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Is climate change the biggest challenge facing us today; if not what is?

Some people have said that climate change is not the greatest stress that we face in California or the United States. Population growth, economic development, changing land use are larger stresses. Our population is growing, its growing increasingly in coastal areas; often these areas are quite fragile in terms of environmental impacts and ecosystem impacts. We have changing land use; farmland, wild lands, are being developed. Certainly in terms of predictions for the next 50 or 75 years, those effects are larger than climate change in numerical magnitude. But climate change is an extra burden which comes on top of that. There's a real risk that will be the straw that breaks the camel's back. So, for example, in terms of California, the growing urban population, the relatively high level of water use in urban populations; that will increase our need for water more than climate change will reduce the supply. But having a reduced supply and a less reliable supply from climate change on top of a population of 50 million by mid century and 70 – 80 million by the end of the century compared to 36 million today. Having climate change on top of those other drastic changes is really dangerous. We have less latitude of error, we have less leeway with the population growth, with the changing land use with the urbanization. It's not true that climate change is the only stress; but it's the case that climate change can be particularly deadly as an aggravator on top of these other changes.

Please discuss the issue of intergenerational equity with regard to climate change?

The basic logic of climate change is that today's generation is being asked to spend money to reduce emissions to avoid harmful effects, many of which, most of which, will be felt, not by today's generation; some will be felt by today's generation but most will be felt by our children and grandchildren and great grandchildren. To some extent, there is an inequity issue. Why should we have to spend money that's going to benefit them. That's basically a moral question. You can turn it around and say if we don't spend the money, we're going to leave a legacy of a damaged planet for our children and our grandchildren and our great grandchildren. Why should we do this? What have they done to deserve this?

Water is an important issue in California; could you tell us about the economic implications of climate change on future water supply and reliability of urban and agricultural water?

Climate change is a huge threat for California's water supply. That's because basically we're living in an arid landscape, we're living in a desert. The statistic is that two thirds of the water of precipitation that falls in California falls north of about Sacramento. Two thirds of the population and water use occurs south of Sacramento. So, we're living in the wrong places; we should all be living in Redding and things would be much simpler. But also, rain falls at the wrong time; most of the rain falls in winter between October and March. Seventy-five percent of all the water used in California is used between April and September. So, the precipitation falls in the wrong location and at the wrong time of year. In order for us to have 36 million people living happily in prosperity in California we have huge engineering systems which store the water so we can use it in the late spring and summer even though that's not when it rains; which

moves it around so we can live in the Bay Area and southern California even though most of the rain occurs in the northern Sacramento Valley. We rely on transportation and we rely on storage to take the winter rain and snow and make it available in the summer when we really need it. We rely on the snow pack in the Sierras for about one third of our major storage. One of the effects of climate change is warmer winters. We're not going to have that much snow; in fact the snow pack may entirely vanish by the end of the century. We lose a significant chunk of our storage which we really can't afford to lose. What that means is less certain water supply. More over, in addition to the winter storage, the projections suggest that we will have more dry years. Our weather and precipitation is tremendously variable. If you look at the average rainfall in California over the last ninety years, the rainfall has varied between one-third of average to about 3 or 4 times average, about a ten fold range. So, you can have a wet year, then you can have a bunch of dry years before you get another wet year. The projections are that, that variability increases. We're more likely to have longer runs of dry years and deeper droughts. We deal with those again by storage; by carrying over and storing water in wet years for use in dry years. We may have longer droughts, more severe droughts than we've experienced in the past. So, that's a major challenge to the reliability of our water supply.

What do you think might be some of the unexpected economic consequences of climate change on the local, national and global scale?

One of the consequences is that our water supply becomes more variable. In that sense we can have more bad surprises. The projections are a paradox; we can have both wetter winters and drier summers. By wetter winters it's likely that a lot of our rain comes in a few intense storms. We may get more intense storms and that's not as welcome as a more steady supply of water. We also face other risks, for example the hottest summers with vegetation in the wild land areas mean a greater risk of wild fires, like the one that happened in the Oakland hills in 1991. We had a heat wave the summer before last, again, those things are more likely to occur. I've talked about temperature, the other major piece of climate change is sea level rise. The sea level has risen about 10 inches over the last century off the coast of California. The projection for the next century is really uncertain; the IPCC projected, best guess, half a meter, about 18 inches. There's big uncertainty about the ice sheets in Greenland and in the Antarctic. Some of the Arctic and Antarctic experts that I've spoken to think that one meter is much more likely and possibly two meters. That's over the course of a century; it doesn't happen over night. The future that's sometimes forgotten is winter storms; when you have storms in winter, the waves can be 4, 5, 6 feet above sea level. If the sea rises 6 inches, a given storm produces waves which are now higher. As the sea rises the likelihood of waves crashing over and flooding the land rises exponentially. We face a flooding risk well before that time the sea level rises 1, 2, 3 or 4 feet. With each inch or couple of inches rise in sea level we have a disproportionately greater chance of flooding, so we face a suite of possible unpleasant surprises.

In 2006 you authored a report called, "Managing Greenhouse Gas Emissions in California"; could you tell us about the findings of this report and what impacts have you seen?

I was the co-author with Alex Ferrel at Berkeley. That report looked at the impact on the California economy of meeting the Governor's 2020 goal which was written into law in AB 32. ... The chapter that got the most attention was by my colleague, David Roland-Holst, which looked at the impact of the California economy in 2020 of meeting the Governor's emissions target. What he found was essentially there wouldn't be a harmful impact, in fact there would be

a small gain to California from meeting this target. There'd be an increase in jobs but it would be small, 1 or 2 tenths of a percent. But this was in a context where most people expected there would be a major cost, a major reduction in jobs, a major reduction in output. What David found is that for several economic reasons, that wasn't likely, it was more likely that California would actually grow slightly. That surprised a lot of people. I think there's solid evidence behind it and that was one of the factors leading the Legislature to pass AB 32.

Please tell us how you predict responding to climate change is going to impact the economy of California?

There are three reasons why it may be beneficial; that is reducing our emissions could be beneficial to California. One is that part of the way of doing this involves a strong emphasis on energy efficiency; improved energy efficiency in buildings; in automobiles, the so called Pavley bill which is being contested because the EPA has refused to certify it which would lower greenhouse gas emissions but also raise fuel efficiency of vehicles. The point about energy efficiency is that in the end, it saves more money than it costs. So, it puts money in people's pockets, individuals and firms, throughout the economy. It actually gives people some extra money to spend on other goods. The second factor is California differs from the US in general; what's produced in California tends to have a smaller greenhouse gas footprint, carbon footprint. The commodities that we consume that have a heavy carbon footprint tend to be produced out of state. If you make carbon more expensive and provide economic incentives to generate less carbon emissions, that shifts part of our spending power away from commodities we import from other states and towards goods and services we produce at home. It actually benefits our domestic California economy. The third piece of this is we assume, again as part of implementing the greenhouse gas reduction policy, there would be a push to promote technological innovation. That would lead to economic growth if it's successful; not just reducing emissions but lowering the costs and making capital more productive. It's these three factors, which means this won't be harmful, in fact it could be a benefit for California.

What is the economic benefit for California being a leader in responding to climate change?

California can gain from improving energy efficiency from technological innovation for its own economy. It's also going to gain because the problem of climate change is going to generate whole new industries. Over time, over the next 50 years, the world economy has to reduce its reliance on fossil fuels and shift to a much heavier dependence on non-fossil fuels, renewables. This requires all sorts of new technologies to measure emissions, to measure the heat in buildings so we can have a more sensitive heating or cooling in buildings, different forms of powering automobiles, electric cars, improved diesel cars. There's going to be a whole host of new technologies, not just in California, but around the world. There's a real potential for California to gain an edge and to gain the commercial benefit by being out in front and developing these technologies and selling them not only to California but to other states and other countries around the world.

Industries have used rationales for not responding to climate change, however, now the table seems to be turning; ultimately do you predict that economics will be the driving force that helps us prevent this disaster?

I think regulation will be the driving force; behind this is regulation and I would include a tax on greenhouse gas emissions, a carbon tax as form of regulation or a limit as other countries have

done under Kyoto, accepting limits or targets to limit their emissions. The point is, in order to make these work you need emission trading, among other things, which then creates an economic incentive. You have a cap and that's a regulation. If you're going to go over the cap you're going to have to either not go over your cap and lower your emissions or spend money to clean up somebody else's emissions. But if you can clean up your emissions more than the cap, you make a buck selling this. What will drive it ultimately is the decision to limit our emissions. Economic incentives will help smooth the way to bringing this about

What is the potential for greenhouse gas emission trading markets in California and how could the market be designed and implemented?

Let me explain the logic of emission trading; it provides a safety valve, that is if you are a firm and you have a limit on your emissions and you're right up against the limit and it's tremendously expensive to find a way to reduce your emissions, you have the option of paying somebody else to reduce his emissions and that goes towards your excess emissions. It gives you the safety valve that if you can reduce someone else's emissions more cheaply than your own. All that matters in this context is the total emissions. It doesn't matter whether I'm emitting in terms of the effect on the planet or you; all that matters is the total emissions. If I can pay you to reduce your emissions more cheaply than mine, the planet is a winner. More over, if I can reduce emissions more than I need to, given a regulation, without emission trading I don't have any incentive to do that. Why should I go above and beyond what I'm required to do. With emission trading I can make a buck buy selling emission reductions that I don't need in terms of my own regulatory situation but somebody else could. It provides flexibility; it encourages more emissions than simple regulations would give; in principle it's a good idea. That said, with any scheme, the details matter and there are different ways of designing it. It's important that emission trading in this case be accompanied by regulatory efforts requiring efficient appliances, automobiles with limited greenhouse gas emissions from their tailpipe; requiring electric utilities when they sign new long term contracts for electricity, to sign contracts with very efficient generators or with very low emission generators. What I see us wanting is a mix of regulatory policies but beyond that as sort of an umbrella, you want an emission trading system; because you want it to be the case that if somebody, somewhere in California, maybe somebody not regulated, has a bright idea and sees a way to reduce emissions, he should get a buck, he should be able to make some money reducing those emissions, given the incentive to do it.

What economic policies do you think should be implemented at the state or national level?

The economic policies that we're going to need to reduce greenhouse gas emissions in California and nationally I think will involve emission trading but also a bunch of regulatory programs aimed at promoting energy efficiency and de-carbonizing electricity production. Most economists when asked this question would say that there is a simple answer, either a tax on carbon or an emission rating. Both of these do something that is very important, they put a price on greenhouse gas emissions. The reason we have this problem is right now it is not in any firms interest to spend good money to change technology, to reduce greenhouse gas emissions because this costs money and there's no justification for that. If you have a limit on emissions, if you have a tax on emissions, if you create a market where you can make money by selling emission reductions that provides an economic incentive to reduce emissions. That incentive is a crucial part of the solution. I believe that it's not the entire solution and I'll explain why. Most economists look at the experience since 1990 in reducing So2 and NoX, air pollutants from

electricity generation. These were caused particularly by coal but also by oil and natural gas. Over a relatively short period of time, starting in 1995, these emissions were reduced by half at a very modest cost through a system of emission trading. That's been a tremendous success."..." Apart from that, there were two major tools in the arsenal; one was switching from high sulfur coal to low sulfur coal which produced lower sulfur emissions; the other was installing scrubbers to remove So2 as an inter-pipe treatment in existing power plants. We reduced these air pollutants just by modifying the operation of existing power plants at very modest cost, certainly lower than expected. What didn't play a role is very important, energy efficiency didn't play a role in reducing these air pollutants; renewables didn't play a role in reducing these air pollutants. The greenhouse gas situation is different; there is no low carbon coal, oil or natural gas that we could switch. There is no scrubber as a mature technology sitting and waiting to be added to an existing power plant. There's the possibility of what's called carbon capturing sequestration; that technology is not even in its infancy. It can't readily be applied to existing power plants and it's not ready for prime time. So, those things that were simple fixes in the past in dealing with air pollution, aren't going to be available for the most part for greenhouse gases. What is available on the shelf, as it were, is improved energy efficiency; driving more fuel efficient cars, insulating buildings better, using less energy in buildings, using more efficient appliances and using renewables. Energy efficiency, renewables and new technologies loom much larger for greenhouse gases. To make that successful, you need more than just emission trading. You need regulatory programs, R&D programs. These are the things California has focused on in its legislation as well as emission trading."

To what extent do you think the government needs to be the driving force behind climate change?

You can't rely on a voluntary approach to deal with climate change. It's not that nothing will happen; it's that not enough will happen. The essence of the problem is that by burning fossil fuels we generate what is in effect a pollution. It's not an air pollution in the sense of dirty air or haze but it's a pollutant in the sense that you have higher temperatures, changed precipitation, higher sea levels. Those are just as harmful as sooty air. The point is, the person that is harmed is, for the most part, not the person that is generating the pollution. The polluter by himself doesn't have really strong incentive to change his behavior. Why should he, it's not a problem for him. The voluntary approach can accomplish something but nothing like what's needed. The same way we got no where with voluntary efforts to reduce air pollution and water pollution before the major legislation in the early 1970s. The essence of climate change is what economists call an externality; somebody takes an action, it seems like a good idea to him but it causes harmful consequences to someone else. In that context you need basically a regulation to put a limit on the action that causes a harm.

Tell us about whether the state is making adequate progress towards policies that are going to reduce greenhouse gas emissions.

California is making good progress but we have a big challenge ahead of ourselves. The law that was passed in 2006, AB 32, sets a very fast time table, basically by the end of this calendar year for coming up with a strategy to reduce emissions between 2012 and 2020. The Air Resources Board and CalEPA have been working overtime this year to develop approaches to reduce these emissions. We're on track but this is a huge task and they've been given a very short window of time to set this in motion.

There are targets set for meeting greenhouse gas emissions, to get to the 2000 levels by the year 2010 and to 1990 levels by 2020; how much of this do you think can be achieved by just individuals making changes?

The target California is focusing on now is the 2020 target, to reduce state wide emissions back to the level they were in 1990 which is going to be about 30% below what they would be if nothing was done and about 15% below what they were in 2005. That certainly involves actions by individuals. I'll mention a couple of examples: using less energy in the home by having compact fluorescent light bulbs, more energy efficient appliances; driving vehicles that generate less emissions. Those are examples of things which you and I could do, should do as individuals. But, it's not going to be just a matter of individuals changing their behavior. It's also a matter of firms, businesses changing the types of products they produce and the way they produce those products. So, it's a mix, firms need to put out more efficient cars with lower emissions, consumers need to buy those cars.

Are there models for us to follow elsewhere in the country or in the world?

It may sound complacent or arrogant, but in a sense, California is the model at this point. California is more a model for other countries than other countries are a model for us. That said, a number of countries, particularly the Scandinavian countries, Norway and some others, have been much more energetic than us in taking steps to reducing emissions, introducing taxes on greenhouse gas emissions. The European Union in the last 18 months, its deliberations on future greenhouse gas policy, has made a serious commitment. The European Union was able to meet its Kyoto target of reducing its emissions 5, 6 percent below 1990 and last year committed to reducing its emissions 20 percent below the present level and 30 percent below the present level if the United States joined in. Others have stepped up to the plate and the United States is still the laggard.

Do you have any recommendations how we should address climate change?

I think what we need to do in California and the United States is a mix of reducing emissions, preparing to deal with impacts, making ourselves more resilient against the impacts and what's called adaptation, learning to cope better with the impacts that occur. Many of the features of adaptation policy are things we ought to do anyway. I'll give you some examples in the form of running a tighter ship. Because of the threat of coastal flooding from rising sea level and the need to find ways to protect the coast, finance coastal protection; we need to do a better job of land use planning, controlling land use and urbanization than we've done up to now. If we don't do that, protecting against climate change, against sea level rise, becomes vastly more expensive than if we can figure out a more sensible, more sane approach to land use planning. Similarly, in urbanized areas if we had smarter growth, if we had styles of development that required less driving around, that lowers our emissions, it lowers our need for energy for cooling and heating in cities. It also makes us more resilient against some of the effects of climate change. I think that controlling population growth, per say, is not easy. But controlling the footprint associated with population growth is the key goal. We need to do a better job of controlling our footprint as human beings than we have done. We need to do that anyway but climate change will force that on us.

Are you optimistic that we will be able to act quickly to avoid catastrophe due to climate change?

I guess I'm not optimistic that we will avoid all of the effects of climate change. It's difficult to act quickly. First of all there has to be the political will and in 2008 and the White House is still ambivalent at best. But also, it takes time to develop regulations, to develop new technologies, to implement the technologies, to replace existing equipment. You need to have time to make these changes. The faster you're required to do them, the more expensive it will be. So, ideally you have some time to face these things. On the other hand, temperature has been warming at an increasing rate; frankly it's somewhat scary. The last two or three decades, the rate of increase in global temperature has been 5 times what it was in the first part of the 20th century. The sea levels looks like it's rising maybe 2 times at least more rapidly, maybe 3 times than it was until 20 years ago. The pace of change is picking up in terms of potential impacts. I'm optimistic we will take actions to reduce emissions; but we may face some unpleasant experiences because we may not act quickly enough to prevent greenhouse gases from reaching bad levels if not the incredibly dangerous ones.