand to lose if we do nothing? What do we stand to lose – or gain – if we take the issue head-on?

These are the kinds of questions the Governor asked this Advisory Group on Global Warming to help answer, and this report is its response. It's far from a complete one. The choices made over many decades have led to the threat of global warming, and the solutions will take time and deliberate effort. There will be difficult choices along the way and surprising, promising opportunities as well. We will have the company of other knowledgeable and committed partners. And while the challenges are formidable, so are our skills and spirit and resourcefulness.

This report tries to answer the Governor's questions in stages. Part One, Section 2 (below) seeks to set out a pragmatic vision for how Oregon can address its global warming responsibilities and, in the process, seek investment and market opportunities for Oregon business and new jobs for Oregon workers. Section 2 also discusses proposed goals, categories of actions to achieve these goals and criteria for selecting actions. Section 3 sets out the scientific context for this response, while addressing the general "What is it?" and "What does it mean to me?" kinds of questions. The Advisory Group also reviewed the consequences for Oregon and Oregonians of a global failure to act decisively.

Part Two contains the detailed set of recommended actions. The Conclusion sums up the Advisory Group's proposition to Oregonians.

SECTION 2

Vision: Oregon Acts on Global Warming

2.1 Oregon's "Fair Share" of Global Greenhouse Has Emissions Reductions

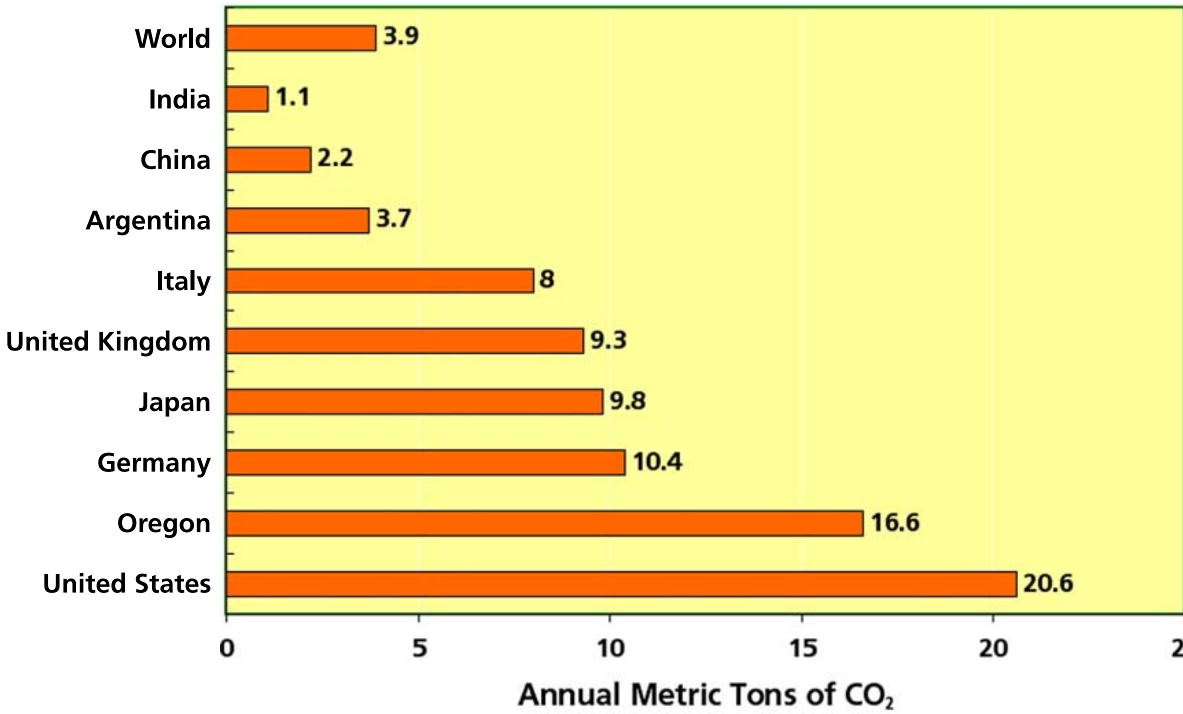
Scientists from the United Nations Intergovernmental Panel on Climate Change and others estimate that global CO_2 emissions need to be reduced by 60 to 80 percent below 1990 levels to avoid dangerous interference with the climate system. This target is based on limiting CO_2 to double the level that existed prior to 1750. Beyond this level, the risks of catastrophic climate change rise steeply. Serious adaptation actions will still be needed, even if emissions are held below this threshold.

The key to stabilizing CO_2 concentrations below this threshold is limiting total world emissions for the 21st century. What should be Oregon's "share" of this global responsibility? We are a small state, but are part of a country that is the world's largest consumer of fossil fuels and emitter of greenhouse gases. Both U.S. and Oregon emissions are growing rapidly.

Figure 2 below shows that Oregon has slightly lower CO_2 emissions per capita than the U.S. as a whole, largely due to our hydro-electric endowment. While about 43 percent of Oregon's electricity comes from carbon-free hydroelectricity, about 42 percent comes from the most carbon-intense source – coal (see Figure 6, Sec. 3.1). Oregon utilities are contemplating a mix of new resources (wind generation and gas- and coal-fired power plants) that is typical for U.S. utilities.

In 2002, electricity sources for the U.S. as a whole emitted 1.34 pounds of CO_2 per kWh. Oregon utilities emitted 1.05 pounds of CO_2 per kWh. Figure 2 also shows per capita CO_2 emissions from fossil fuels for the world as a whole and a sample of other countries. Oregonians emitted almost 17 metric tons of CO_2 per capita, compared to the worldwide average of about 4 metric tons. On this basis, Oregon is producing four times its "share."

FIGURE 2
CO_2 Emissions Per Capita From Fossil Fuels



Sources: United Nations, U.S. Department of Energy, Oregon Department of Energy

Other factors will play into global negotiations that will eventually have to allocate pollution rights and reduction obligations. It is unlikely, however, that in any such negotiations the United States and its constituent parts – the states – would be allocated any reduction target that is less than the worldwide average, given our higher than average per capita emissions. More likely, it would be some weighting of population, current emissions levels, cumulative greenhouse gas emissions and other factors.

Thus, a 2050 goal of reducing greenhouse gas emissions 75 percent below 1990 levels would likely be the least demanding target we might merit. We will likely be called upon to deliver more significant reductions than this, rather than less.

2.2 Principles

The Advisory Group began with the following principles to guide the selection of goals and actions to reduce Oregon's greenhouse gas emissions:

A. Oregon's greenhouse gas reduction goals and solutions must be meaningful, firmly grounded in science, and lead to effective reductions in Oregon's greenhouse gas emissions, commensurate with the state's share of the larger global problem.

B. Oregon should first begin with the most cost-effective solutions.

C. To the fullest extent possible, Oregon's actions should be designed to serve both the long-term economic well-being of the state and the goal of climate stabilization.

D. Recognizing that there are always tradeoffs between a long-term investment strategy and near-term costs and cash flow, the Advisory Group believes Oregon can and should be a leader – but the State can't get so far ahead that Oregon's businesses are not competitive in the short term. The State will need some safety valves to relieve short-term competitive pressures if others aren't living up to their responsibilities along with Oregon.

E. Oregon creates long-term economic well-being with an "investment strategy" that buys efficiency savings, new technologies, energy price stability and a competitive edge in marketing – and profiting from – the tools developed and the lessons learned.

F. Oregon will take no actions that impair energy reliability.

G. Oregon will look for ways to support innovation, especially if it leads to marketable products and services.

H. Oregon will partner with other states, Canadian provinces, tribal nations and other nations, where doing so will enhance the effectiveness of state-level actions and their co-benefits for Oregonians.

I. Reducing the state's greenhouse gas emissions won't eliminate the need to adapt to the warming climate that will result from changes already fixed in the atmosphere. Oregon must next develop an adaptation strategy.

J. Oregon is committed to equity in allocating both costs and benefits of this enterprise.

2.3 Goals, Strategies and Implementation

The package of actions recommended by the Advisory Group represents no more than a down payment on the long-term commitment the State – and nation – must make. Many other choices will be required of Oregonians and their successors over the next several decades to arrest and reverse the growth of greenhouse gas emissions that threaten our world. But isolated action, viewed out of context, will not persuade Oregonians to support the commitments and participate fully in implementing the actions, as they must, if we are to stabilize our climate at historically habitable levels.

The Advisory Group offers its recommendations embedded in a pragmatic vision of goals, ways and means. This vision statement may seem deceptively simple, but the Advisory Group believes it can serve to anchor the full range of its recommendations.

2.3.1 Goals

The Advisory Group believes that setting goals for Oregon, expressed together with actions that can plausibly meet those goals over time, gives purpose and structure to the task of reducing greenhouse gas emissions. The goals proposed here offer a pathway to climate stabilization that requires vigorous action, but also allows time for necessary individual and business adjustments. Oregon should adopt greenhouse gas emissions standards along with other states and local governments. A fuller discussion of the rationale for setting goals and for proposing these can be found in Integrating Action IA-1 in Part Two.

> **Near-term Goal**: The Advisory Group believes the State should first seek to meet its existing Benchmark #76, that CO_2 emissions not exceed 1990 levels. The Advisory Group recognizes that Oregon is unlikely to meet that benchmark by 2010 because Oregon exceeded the benchmark by 18 percent in 2000.
>
> In Integrating Action IA-1 (see Part Two), the Advisory Group recommends, as a near-term goal, that by 2010 Oregon will arrest the growth of and begin to reduce the state's total greenhouse gas emissions, meeting or making measurable progress toward meeting Oregon's current CO_2 benchmark.

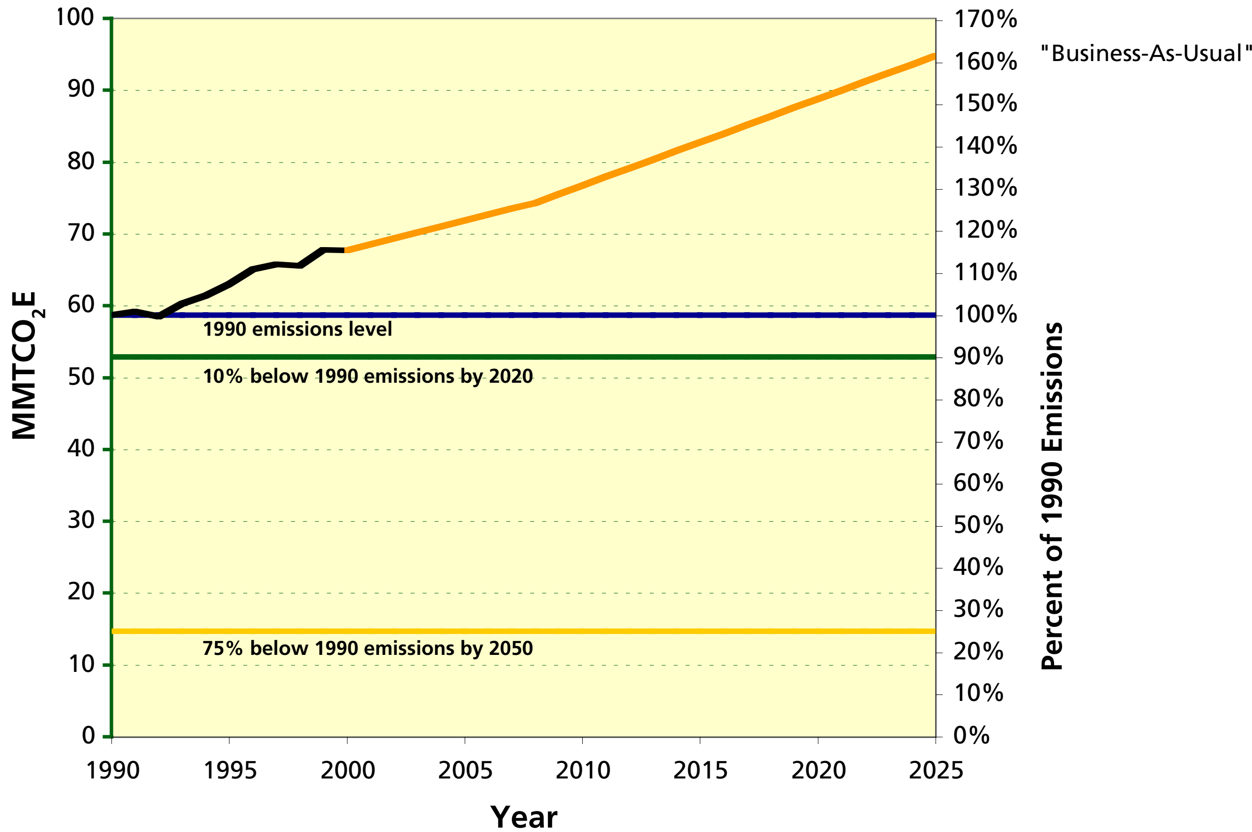
Based on current scientific guidance and targets adopted by other states and countries, the Advisory Group considers the following goals to be appropriate for Oregon:

> **Intermediate Goal:** By 2020, Oregon's total greenhouse gas emissions will not exceed a level 10 percent below 1990 levels.
>
> **Long-term Goal:** By 2050, Oregon's total greenhouse gas emissions will achieve a "climate stabilization" level at least 75 percent below 1990 levels.

The Intermediate and Long-term Goals are predicated on the United States government and the global community achieving comparable goals roughly synchronous with Oregon's efforts. Oregon can exercise leadership in setting goals and acting to attain them, understanding that leaders need followers (or, better yet, partners) to accomplish the global goal.

Having long-term goals will facilitate a long-term Oregon investment strategy to achieve those goals, rather than a series of short-term controls and costs (see Section 2.4, An "Investment-Based" Solutions Strategy, below). Figure 3 shows the projected emissions compared to the goals.

FIGURE 3
Historic and Forecast Gas Emissions in Oregon
Showing Proposed Goals



Along with the historical and forecast emissions shown in Figure 1, the horizontal lines in Figure 3 above show the level of greenhouse gas emissions (a) in 1990, (b) at 10 percent below 1990 levels, and (c) at 75 percent below 1990 levels. These levels represent proposed goals for the State's strategy and provide a context for the reductions from the proposed actions. The 75 percent reduction of greenhouse gas emissions is what is required globally to stabilize atmospheric concentration of greenhouse gases at 550 parts per million (ppm) of carbon dioxide. Although double the pre-industrial concentration, this level is assumed to avoid serious climate impacts.

2.3.2 Strategies

Implementation of the Advisory Group's recommended actions will greatly reduce Oregon's greenhouse gas emissions. Collectively the actions can be summed up in the following four common sense strategies:

Strategy One: Invest in Energy, Land Use and Materials Efficiency
This is nothing new for Oregonians, who have often set the pace for the rest of the country in the efficient use of these commodities. Oregon's efficiency investments have almost always

generated positive economic returns, together with environmental and quality-of-life dividends. Some payouts are quick (e.g., energy-efficient appliances); others may generate returns over decades (e.g., "green" buildings and mass transit in urban areas).

Many investments of this type will also generate business opportunities as described below in Section 2.5: The Economics of Addressing Global Warming: Costs, Investments and Opportunities.

Over the next 20 years, Oregon must, at a minimum:

- Equal the electric energy conservation savings achieved over the last 20 years, about 1,000 average Megawatts (aMW).
- Achieve comparable efficiency savings among natural gas and oil users.
- Offer more convenient and more efficient transit and other alternatives to driving cars and trucks, principally in urban areas along the I-5 corridor. Those areas have the ability to reduce the number of vehicle miles traveled and trips taken through careful land use and transportation planning.
- Insist on products that: 1) use fewer materials and require less energy to produce and transport to market; 2) last longer; and 3) are designed to be reused and recycled more easily and completely using less energy.

Strategy Two: Replace Greenhouse Gas-Emitting Energy Technologies With Cleaner Technologies

This strategy calls for reducing the amount of conventional coal, oil and natural gas used in vehicles, homes and businesses unless technological means can be devised to lower their greenhouse gas emissions dramatically.

It requires focusing investment dollars (and government policies) on developing renewable generating technologies that today are not sufficiently advanced to take up the slack.

Higher marketplace costs of conventional, mostly fossil-fueled energy sources are already upon us and are stimulating research and development. But new and more effective government policies – such as greenhouse gas emissions allowances and trading mechanisms – will be needed to meet the proposed goals. No less critical will be government procurement policies that explicitly value low greenhouse gas content (also referred to as "carbon content"), thereby creating a base market for these resources and setting an example.

By using a variety of electric-hybrid and other technologies, Oregonians will have new gas and diesel cars and trucks that produce far less CO_2 per mile traveled than existing vehicles. The transportation sector may ultimately rely on electric or hydrogen-powered vehicles, but biofuels are available now and hold considerable near-term promise, not to mention economic opportunity for Oregon's farmers.

The fossil fuel industries are exploring geological greenhouse gas sequestration (capture and storage) that could ultimately have costs comparable to other mitigation technologies.

Strategy Three: Increase Biological Sequestration (farm and forest carbon capture and storage)
Oregon's fields and forests are valued by Oregonians for economic, environmental and recreational reasons, but they can and must perform an additional service. The Advisory Group recommends actions to increase the amount of carbon that can be captured and fixed in new or restored forest and field growth and in the soil beneath. Decades of clearing forests, turning the soil, and building cities and highways where there had been undisturbed ground have both released large quantities of greenhouse gases and impaired the land's physical ability to take up and sequester excess gases. While we will continue to work the lands that must feed, clothe and shelter us, there are still land management choices that will restore much of this natural sequestration capability. Reforestation and conservation reserves in lands of marginal economic value are familiar tools. These uses must be stepped up dramatically, encouraged and sustained with government policies and public investment dollars.

Strategy Four: Educate Citizens, Conduct Research and Develop Technology
Reversing the causes of global warming and adapting to its near-term effects will be multi-generational tasks for Oregonians. Success is more likely if succeeding generations of Oregonians are educated about causes and cures and how these will evolve over time. Oregon also will cope better if it enlists the expertise in its colleges and universities to educate citizens and to conduct research into impacts and remedies that also can produce marketable products and services. Developing electrical and mechanical engineering skills will be essential.

Oregon can benefit from taking the early initiative in addressing global warming with such tools. Economic and export opportunities may emerge, particularly in areas such as energy efficiency, small-scale distributed renewables, and bio-sequestration techniques, where techniques and smaller-scale technologies can have broad application with lower capital requirements. Developing good quality curricula on global warming for freshman physical science, chemistry and physics courses is also essential.

2.3.3 Implementation

The Advisory Group issued a *Draft Oregon Strategy for Greenhouse Gas Reductions* for public review on October 13, 2004. After three public meetings and a public comment period (October 13 through November 15, 2004) the Advisory Group revisited the draft recommendations in light of 250 public comments and modified them where appropriate.

The recommendations are now forwarded to the Governor and copied to the Sustainability Board, which can then offer its thoughts to the Governor.

Even after the Governor acts to accept, decline or defer the recommendations, the process doesn't end. For some recommended actions, the next step will be an interim task force focusing on a specific measure and including a more targeted group of stakeholders along with state staff.

Finally, some actions will require legislative action. Some of this may come in the 2005 session, but more complex and far-reaching questions may not be ripe for legislative treatment until 2007. This is to ensure that sufficient analytic work has been performed to gauge costs and benefits and their distribution. It also will ensure that interested parties will participate as the measure is designed and evaluated.

The Advisory Group appreciates that major actions with significant and widely distributed consequences will require deliberation, not a rush to judgment. Given the imperatives of climate change effects, the Advisory Group does not suggest indefinite delay, but strongly favors a deliberate, yet urgent process with access for all affected parties.

2.4 An “Investment-Based” Solutions Strategy

Many, perhaps most, of the actions considered by the Advisory Group look and act more like an investment portfolio than unrecoverable costs. That is, they require that the State and its citizens *invest* financial — and political — capital in energy efficiency and new technologies. The net effect will be both reduced emissions of greenhouse gases such as CO_2 and positive long-term financial and quality of life returns to the State and to Oregonians.

To collect these benefits, Oregonians will have to be disciplined investors with a long-term investment horizon. Year by year state and private business investment dollars must be put into improving the emissions efficiency of Oregon’s economy. While some of these investments may not pay off for years, or in a few cases, even decades, many will recover their costs and pay dividends within only a year or two. Some may involve actions that would not have been taken except to contain the effects of global warming. Short-term needs and satisfactions may have to be deferred.

Advisory Group members understand there will be competing demands for these investment dollars and political tradeoffs to be made. Political processes often yield to near-term consumption over investment, whether expressed in popular government benefit programs or demands for tax cuts. It will be necessary to distinguish and perhaps separate these capital investments from the costs of day-to-day government and business operations.

Two examples from our own Pacific Northwest history are pertinent to choices facing us today and illustrate this effect.

1) **The Columbia River Hydropower System:** In the 1930s, investment began in what has become one of the largest hydroelectric power plants in the world with the energizing of Bonneville and Grand Coulee dams on the Columbia River. The projects were very costly at the time. Concerns were expressed that they would be financial “white elephants,” producing far more electricity than the region could absorb or pay for. Roosevelt’s New Deal Administration went ahead with them anyway, justifying them on other public policy grounds: they would put people to work during the Depression; they would make the central Washington desert bloom with agricultural products; and they would ease

navigation and river commerce inland past the Cascades of the Columbia, the fearful rapids now covered by the waters behind Bonneville Dam.

In the ensuing seventy years, the long-term financial benefits have paid back the initial investment many times over, as some of the lowest power rates in the nation have supported the region's economic development. Today about 40 percent of Oregon's electric power comes from this system at low and relatively stable rates that modulate swings in fossil fuel commodity costs. While we are still struggling to reconcile hydroelectricity with sustainable salmon and steelhead populations, the hydroelectric system gets us over 40 percent of the way to climate neutrality in our electric power system.[5]

Several of the Advisory Group's key recommendations involve developing a second generation of renewable resources: new wind, solar and biomass plants added to the existing hydroelectric base to meet our energy supply needs while producing no greenhouse gases.[6]

2) **Energy Efficiency Investments Under the Northwest Power Act of 1980:** The second example is more contemporary. In 1980 the region decided that, as new electric generating capacity was needed, we would invest first in energy conservation – in reducing demand for power – if that was less costly than building new power plants. We would do so, principally, by investing in more energy-efficient light bulbs and refrigerators and in set-back thermostats that lowered the heat when you weren't home, then automatically raised it when you returned from work. We invested in more efficient commercial lighting and industrial motors. Overall the utilities in the Pacific Northwest invested some $2.3 billion between 1991 and 2002, resulting in savings of some 1,818 average megawatts (aMW) annually. That's equivalent to three large coal plants' worth of electricity we have not had to generate. It came at a fraction of the cost of nuclear generation, gas, coal, or any other source, and at near-zero environmental cost. The average real levelized cost of these savings was approximately $12 per MWh. This is about one-third the market price of electricity during this period.

That entire $2.3 billion investment is fully recovered in electricity bill savings about once every 24 months.[7] The Advisory Group proposes to rely heavily on Oregon's ability to replicate this investment and these returns again in the next 20 years, realizing 960 aMW in Oregon and a regionwide total of 3,000 aMW, at comparable investment levels and savings.

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[5] The hydropower system is, however, threatened by global warming, which is projected to reduce Cascade Mountain snowpack by 50% or more by 2050 (University of Washington: "Effects of Climate Change on Water Resources in the Pacific Northwest." July 3, 2001). The snowpack serves as an extra "reservoir" for storing water to be used throughout the year. Potential increases in spring runoff would have to be spilled, rather than used to generate power.

[6] Recent studies have evaluated the cost-effectiveness of a "Renewable Portfolio Standard" that would require at least 20% of a utility's supply come from renewable resources. In 2001 the U.S. Energy Information Administration (USEA), using generally conservative assumptions – stable fossil fuel costs, higher renewable costs – found virtually no cost difference between the first case (no RPS) and the second (20% RPS). Two other studies, by USDOE's Interlaboratory Working Group and the Union of Concerned Scientists, using cost assumptions closer to market conditions that have prevailed since 2001, both found the 20% RPS case produced lower consumer costs as well as conferring co-benefits such as more jobs and reduced local air pollution. For Oregon, the UCS study projected ±1500 more jobs and $620 million in consumer cost savings by 2020.

[7] Per personal communication Tom Eckman, Conservation Resources Manager, Northwest Power and Conservation Council, September 16, 2004. This assumes an average value of the savings (i.e., the costs utilities avoided from reduced purchases from the short-term wholesale power market) of $37/MWh (= 3.7¢/kWh). In 2001, when West Coast market prices for electricity spiked to $250/MWh and higher, the savings realized in the Pacific Northwest were commensurately greater.

These investments to create lower energy costs for Oregon and Northwest businesses have also created new jobs insulating houses, installing thermostats, and designing and building energy-efficient windows and manufactured housing. Along the way Oregon companies developed markets in other states for those same windows and manufactured housing units, bringing new dollars and jobs back into Oregon.

Today, if Oregonians had the option of driving more fuel-efficient cars that still met their needs and the option of driving them fewer miles to work or shopping, they would realize a similar return on investment when gasoline prices rise as they did in 2004.[8] Citizens would be better insulated against the disruptions that such price spikes cause in Oregon's economy, and the dollars saved could circulate within Oregon, creating more state jobs and goods.

This time the "public purposes" are different from those of other eras: not creating jobs in a Depression or saving energy in an oil embargo, but reducing emissions of CO_2, methane and other greenhouse gases. They also include creating energy price stability and building economic opportunity for the next generation of Oregon workers and entrepreneurs.

The tools should look very familiar, however. They are tools for investing in energy efficiency — in homes and businesses, in the means of transportation, and in land use and transportation systems design for our urban areas. They are also investments in a new generation of renewable energy technologies — not in large hydroelectric dams this time, but in smaller, run-of-the-river projects, wind turbines, solar photovoltaic cells, and crops from Oregon farms that can be converted to biodiesel fuels.

Some energy efficiency investments can be earning positive returns in two years or less. Some renewable energy technologies, such as large wind, are competitive today with fossil fuels, so those early returns will be positive also. Other investments will take longer to turn positive, as the dams did, but they will immediately result in more stable energy costs for Oregonians, again, as the dams did.

In the larger process, Oregonians will discover products and services to be marketed to other areas that are slower in responding to global warming threats as described in Section 2.5 below.

There will be other less intuitively obvious benefits. Lower emissions from power plants and vehicles will mean cleaner air in Medford, Bend, Portland and other communities. Not only will there be more clear days for admiring Mt. McLoughlin, the Sisters and Mt. Hood, but there will be healthier people to enjoy the view and fewer kids handicapped by asthma and other respiratory diseases.

Energy market competition from conservation and renewables can have the effect of lowering demand for fossil fuels and, therefore, damping energy prices from those and competing sources.[9] A future energy user who is relying on a mix of conservation, renewables and gas will be

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8 Even before 2004's price increases at the gas pumps, from 1999 to 2003 Oregon monthly household energy budgets were squeezed by average increased costs of 12% in electricity, 17% in natural gas, and 50% in gasoline (data compiled by The Oregonian from USEIA and other sources, September 11, 2004).

9 See, for example, U.S. Energy Information Administration Study SR/OIAF/2001-03, June 2001.

contributing to environmental values, *and* saving on energy not used due to efficiency gains, *and* paying a lower rate for each delivered kilowatt hour (or therm of gas).

Where it seems the fairest and most efficient way to accomplish our goals – especially in capturing energy efficiencies in buildings and equipment – we rely on regulatory tools such as building codes. We appreciate that regulation can be politically difficult to propose and sustain. We note, however, that over 40 percent of the 3,000 MW the region now is conserving is coming from building codes and appliance efficiency standards. These are the *lowest cost savings* being captured day in and day out. Households save money directly on their energy bills and in lower costs for the goods they buy. Oregon businesses save on operating costs and produce more cost-competitive products and services. Designed properly and applied consistently, regulatory tools can contribute to a competitive "level playing field" among businesses. Each could make comparable investments to conserve energy, so that no one competitor can offer lower costs in the short term by deferring these investments and the benefits they confer on the community as a whole.

2.5 The Economics of Addressing Global Warming: Costs, Investments and Opportunities

2.5.1 Overview

In any discussion of the economics of addressing global warming, it's easy to get trapped in the underbrush of near-term costs and to miss the forest of rational economic calculation of long-term savings. In some cases, those near-term costs are going to be higher, but often the costs will be matched and more by the returns Oregon families and businesses will see directly. The savings that are captured as *avoided costs* of adaptation to a warmer, wetter and more uncertain world may be more substantial still.[10]

Near-term costs are further offset by helping Oregon businesses stay *competitive* in a world moving to greenhouse gas limits. Costs of recommended actions should also be measured against the *economic opportunities* that will open for Oregon businesses that develop goods and services for sale to a world in the market for low greenhouse gas solutions.

Most activities we engage in as Oregon citizens and businesses – driving a car, turning on a light, disposing of garbage – result in emissions of greenhouse gases. Any serious proposal to reduce these emissions affects us all, and we need to understand its costs and benefits. This is challenging for a set of actions that looks ahead fifty years. Much is unknowable: what fuel prices will do; what statutory constraints may be adopted; and what technology breakthroughs can mitigate costs. Once firm decisions have been made on actions, we can use computer models to predict costs and benefits (with the qualification that uncertainty increases the farther ahead we look).

[10] The effects of global warming on Oregonians and the costs we will bear in adapting to climate change are not just a function of what we do in one state. They also depend on the degree to which our leadership and actions are matched by leadership and actions across the country and around the globe.

It also may be useful for us to think about "cost" in more than one way. For example, there is the "cost" of an investment we might make, whether in the stock market or in buying a more efficient refrigerator. We pay an up front "cost," but we recover that cost and begin to earn net "benefits" (e.g., savings on energy costs) if it is a good investment. Many actions proposed here accomplish both lower emissions *and* efficiencies that are cost-effective. That is, they will return to consumers a net return independent of their value in reducing greenhouse gas emissions.

Other actions involve developing products and services that can be marketed outside of Oregon, as well as applied at home. As greenhouse gases are increasingly regulated by states, the federal government and, through international agreements, Oregon can gain an economic advantage by selling mitigation actions we have developed to reduce Oregon's emissions.

We incur a "cost" when we buy health or fire insurance. We don't know if we'll be sick or have our house burn down, but we believe paying these "costs" is justified to mitigate our risk against those outcomes. We still shop for the lowest-cost insurance that will do the job, but we understand it's a good decision even though it may not provide a return under all scenarios. We're advised not to underinsure, so there's enough coverage to rebuild our house or our health.

When we pay for building dams and levees to protect against devastating floods, we're incurring a similar "cost" for a different kind of insurance, one that diverts the potential for catastrophic danger and damage. There is a difference: we speculate that our house *might* burn down, but we know floods *will* occur. We know that occasionally – every fifty to one hundred years – a truly catastrophic flood will occur (for example, in 1996, 1948 and 1894). We pay an upfront cost and get our return in the form of less destruction and lower costs to rebuild. We think it is money well spent.

The actions in this package are insurance that is similar in different respects to both examples. We are insuring against the potentially calamitous consequences of overheating the planet. We can only approximate their specific effects, geographic distribution and intensities; but science tells us that they are at least as likely as that hundred-year flood. We can choose to pay an up front "cost" to mitigate against the worst of these effects by reducing our use of fossil fuels and the emissions that are released. We want the lowest cost actions in our "policy," certainly. We also want them to add up to an effective response.

The question for Oregonians is: Do we think these measures are a good value for our dollars?

2.5.2 Costs of Measures

The Advisory Group is recommending to the Governor a package of 46 actions across seven areas of State, business and citizen activity. In most cases, staff has developed a preliminary estimate of whether an individual measure is projected to be *cost-effective to the consumer over the effective lifetime of the measure.*[11] More than 60 percent of the proposed measures meet this

[11] The summary tables at the front of each category of measures (e.g., Energy Efficiency) show, in two columns to the right, the estimated savings in greenhouse gas emissions and a preliminary staff estimate of whether the measure is cost-effective.

first test (or are policy choices without direct cost implications). Other measures may also prove to be cost-effective for their insurance value or when weighed against the costs of adaptation.

Some measures – developing renewable energy technologies or increasing forestation of under-producing lands – in many applications can be expected to yield commercial profits and jobs to offset implementation costs.

Of the most significant (Category I) actions, two are constrained by law to be cost-effective. The Northwest Power and Conservation Council's 20-year energy efficiency goals (incorporated in action EE-1) must meet a test, established in federal law, of being cost-effective to the region (and in nearly all cases, to individual electricity consumers). The California state law establishing the "Pavley" auto tailpipe pollution standards (TRAN-1) requires that new cars be able to meet the twin tests of low greenhouse gas emissions and cost-effectiveness to the purchaser.[12] For these and other recommended measures, the Advisory Group has adhered to this "investment" standard of cost-effectiveness to the buyer over the life of the measure or vehicle. Note also, that if the energy-efficient appliance or auto purchase is financed, the added capital costs would be offset by the consumer's month-to-month savings.

The other Category I action with the greatest potential for cost consequences is the proposed greenhouse gas allowance for electricity, gas and oil (GEN-2). Estimating the costs and benefits of this measure depends on its design, on future energy markets and costs, on technology evolution and on future regulatory actions. We have little control over most of this, but we can model different paths to our greenhouse gas content goal and select one that offers the greatest greenhouse gas savings at the lowest cost and risk. For example, a least-cost path may be one that allows utilities and other suppliers time to phase out old equipment and ramp in new renewable and other technologies. An effective design may maximize the ability to trade emissions savings and offsets with California and Washington, lowering compliance costs. By relying on energy efficiency and renewable technologies that are unaffected by fossil fuel markets and price swings, compliance actions can minimize abrupt rate shocks to consumers and cost impacts that could undermine the competitiveness of Oregon businesses. The design of a greenhouse gas allowance mechanism can be made sensitive to competitive pressures on Oregon businesses if other states and countries are not pursuing parallel paths to greenhouse gas reductions.

It is also true that many of the actions that could be required to meet a greenhouse gas content allowance will be cost-effective, beginning with the energy efficiency actions recommended above (EE-1). Many of the wind, hydroelectric and biomass projects that could be used to comply with the standard are cost-effective today and are being installed. We can also expect technologies that are still higher-cost today, such as solar photovoltaics, to drop in price as production economies of scale are achieved and technological gains are made.[13] Well-crafted public policies such as Renewable Portfolio Standards can accelerate this effect by creating market demand that encourages technological advances and cost gains. The nation and the Northwest have

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[12] California, AB1493, Pavley, 2002.

[13] When modern wind turbines were first being designed and installed in 1980, they offered about the same unsubsidized output cost ($0.25/kWh) that unsubsidized photovoltaic solar generation offers today, supporting expectations that similar output cost reductions can be anticipated. See also Footnote 6 for renewable energy cost projections from different informed analysts.

experience with this effect through development of auto, appliance and housing energy efficiency standards that resulted in miles-per-gallon gains, more efficient refrigerators and thermally-efficient windows.

Because the cost and other consequences of a greenhouse gas content allowance are not knowable until a design has been developed and modeled against a range of future scenarios, the Advisory Group recommends that an interim task force do the designing and modeling over the next 12 to 18 months. Prior to the submission of any proposal to the 2007 legislature, all interested parties will have a reasonable idea of how the allowance mechanism would work and what the cost and other outcomes should be.

All far-reaching measures such as these three will need to be revisited regularly by State officials and legislators. Circumstances will change, new choices will emerge, market costs of energy will move up or down, and adjustments will be needed to maintain a least-cost path.

2.5.3 Avoided Costs

No one likes paying more up front for an appliance, a car or a house. But as noted above, we've been doing just that in Oregon and the Pacific Northwest for the last 20 years as we've bought more efficient appliances, cars and houses, installed insulation and better windows, or introduced more efficient equipment in our stores and factories. They've paid back the extra cost, on average, in about eighteen months from the date of purchase.

Avoided costs from efficiency gains are just the beginning. Slower growth in demand for power and gas means less new transmission infrastructure – poles and pipelines – has to be built, saving more cash. Competition from new efficiency measures and renewable technologies will act to hold down costs from competing fossil fuels.

Efficiency gains are exactly like having a share of your power coming in at a fixed price (renewables also possess this price stability attribute). So households, and especially businesses, avoid the uncertainty for a crucial cost input into their budgets and cost-of-goods. Any energy-dependent company can tell you about the cost of electricity price uncertainty when unprecedented price spikes hit the West Coast as they did in 2001.

Then there are the avoided costs of coping with the physical changes global warming is already bringing: heavier rains, longer dry spells and more extreme storms. We think of those as "future" costs that we can discount (maybe they won't arrive?). But we're already starting to pay them in the form of higher insurance premiums today, as insurers try to anticipate their liabilities for *future* loss claims. Companies that are susceptible to higher costs of doing business in a warmer world are paying higher insurance premiums if they fail to address this business risk. Flood insurance costs are rising in low-lying coastal and other storm-prone areas.

There's one other aspect of avoiding costs that gets too often overlooked. It's the value to Oregon of keeping dollars at home, circulating in our local economy, supporting new businesses (preferably ones that can export products and import more dollars). When we spend our limited capital on imported energy from the Middle East or Venezuela, on coal from Wyoming, on gas from Alberta, and soon from overseas as liquid natural gas (LNG), it's gone. Every dollar exported to buy non-local energy is like a little loss of muscle fiber from our collective economic body. We have to compete in a muscular world economy, and we're a little weaker each time we fill the gas tank.

2.5.4 Staying Competitive

Our major trading partners in Europe, Canada and Japan are already investing in new goods and services to deal with global warming. We cannot stay competitive by standing still. If you're a multinational doing business in the European Union or Japan (think Intel, Hewlett-Packard, Boeing, or Nike), you're already working out your greenhouse gas reduction and trading strategies. This is particularly true now that the Kyoto Protocol on greenhouse gas reductions became effective following Russia's signature. All of Oregon's major trading partners in Europe and Asia, plus Canada, will be doing business with consideration for the greenhouse gas emissions consequences of their actions. If trading with the United States results in a greenhouse gas penalty, these countries may adjust the volume or value of their transactions. Conversely, if Oregon's products and services come at a lower greenhouse gas cost, we could gain a trading advantage over states that are slower off the mark.

Oregon businesses will need to adjust to a Kyoto-constrained world or risk their overseas markets going to companies, states and countries that anticipated the greenhouse gas rules taking shape globally. As Canadian Ambassador Michael Kergin warned in speaking to a Portland business breakfast on December 8, 2004, "American businesses risk being shut out of many commercial opportunities in Kyoto-compliant markets."[14] Kergin applauded the self-starting qualities of U.S. businesses that adapt their products and practices to the expectations of their customers, an attribute he said they must leverage to compete in a Kyoto-constrained world.

[14] Quote from notes taken during Ambassador Kergin's presentation.

The Kyoto Protocol

The Kyoto Protocol to the United Nations Climate Change Convention will become legally binding on its 130 Parties on February 16, 2005. The Protocol's entry into force means that from that date:

1) Thirty industrialized countries will be legally bound to meet quantitative targets for reducing or limiting their greenhouse gas emissions.
2) The international carbon trading market will become a legal and practical reality. The United States will not be able to participate in that market unless it elects to ratify the Protocol.
3) The Clean Development Mechanism (CDM) will move from an early implementation phase to full operations. The CDM will encourage investments in developing-country projects that limit emissions while promoting sustainable development.
4) The Protocol's Adaptation Fund, established in 2001, will start preparing to assist developing countries to cope with the negative effects of climate change.

Under the Kyoto Protocol, industrialized countries are to reduce their combined emissions of six major greenhouse gases during the five-year period 2008-2012 to below 1990 levels. The European Union, for example, is to cut its combined emissions by 8 percent, while Japan will reduce emissions by 6 percent. The total cut in greenhouse gas emissions is at least 5 percent from 1990 levels in the commitment period 2008-2012.

Only four industrialized countries have not yet ratified the Kyoto Protocol: Australia, Liechtenstein, Monaco and the United States. Together Australia and the United States account for over one third of the greenhouse gases emitted by the industrialized world. The 30 industrialized countries that have committed to individual, legally-binding targets to limit or reduce their greenhouse gas emissions represent 62 percent of the greenhouse gas emissions emitted by the industrialized world, which is 32 percent of total global emissions.

2.5.5 Exploiting the New Markets

Business Week, in its August 16, 2004, cover story on global warming, argues that "Companies that pioneer low-emissions cars . . . or find cheap ways to slash emissions will take over from those who can't move as fast." What are some of those opportunities for Oregon businesses and entrepreneurs?

(A) Services

The Pacific Northwest pioneered energy conservation in the 1970s and '80s. The Northwest Power Act of 1980 directed us to buy the cheapest "electricity" first, even (especially) if it came from efficiency savings. In the process, we developed expertise that we've marketed elsewhere in the U.S. Portland Energy Conservation, Inc. (PECI) started life as a City of Portland office, spun itself off as a private enterprise, and pioneered commercial building "commissioning" to verify that the new building controls and other efficiency technologies would deliver savings as advertised. It now sells these services nationwide.

In Oregon and Washington, members of the International Brotherhood of Electrical Workers (IBEW) and National Electrical Contractors of America (NECA) are developing skills in photovoltaic equipment installation, sometimes by providing their services free to install solar panels at schools. Lane Community College in Eugene now trains renewable energy technicians.

Large wind energy projects in Eastern Oregon are generating power at competitive and stable costs, paying royalties to farming families double-cropping their lands with windmills, and raising rural tax bases. They're also creating marketable skills at engineering firms like CH2MHill and law firms like Stoel Rives, both of whom now sell their project development services outside Oregon.

Another play for eastern Oregonians is likely to be *bio-sequestration* services – a fifty dollar word for growing more trees and plants that can retrieve carbon from the atmosphere and hold it for long periods of time. They could also make money from animal manure from which methane can be retrieved and converted to electricity. Other sources include biomass crops, which can be burned for energy with zero net CO_2 emissions, and changing fertilizing and tilling practices to approaches that reduce emissions or allow soil uptake of carbon. As carbon limits are imposed around the globe on utilities and other companies, agricultural practices that can offset carbon emissions will have growing market value.

Portland has an international reputation in urban design circles for being a city that takes planning and quality of urban life seriously. A co-benefit, which is becoming a marketable service, is that a city planned for efficiency is a city that can manage its greenhouse gas emissions. Portland and Multnomah County are working toward a goal of reducing greenhouse gas emissions to 10 percent below 1990 levels by 2010. Urban design firms like David Evans and Associates can leverage their contributions to Portland into competitive advantages elsewhere. Oregon architecture and engineering firms are learning to design "green" buildings that can earn national certification points and lead to contracts inside Oregon and out.

The Climate Trust, an Oregon-based private non-profit organization, has created a service niche that uses CO_2 offset dollars from new power plants and other sources to fund renewable energy, energy conservation, transportation savings, bio-sequestration and other projects that reduce greenhouse gas emissions.

As an example of how we can gain even when Detroit is slow to react, Portland stands to benefit as the market for hybrid (gasoline plus electricity) cars grows in the U.S., fueled by new greenhouse gas-reduction regulations being adopted by California (and recommended in this Oregon Strategy). The major companies supplying these cars today are Toyota, Honda and Ford. The Port of Portland is the primary West Coast port of entry for Toyota and Honda. More manufacturers and suppliers are needed.

(B) Goods

Oregon builders of windows and manufactured housing, to take two examples, were pushed to build their products to the higher efficiency standards set under the Norhtwest Power Act of 1980. Both industries found outside markets for those same products as other areas responded to higher energy costs in the 1990s.

Their counterpart today may be Shell Solar in Vancouver, Washington, which manufactures photovoltaic panels. Soon Shell could be using the silicon-producing capability of firms like Wacker Siltronics in North Portland or other wafer manufacturers from the high-tech community.

As markets generally value "green" products more highly, there can be spinoff benefits for Oregon Country Beef, wild (and sustainably-harvested) salmon, and the emerging Oregon organic natural foods cluster. It's no coincidence that Kettle Chips, with a state tax credit, assistance from Oregon Department of Energy and funding help from the Energy Trust of Oregon – innovative responses – installed the largest grid-connected solar energy facility in the region on its factory rooftop in Salem this year.

Oregon firms like PPM Energy develop wind farms all over the country. A new product, Green Tags, was pioneered by the Bonneville Environmental Foundation in Portland. BEF sells Green Tags that are wind-based (supplied by PPM, BPA), solar-based (from developer Gerding-Edlen's Brewery Blocks and other solar installations), and even cow manure-based (from the Port of Tillamook's waste-to-energy project) in 30 states and up into Canada.

As the market for efficient products and processes heats up, the high-tech and software industries on the West Coast all stand to profit if they anticipate where more precise and responsive instruments and controls will deliver efficient energy results. Opportunities range from home heating systems to interstate high-voltage transmission lines.

(C) Investment Opportunities

The Pacific Northwest was once the international leader in renewable energy technology and applications. That was when we were investing in and developing the hydropower capability of the region's rivers and snowpack.

Renewable energy could again be a key economic development "cluster." In addition to devising new efficiencies for the existing hydropower and transmission infrastructure, Oregon has wind, biomass and waste conversion opportunities awaiting smart exploitation.

Oregon isn't positioned to sell anyone gas or coal conversion technology, but we could be leaders and net gainers if we move earlier than the competition to develop the renewable and co-generation technologies and siting services that can then be offered for sale. What's needed? First, a regional market that's big enough and active enough to stimulate entrepreneurial activity and attract investment capital. Oregon by itself probably isn't big enough. But this is no time to be parochial. The states of the Pacific Northwest, plus British Columbia, are a respectable market with a good number of companies already developing products for the renewable energy market. If we want them to stay here, creating jobs and wealth, we have to offer them an accessible West Coast market. We'll have to work California into the strategy as well.[15]

Fortunately, our Governor has joined with these neighboring jurisdictions to establish a framework – the West Coast Governors' Global Warming Initiative – with the shared goal of reducing greenhouse gas emissions West Coast-wide. Developing renewable generating technologies and infrastructure, including transmission capacity, is on the common agenda.

Oregon, Washington and California will all need to do their part, starting with public commitments to purchase output, setting expectations for greater utility reliance on renewables to meet load growth and replacement needs, and addressing regional infrastructure needs (e.g., transmission and integration services, expedited siting and permits). The states will need to consider how regulatory and tax codes may be adapted to encourage local industry development.

Oregon's educational system needs to be supported and, in turn, needs to provide industry support by building basic and applied skills in energy efficiency and renewable technologies. Our universities already support resource evaluation (Oregon State University has wind resource expertise and the University of Oregon has solar expertise). Technology research, development and demonstration are relatively weaker here. One idea is establishing a regional "incubator" for technologies that are past laboratory work, but not yet ready for commercial prime time, something Oregon and Washington could elect to collaborate on.

2.6 Partners

So, Oregon makes its contributions and investments. What difference can we make? We're not even one of the largest states in this country, and global warming is a global concern. If we make these investments today, what's to keep competitors in other states from tilting the playing field to take short-term advantage of Oregon businesses while they invest for long-term sustainability?

[15] California has demonstrated the importance of local market stimulation when it became the world leader in installed windfarm capability in the 1980s. Today it has a 20% Renewable Portfolio Standard requirement for its electric utilities, tax credits for citizens and businesses to install their own equipment and is considering committing an additional $100 million in state funding to further buy down the costs of solar installations and to build solar manufacturing capability in the state.

These are all good questions that the Governor must be prepared to answer, and the Advisory Group offers its help in doing so.

First, we're not alone. The agreement reached among the three governors of Oregon, Washington and California means the West Coast states will proceed in parallel and sometimes joint efforts. If our three states were a single nation, we'd be the seventh largest emitter of CO_2 from fossil fuels globally, so we are a player. Our emissions are significant, and our efforts to reduce them can and must be comparably substantial. The actions being proposed in that process, which parallel our own, include joint procurement efforts for hybrid and low-emissions vehicles for state fleets, providing electric hookups at truck stops along the Interstate-5 corridor, and other actions where lower costs and greater benefits can be obtained through three-state coordination.

While many recommendations that the Advisory Group is making to the Governor are consistent with the West Coast Governors' Global Warming Initiative, the Advisory Group also explicitly adopted the seven key recommendations from the "West Coast Governors' Global Warming Initiative, Staff Recommendations to the Governors," November 2004 (Appendix E):

1. Set new targets for improvement in performance in average annual state fleet greenhouse gas emissions.
2. Collaborate on the purchase of hybrid vehicles.
3. Establish a plan for the deployment of electrification technologies at truck stops in each state on the I-5 corridor, on the outskirts of major urban areas and on other major interstate routes.
4. Set goals and implement strategies and incentives to increase retail energy sales from renewable resources by one percent or more annually in each state through 2015.
5. Adopt energy efficiency standards for eight to 14 products not regulated by the federal government, establishing a cost-effective efficiency threshold for all products sold on the West Coast.
6. Incorporate aggressive energy efficiency measures into updates of state building energy codes, with a goal of achieving at least 15 percent cumulative savings by 2015 in each state.
7. Organize a West Coast Governors' conference in 2005 to inform policy-makers and the public of climate change research concerning the West Coast states.

Second, we have other partners in the six New England states and five eastern Canadian Provinces that form the Conference of New England Governors and Eastern Canadian Premiers, who have committed to a regional "Climate Change Action Plan." Other states — New York, New Jersey, Delaware, Maryland — are stepping up to their responsibilities. The state-based initiatives have one other important quality: they are bipartisan. Both Republican and Democratic governors are leading their states into this effort.

Third, our major trading partners in Europe and around the Pacific Rim are Oregon's partners as well. The nations of the European Union are considering ways that would allow individual U.S. states to participate directly with European countries in greenhouse gas credit trading programs if the states adopt comparable limits on emissions.

In fact, we should be less concerned about acting prematurely and far more concerned with being into the marketplace too late. Already other countries have established leads in important commercial areas: Denmark in wind turbines, Japan in solar cells, and Canada in fuel cells. We believe Oregon and the West Coast can compete in greenhouse gas technology markets, but not if we lag behind in our commitments at home (see Section 2.5 above, The Economics of Addressing Global Warming: Costs, Investments and Opportunities).

SECTION 3

Context

3.1 A Primer on Global Warming

The Earth is kept habitable by gases in the atmosphere that capture part of the sun's energy. Those gases are called "greenhouse gases" because of their heat trapping properties. At a relatively stable concentration, these gases are beneficial. However, human activity has produced a significant increase in greenhouse gases in the atmosphere since the beginning of the Industrial Revolution in the mid-18th century. At this point, additional greenhouse gases are pollutants that are destabilizing the earth's climate with potentially catastrophic consequences.

Climate and Weather

We all confuse the two words in everyday speech, usually with no dire effect. But for purposes of dealing with climate change, the distinctions are crucial.

Weather is changeable day by day. Cool, wet Augusts are not unknown, nor are 70 degree days in February. Local, transient phenomena produce local, transient weather effects. Can the planet truly be warming if we're having a damp and dreary summer?

Yes, because climate is "weather" averaged over time. Western Oregon's climate typically consists of cool, wet winters that build snowpack in the mountains, showery springs that last through the Rose Festival in June, and dry, warm to occasionally hot summers that end about mid-October. Eastern Oregon is colder in winter and hotter in summer, while the coast is the reverse due to climate effects of the ocean and mountains.

There are larger temporal climate effects too. Most of us recognize that an El Nino disturbance will result in drier than normal weather over the year, while a La Nina will be wetter than usual. More expansively, there is a switch (known as the Pacific Decadal Oscillation) that seems to flip over every 20 to 30 years, going from a drier-than-usual climate to a wetter-than-usual one.

None of these tells us if it's going to rain this weekend. That's weather.

Global warming is a climate effect, a rise in average temperatures, a background effect with which shorter-term climate effects interact to produce weather. A hot year will tend to be hotter and a cool year not as cool. A La Nina might produce more intense rain in April and less moisture in August than it would have absent the effects of climate change. Global warming will have – is likely already having – such weather effects. Some of these are predictable: overall warmer weather year round, less snowpack, melting glaciers, more extreme storms and so on. Some are far harder to predict. Will it rain more or less? On the same time table as now or will the pattern shift?

We can't use today's weather to judge in what ways climate change is already affecting us. We can look at global average effects and effects observed over the passage of years to see where the disturbing patterns of climate change are coming into focus.

There are growing numbers of dramatic signs that this is occurring. Every writer on the subject has a favored illustration. The snows atop Mount Kilimanjaro that inspired Hemingway's famous story will be gone within fifteen years after enduring for thousands. Robins are seen 250 miles north of the Arctic Circle, where native Inuits have no word in their language for "robin." Alaska permafrost is melting, buckling highways built atop it, while the Iditarod sled race must start two weeks earlier to be certain of snow on the trail to Nome. Glaciers are retreating around the world. The Arctic ice cap is 20 percent smaller than it was 25 years ago, and scientists predict open seas at the North Pole within 50 years.

Closer to home, University of Washington scientists project a 50 percent reduction in Northwest snowpack by the middle of this century. The glaciers in Montana's Glacier National Park are retreating at an accelerated rate, and the forest fire season is arriving earlier and staying longer.

The *Third Assessment Report*, published by the United Nations Intergovernmental Panel on Climate Change (IPCC) in 2001, concluded that human-generated emissions have contributed substantially to the observed global warming over the last 50 years (see Figure 7 below). Since 1990, the globe has seen the 10 warmest years on record. Since 1980, we've seen 19 of the 20 warmest. The Earth is warming faster than any time in the past 1,000 years.

Global warming, or global climate change caused by greenhouse gas pollution, is arguably the single most serious threat to human civilization and even to the most robust and insulated ecosystems. Sources of greenhouse gas pollution from human activity have changed the global climate and will continue to change the climate for the foreseeable future. Our challenge is to slow, then reverse these global changes, so their near-term effects can be contained and the longer-term life-threatening impacts do not occur.

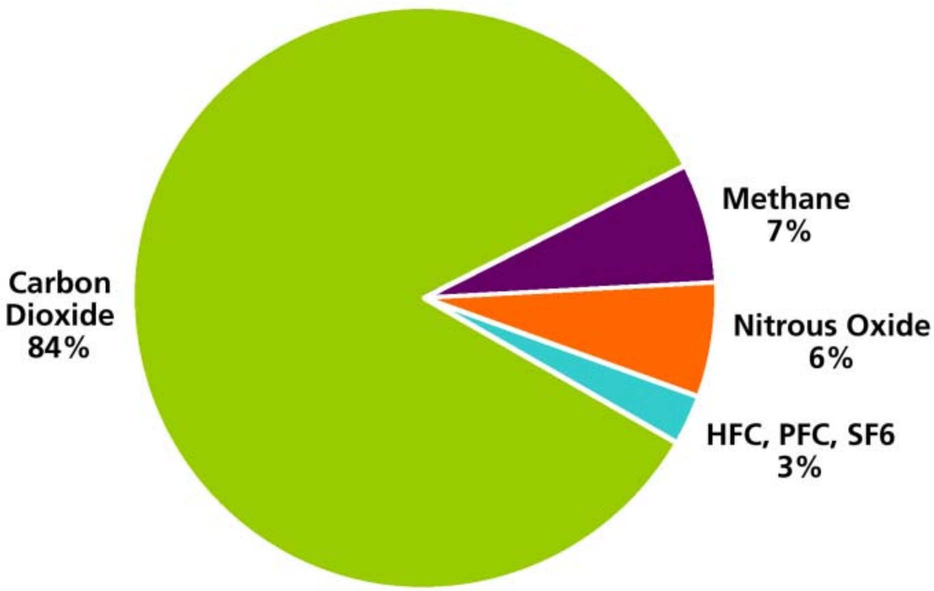
The United Nations Framework Convention on Climate Change (UNFCCC), ratified by the United States in 1992, set an objective to meet the challenge:

> The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic [human-induced] interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner. *(UNFCCC, Article 2*)

Many IPCC scientists believe that stabilizing the atmospheric concentration of carbon dioxide at 500 to 550 parts per million (ppm), which would represent a doubling since 1750, would help avoid the most dangerous changes. However, that is a best estimate and assumes that sudden, unanticipated shifts in climate conditions do not occur. In any case, we are on a track to reach this level of atmospheric CO_2 by around 2050 and to continue onward to a tripling or quadrupling of pre-industrial CO_2 concentrations in a "business as usual" scenario. At these higher levels, we face dangerous, potentially calamitous effects on our economy and our physical environment.

Methane, nitrous oxide and halocarbons are significant greenhouse gases, but the pollutant of greatest concern is CO_2. Figure 4 below illustrates that about 84 percent of greenhouse gas pollution in Oregon comes from CO_2 emissions. The majority comes from burning fossil fuels, such as coal, gasoline, diesel and natural gas. Emissions from methane, primarily from cattle and landfills, contribute 7 percent to the state's greenhouse gas pollution; nitrous oxide emissions, primarily from agricultural practices, contribute about 6 percent. Manufactured halocarbons, which include hydrofluorocarbons, perfluorocarbons and suflur hexafluoride, account for the remaining 3 percent.

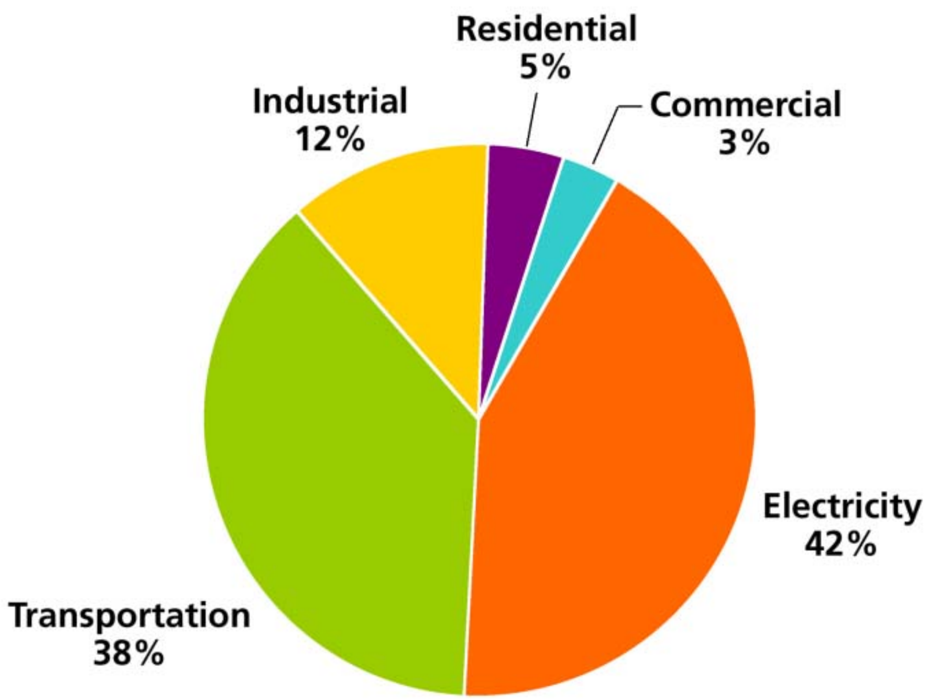
Figure 4
Oregon Greenhouse Gas Emissions Sources in 2000



Source: Oregon Department of Energy (see Appendix B)

Figure 5 shows the percentage of CO_2 emissions from each major sector in 2000. CO_2 is the predominant greenhouse gas emitted by Oregon. The largest source of CO_2 emissions is from the production of electricity that Oregonians use including electricity generated out-of-state for Oregon consumers. Transportation emissions, mostly from cars and trucks, account for a close second. Fossil fuels used directly in the industrial, residential and commercial sectors are mostly from burning natural gas and distillate fuel.

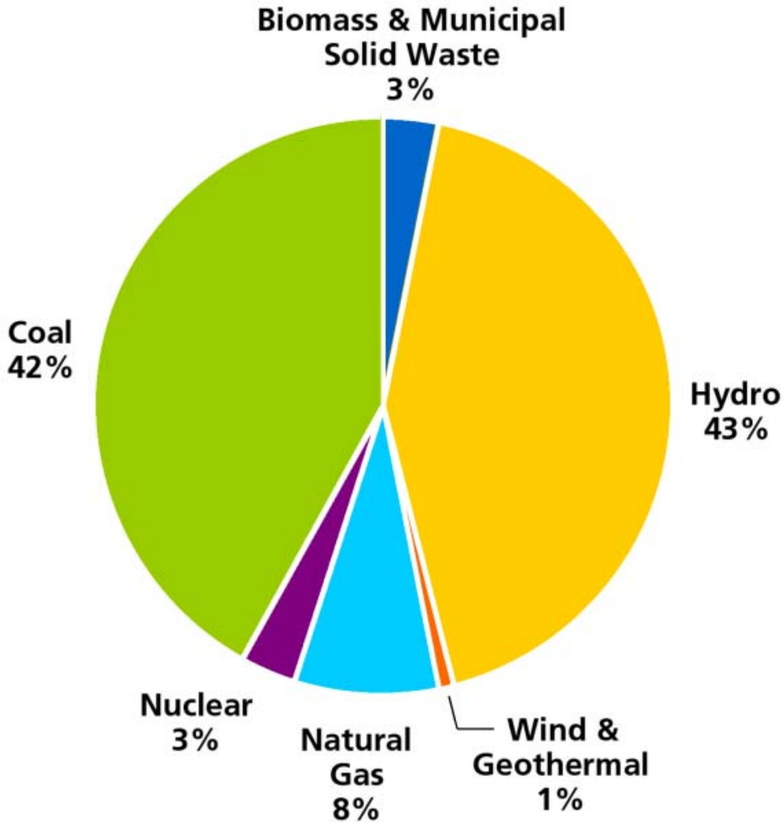
Figure 5
Oregon's CO_2 Emissions from Fossil Fuels by Sector



Source: Oregon Department of Energy (see Appendix B)

Figure 6 looks in greater detail at the types of electricity generation that supplied Oregon's consumers in 2002. The generation mix in Figure 6 is based on power plants whose output is dedicated to Oregon utilities. Utilities can generate this output at facilities that they own, either in-state or out-of-state. It also includes cases where a utility purchases the output of a specific power plant. For Portland General Electric (PGE), the total of such purchases and ownership is less than its total electric load. In that case, the calculations for the figure assume that the remainder of the electricity is supplied to PGE by a mix of resources from the Northwest Power Pool. Utility purchases from the Bonneville Power Administration (BPA) under long term contracts are credited with the BPA resource mix.

Figure 6
Electricity Generation Mix Supplying Oregon 2002



Source: Oregon Department of Energy (see Appendix B)

In addition to these greenhouse gases, changing patterns of land use and land cover are altering the atmospheric concentrations, especially from changes to tropical forests. Everywhere, soils, forests and other vegetation have the potential to remove CO_2 from the atmosphere. They also contribute emissions of CO_2, methane and nitrous oxide as forests are cut and as agricultural practices disturb soils and add chemicals.

Emissions of sulfate aerosols, microscopic airborne particles released from burning fossil fuels, introduce a further complexity. These aerosols tend to reflect sunlight before it reaches the Earth and, therefore, have a cooling effect on the atmosphere. On the other hand, carbon black, or soot, is also released from burning fossil fuels, and it can have a localized warming effect that is only just beginning to be understood.

Scientific Uncertainty

Critics of efforts to contain global warming often argue that the science is "uncertain." Of course all science is "uncertain" in that it is subject to challenge by new evidence or interpretation. The "scientific method" requires that challenges to an assertion or hypothesis must be based on data and analysis that are peer-reviewed and critically examined by other scholars with expertise in the same field to see if it stands up to scientific scrutiny.

We rely on the "greenhouse effect," a phenomenon not seriously disputed in any academic institutions, to maintain the habitability of the earth. This effect is the result of a layer of gases in the upper atmosphere that surrounds the earth. This necessary layer traps, as heat, some of the solar energy that enters the atmosphere, maintaining a temperature range within certain optimal limits that sustains life on the planet as we know it. Without this effect, scientists estimate that temperatures would be over 50 degrees F. cooler, too cold to be habitable. Conversely, too thick a "blanket" of these greenhouse gases can overheat the surface of the earth and affect habitability.

Skeptics of global warming sometimes imply that "uncertainty" is the same as a 50/50 possibility that global warming is either occurring or not. Even if this were true, a 50% chance that the world would see some of the likely impacts scientists are forecasting would merit a determined response. But the inference is both misleading and untrue.

An overwhelming majority of the world's climate scientists are finding a causal link between growing concentrations of CO_2 and other greenhouse gases generated from human activity (fossil fuel and other sources) and a warming of the planet – beyond levels known to prevail in pre-industrial times. These scientists serve on the Intergovernmental Panel on Climate Change (IPCC), assembled by the United Nations from leading academic institutions around the globe.

Considerable uncertainty remains over the timing, distribution and potential severity of climate change on storm activity, sea level rise, forest health, water supplies, tropical disease propagation and other terrestrial effects. These effects could as easily be more severe, or occur more rapidly and abruptly, as less severe and slower to gather. As computer models become more refined, we can expect to understand in greater detail the timing and distribution of effects. What is clear, however, is that the more greenhouse gas concentrations accumulate, the more we will be affected by these changes.

Climate science asks that we apply probabilities to complex, long-term effects and adopt policies in response that must span decades. For example, Climate Change 2001: The Synthesis Report by the IPCC gives 66 percent to 90 percent confidence in data that show that there were higher maximum temperatures and more hot days over land areas in the latter half of the 20th century, but it has 90 percent to 99 percent confidence that the globe will see such changes during the 21st century. It also has 90 percent to 99 percent confidence that there were and will be higher minimum temperatures, fewer cold days, fewer frost days, and a reduced range of temperature changes from day to night over land areas. We must learn to work with such probabilities, acknowledge both the evidence and the remaining uncertainty, and focus on solutions.

When global climate change models incorporate the effects of increased concentrations of greenhouse gas pollution, aerosols and cyclic changes in the sun's output, the models most closely recreate the past climate history and give us most confidence in future estimates. While all three components play a role in our climate, greenhouse gases are now the major determinant.

Figure 7

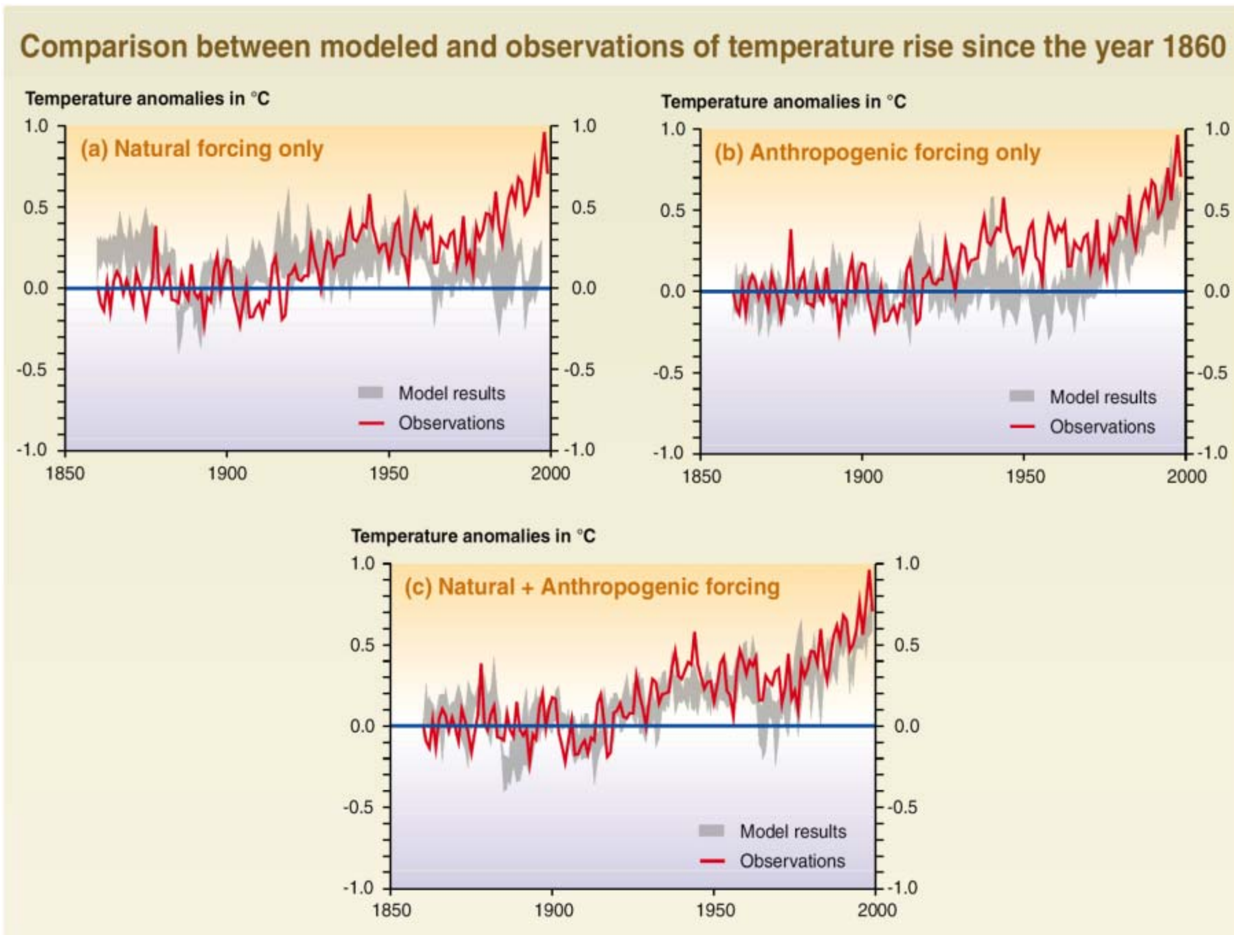


Figure SPM-2: Simulating the Earth's temperature variations (°C) and comparing the results to the measured changes can provide insight to the underlying causes of the major changes. A climate model can be used to simulate the temperature changes that occur from both natural and anthropogenic causes. The simulations represented in the band in (a) were done with only natural forcings: solar variation and volcanic activity. Those encompassed by the band in (b) were done with anthropogenic forcings: greenhouse gases and an estimate of sulfate aerosols. And those encompassed by the band in (c) were done with both natural and anthropogenic forcings included. From (b), it can be seen that the inclusion of anthropogenic forcings provides a plausible explanation for a substantial part of the observed temperature changes over the past century, but the best match with observations is obtained in (c) when both natural and anthropogenic factors are included. These results show that the forcings included are sufficient to explain the observed changes, but do not exclude the possibility that other forcings may also have contributed.

Figure 7 above demonstrates the relationship between natural and anthropogenic (human-generated) sources of climate variation. Credible forecasts require modeling both sources of variation. In the period after 1960, most of the modeled variation is man-made, rather than natural. The combined model (c) using both sources of variation closely tracks observed climate changes.
Source: The Third Assessment Report of the Intergovernmental Panel on Climate Change, "Climate Change 2001: The Synthesis Report, Summary for Policymakers," p.7.

Complexity and Modeling Climate Change

The physical systems that shape our climate are staggeringly complex. Computer models can begin to simulate this complexity and predict the future, but in broad rather than detailed terms. Current models of climate cause and effect are now delivering useful results at the global level. More localized effects – such as storm activity in the Pacific Northwest – are cautionary, but still imprecise. This is because local climate is affected not just by global shifts in temperature regimes, but by the interactions of those changes with local topography, ocean currents and heat exchanges.

Depending on how global heat exchangers (ocean currents and winds) are altered, the Northwest might see more weather systems coming in from the Pacific (therefore, wetter weather) or from Alaska and Canada (more storms bringing less moisture). More dramatic changes in the globe's engines of heat exchange could bring weather patterns that are largely unpredictable locally, except that as more heat is moved about the earth, there likely will be more intense storms and other weather events.

Since 1958, an observatory on Mauna Loa, Hawaii has measured atmospheric CO_2 concentrations. Based on data from polar ice cores, the pre-industrial concentration was about 275 parts per million (ppm). In March 2004, the atmospheric concentration reached 380 ppm. Until recently, the annual growth in the CO_2 level was less than 2 ppm. For the last two years it has been about 3 ppm. Because the immediate increase in the rate is not understood, it is not possible to know how long concentrations will continue to increase at this higher rate.

About half of annual human CO_2 emissions (which include the burning of tropical forests) are absorbed by terrestrial plants and oceans. This absorption is also referred to as a "carbon sink," or bio-sequestration, as mentioned earlier. It includes physical and biological processes in the upper layer of the oceans. It also includes re-growth of trees in the eastern U.S. and Europe and expanding Siberian forests from changes in precipitation and temperature. It appears, however, that sinks are not taking up CO_2 as fast as they were. In any case, uptake is not increasing to compensate for increased emissions. Science is finding the potential for serious adverse consequences to ocean life from CO_2-induced changes in water chemistry.

The IPCC projects that CO_2 concentrations will rise to between 450 and 550 ppm by 2050 and will continue to increase until the international community agrees to change worldwide emissions. The increase in CO_2 emissions since 1750 has not been exceeded during the past 420,000 years and likely not during the past 20 million years.

Greenhouse gases affect global warming on long time scales, both because of their lifetime and the long time it takes the atmosphere to reach equilibrium with the warming effect of the gases. Many greenhouse gases remain in the atmosphere from many decades to centuries. Achieving a stabilized concentration level requires significantly reducing emissions over a long period. Even on a path to significant reductions, carbon dioxide concentrations and temperature continue to rise for centuries after emissions peak and begin to be reduced. Temperatures will also continue to rise even after the concentration has stabilized at a new level, such as double CO_2 concentrations at 550 parts per million. Even under the reduction scenarios depicted, we should expect impacts at a scale that will require adaptation as well as mitigation actions.

Given the path we are on, the IPCC projects that global average temperatures will rise from between 1.4˚Celsius to 5.8˚C (2.5˚Fahrenheit to 10.4˚F) by 2100. While there is uncertainty about the specific consequences of global warming in the Northwest, scenarios from various global climate change models show the types of changes we could expect to see within the next few decades. *The Scientific Consensus Statement on the Likely Impacts of Climate Change on the Pacific Northwest* (see Appendix C) states, with intermediate certainty, that the average annual temperature in the region will increase by 2.7˚F by 2030 and by 5.4˚F by 2050, with consequences outlined below.

3.2 The Costs and Consequences to Oregon of a "Business as Usual" Strategy

Dr. Thomas Karl of the National Atmospheric and Oceanic Administration and Dr. Kevin Trenberth of the National Center for Atmospheric Research published a paper in the December 5, 2003 issue of *Science* warning that, on our current course, "the likely result is more frequent heat waves, droughts, extreme precipitation events and related impacts [such as] wildfires, heat stress, vegetation changes and sea-level rise." A 2001 report from the National Research Council says greenhouse warming and other human alterations of the climate system may increase the possibility of large, abrupt and unwelcome regional or global climatic events. Researchers do not know enough about such events to predict them accurately, so surprises are inevitable.

In the Northwest, scientists at Oregon State University, the University of Washington and other study centers have already observed measurable warming. The Institute for Natural Resources at OSU hosted an all-day symposium in June 2004, "Impacts of Climate Change on the Pacific Northwest," to solicit guidance from the region's own cadre of qualified climate and resource scientists. The objectives included pooling what is now known about state-level and regional effects and identifying critical gaps in our knowledge. The symposium resulted in the *Scientific Consensus Statement on the Likely Impacts of Climate Change on the Pacific Northwest.*

The Climate Impacts Group of the Joint Institute for the Study of the Atmosphere and Ocean at UW reports that, over the last century, the regional average temperature increased by 0.8˚C (1.5˚F). Precipitation has increased both east and west of the Cascades. East of the Cascades, the increases are dominated by changes from April to July. West of the Cascades, the largest increases are in November, which has overtaken December as the wettest month. While precipitation has increased, there has been a decline in snow water equivalent in the spring. Likewise, the timing of the peak snowmelt has advanced 10 to 40 days earlier in most of the Western United States over the last 50 years, according to Dr. Edward Miles of the Climate Impacts Group. Likely specific impacts are summarized in the next sections.

3.2.1 Water. Warmer temperatures will lead to less snow pack on the mountains in the winter, which would mean less water available later in the summer. A study by the Climate Impact Group indicates the April 1 snowpack in the Cascades declined about 50 percent from 1950 to 2000. The largest losses are at the lower elevations, consistent with increased warming. Scenarios of future climate change show a further decline by 2090 that could reach 72 percent below the base period of 1960 to 1990. This could reduce summertime stream flows by 20 to 50 percent, according to an article in Science (February 20, 2004, p. 1124). Peak flows will occur four to six weeks earlier than present. This will increase the risks of both winter and spring floods and summer droughts. In particular, rainfall-dominated rivers in the low-lying basins west of the Cascades would likely see increased flooding from more rain-on-snow events.

Earlier melting is expected to change the timing of water in the rivers, which will affect fish and wildlife and commerce on the river. Lower summer flows would reduce water for irrigation, especially in Eastern Oregon where irrigation districts rely on melting snow to sustain rivers through the summer and to refill reservoirs. Lower summer flows would also increase the impacts of water pollution or require more restrictions on discharges into rivers.

In addition to increased winter runoff, streams and rivers are likely to be affected by more intense storms. Both will increase the peak surge in rivers, which increases erosion and flooding. Increased storm intensity would affect smaller and urban drainages more than larger streams and rivers. Increased erosion can reduce available farmland, create hazards and difficulties in navigable waterways, and harm fish and wildlife.

Warmer water temperatures will harm native species such as salmon and could interfere with the life cycle of all fish, as could a change in the timing of runoff and precipitation going into rivers. For example, the Climate Impacts Group reports that the migrating smolt stage is when salmon are most vulnerable to climate variations. The timing of arrival in the coastal waters plays a big role in their survival, and changes in water flow from climate variability can change that timing. Climate factors also influence the type, distribution and abundance of predators, as well as the salmon's food supply in estuaries and the ocean.

Changes in the timing and volume of stream flow in the snow-melt dominated rivers could have economic impacts on the hydropower system. If climate change decreases the summer flow at the same time rising temperatures increase demand, both locally and in California, then the price of summer power could rise substantially. On the other hand, the price of winter power could drop as warmer temperatures decrease demand for heating while more precipitation as rain increases the supply of hydropower.

The Climate Impacts Group projects that precipitation will increase above that of the 1990s by about 7 percent by 2050, but it has less confidence in that projection, which is based on the combined results of eight climate change models. There will likely be larger year-to-year variation in precipitation.

On the other hand, some models suggest that as Arctic ice cover diminishes, storms will tend to track further north at key times of the year and the Pacific Northwest could see reductions of precipitation of up to 40 percent. Some 20 percent of the ice cap over the North Pole has melted since 1979, according to Dr. Kelly Falkner at Oregon State University. If the current rate of loss of the Arctic ice cover continues, the summertime cover could disappear by 2050.

There is little or no room for growth in supply in the regional reservoir storage system. According to Dr. Miles, the regional system was designed on the assumption that about 70 percent of the regional storage would be snow pack. Consequently, we have the ability to store behind dams only about 30 percent of the annual average flow. It would be hard to increase that storage. The level of water scarcity is relatively new. Demands on water systems are growing, but supplies remain essentially fixed. There is less margin of safety available to cope with the unexpected.

3.2.2 Human Health. Scientists expect a higher increase in human mortality due to higher temperatures, even though there may be a decrease in cold-related illnesses and mortality. Abnormally high temperatures in Europe claimed more than 20,000 lives in August 2003. Another potential threat is from changes in regional diseases when vectors, such as insects that live or thrive in warmer climates, migrate northward.

3.2.3 Agricultural Production. Changes in temperature, precipitation, water availability and soil moisture will affect the distribution and productivity of crops. They will also increase the prevalence of diseases and pests. Although Northwest agriculture will probably be able to adapt to any changes with the first doubling of CO_2, adaptation will likely be costly. Dr. Eban Goodstein and Laura Matson of Lewis and Clark College suggest, in an initial estimate, that the lost value of irrigation water could range from $465 million to $2.4 billion. They caution that the estimate should be considered illustrative, not predictive.

3.2.4 Oceans and Coasts. The IPCC's most recent mid-range estimate is for an average rise in sea level of 9 to 88 cm (4 inches to 35 inches) by 2100. Recent studies of Greenland glaciers indicate greater instability than previously expected. This indicates that average global sea level rise may be close to one meter this century, the high end of the IPCC predictions.

This sea level rise could cause severe disruption for ecosystems and people along the coast. Likely effects include increased coastal erosion, both from sea level rise and increased wave height. The Climate Impacts Group notes that the increased frequency of storm surges may be more significant for low-lying areas than sea level rise alone.[16] Likewise, increased storms could lead to saturated ground and more slope failure in coastal bluffs and hills. Impacts would vary along the Oregon coast because of the variation between rocky shores and sandy beaches and because the southern part of the coast is rising due to

[16] Scientists and engineers in the United Kingdom have estimated that by 2080, "hundred-year" floods could be occurring every three years, potentially affecting 3.5 million people in low-lying areas and inflicting costs in the tens of billions of pounds annually. Large numbers of properties would become uninsurable. (David King, Chief of the Office of Science and Technology, United Kingdom, quoted in Science Magazine, January, 2004, p 176).

geological forces. To the south, that coastal rise is offsetting initial sea level rise. However, relative sea level is rising between Florence and Astoria.

According to Dr. Roger Samuelson at Oregon State University, global climate change is likely to change the local coastal ocean circulation and ecosystem and regional meteorological conditions. There would be both direct and indirect effects from global warming on regional winds in terms of mean wind direction and, hence, waves; in addition, warmer temperatures would result from the enhanced greenhouse effect. Winds, stratification of water levels and currents are extremely important for coastal habitat.

Concurrently, climate change will produce a different fish community in the ocean waters off the Northwest coast. This fish community may not support large salmon populations or other commercial species, according to Dr. Robert Emmet at the National Oceanic and Atmospheric Administration Northwest Fisheries Science Center. Dr. Goodstein and Ms. Matson estimate that economic damage from salmon population decline due to global warming will range from $359 million to $7.2 billion by 2050. Given other influences on salmon productivity, the Climate Impacts Group notes that future changes in salmon population and distribution are speculative; it is clear, however, that a warmer climate and lower summer stream flows can be expected to further affect the stocks adversely.

3.2.5 Forests. Forests are expected to experience stress as well. Tree growth is likely to be limited by drier summers, and the possible increase in wildfires, pests and disease are significant threats. At higher elevations there will be loss of alpine habitat.

In the near term, increased levels of CO_2 may act as a fertilizer. Along with possibly increased precipitation and slightly warmer temperatures, tree growth may increase. However, as forests become denser under favorable initial circumstances, they will demand more water and, therefore, will become even more vulnerable to stresses from increasingly dryer, warmer summers and from climate variability.

The Climate Impacts Group points out that increases in summer temperatures without increases in precipitation would result in greater potential evapo-transpiration and decreased soil moisture. That would result in increased stress and decreased productivity, which would overwhelm any benefit from increased CO_2 fertilization of trees.

Warmer temperatures will also favor pests and disease. As the climate continues to change and become more severe, the forests will become even more susceptible to variable climate. Larger and more intense forest fires are a likely result.

Dr. Ron Neilson, U.S. Department of Agriculture Forest Service, reports that there have been high fluctuations in wet-dry climate cycles for the last 30 years in the Northwest. Climate change may increase the annual and decadal variability of precipitation. He concludes that climate variability, far more than fire suppression, has led to the sudden rise and severity of wildfires in recent years. In fact climate variability is the primary determinant of fire occurrence, location and timing. Fuel buildup from previous fire suppression exacerbates fire intensity, but not its occurrence, according to Neilson.

3.3 Mitigation and Adaptation

The Advisory Group distinguishes between "mitigation" of greenhouse gas emissions (actions that will reduce emissions and their warming effects) and "adaptation" to global warming (those actions necessary to cope with the warming effects that are already unavoidable). Nearly all the actions included in this Strategy are mitigation actions intended to arrest and reverse the growth of such emissions, eventually reducing them to levels compatible with historically stable global climate patterns. Mitigation is generally afforded highest priority by scientists, given the potentially calamitous consequences to the planet of unrestrained warming.

However, Oregonians and their counterparts in other states and countries will also face adaptation questions, even if the mitigation actions are all adopted and implemented vigorously. This is because the accumulation of CO_2 and other greenhouse gases in the atmosphere has grown significantly from levels generally associated with sustainable climate patterns; and, as discussed above, global temperatures are already rising and will continue do so for the next several decades, even with deliberate and effective mitigation.

Since it is unrealistic to propose that modern industrial societies will be able or willing to end fossil fuel consumption abruptly and live with the ensuing social and economic disruptions, most scenarios assume continued emissions and accumulation of greenhouse gases well into this century. Under the most optimistic assumptions, accumulations level off at between 450 parts per million (ppm) and 550 ppm by mid-century before effective mitigation – if it is vigorously and effectively pursued – begins to reduce concentrations. If this is the case, then Oregonians and others will be adapting to the effects of warming for several generations to come.

These effects on Oregonians, discussed elsewhere, may include: more frequent and more intense floods, forest fires and sea level rises that could threaten low-lying coastal communities. Additional effects will likely include altered habitats and changes in wildlife species distribution; more constrained water supplies (affecting hydroelectricity generation); warmer, wetter winters; hotter, drier summers; and heightened exposure to diseases now largely confined to the tropics. All of these effects and more will require adaptation.

If only Oregon and a few other jurisdictions act to mitigate emissions, the adaptation challenge grows commensurately and, eventually, beyond our capacity to adapt. The Advisory Group's mitigation strategy assumes that Oregon does not act to mitigate alone, but as one of a growing alliance of states and nations rising to this challenge.

The Advisory Group believes the next task, once Oregon has determined its near-term mitigation course, will be to identify adaptation actions, set an adaptation strategy and implement it. This task is beyond the charter of this Group, but final recommendations include encouraging the Governor to assemble a successor group of citizens and government agencies to take on this next great challenge.