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**Climate Change Economics Presentation Narrative**

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Slides:

1. **Title Slide:**

It is a pleasure to be here with you all today. I’m BLANK with BLANK organization. I’m here to talk with you about the economics of climate change.

Climate change will produce complex effects—with warming in most areas, changes in rain and snow levels, and generally increased variability in weather patterns. There are some uncertainties about how climate change will progress. What we know, however, is that it will hurt people and damage livelihoods all over the world. We’re already feeling its effects. Because of the ongoing potential for damage, climate change is a major issue confronting policymakers worldwide.

1. **DO NOT DEELETE: National Economic Education Delegation**
   1. Brief discussion of what NEED is and NEED does
      1. 251 delegates, one in each state
      2. 37 honorary board – 2 Nobel prize winners, 5 former chairs of council, and 2 former Chairs of the Federal Reserve
   2. Use your judgement for what should be said
2. **Who Are We?**
3. **Where Are We?**
4. **DO NOT DELETE: Credits and Disclaimer**
5. **Outline Slide**

* Climate change science
* Impacts of climate change
* Economics of responding to climate change
* Addressing the sources of our emissions
* Climate change policy
* Policy in action

1. **What Is Economics?**

There are a lot of definitions of economics, perhaps because economics can be viewed as a set of methodologies rather than a narrow area of study. Some people say that economics is the study of decision-making by individuals, firms, and other entities. Other people say it is the study of how value is created through trade, and by extension, how scarce goods and services (and therefore value) get allocated among people. A lot of people associate economics with markets. Although economists do study the things that happen in markets, they also study what we call “market failures”—situations in which decisions made by people who are guided by their own incentives will lead to unfortunate outcomes for people and society.

1. **Economics Informs Almost Everything**

This slide is mainly used in high school classes, but may be useful elsewhere.

1. **How does economics contribute to thinking about climate change?**

You might think that climate change has nothing to do with economics, but you’ll see that economics offers very useful tools for thinking about why climate change is happening and how we can design policies to address it. Also, and maybe most important, economists design policies that achieve goals at the lowest possible costs. In the context of climate change, that means that we reach our climate goals while having to give up the least amount of economic growth possible. This makes climate policies more politically viable.

1. **Climate Change Science**

Let’s talk about the science of climate change first.

1. **The Atmospheric Greenhouse Effect**

When sunlight passes through the earth’s atmosphere and warms the surface of the earth, some light is reflected back into space and some is reflected back onto earth due to greenhouse gases, which act like a blanket.

Some of these gases exist naturally in the atmosphere, as there are natural sources of emission (such as animals and fires) and some natural “sinks” that soak them up (like forests). Without human interference there’s a natural balance of gases going into and out of the atmosphere, leading to a stable climate. But we are adding to the gases. Many human activities either put more greenhouse gases into the atmosphere (for example, the burning of fuels or the release of methane from ranching and farming) or reduce the natural “sinks” that pull greenhouse gases from the atmosphere (like deforestation). This causes the atmospheric “blanket” to become thicker, warming the planet.

Greenhouse gas emissions thicken the atmospheric blanket, increasing the average temperature on earth. Carbon dioxide also goes into the ocean, causing it to become more acidic. And, of course, the heat and CO2 stored in the oceans influences land and air temperatures and vice versa, until we reach a global equilibrium of gases and temperatures.

If we don’t address climate change, temperatures are expected to rise by 3.7 to 4.8 degrees Celsius (6.7 to 8.6 degrees F) by 2100 on average across the globe, and to continue rising after that time. As we’ll discuss later, this is significantly higher than the commonly discussed goal of 2 degrees Celsius.

Another thing that’s complicated about all of this is that greenhouse gases stay in the atmosphere for a long time, and carbon dioxide and heat stored in the ocean take time to dissipate, so even if we stop all of our emissions right now, we’ll still feel the effects of climate change for some time.

Each of these direct effects then leads to more indirect effects. For example, the increase in temperatures causes changes in precipitation patterns, an increase in extreme weather events (e.g., droughts and floods), sea level rise and storm surges, and melted permafrost.

It’s worth noting that the temperature and precipitation changes that will happen will vary significantly from place to place. Some places will get much warmer and some only a little warmer; some will get wetter while others will get drier. We can generally predict that precipitation will come in increasingly concentrated bursts, so that there will be more of both droughts and floods.

These changes in the earth systems will change the patterns of storms we experience. However, some of the science of exactly what will happen to hurricanes is still unsettled.

The changes in temperature, precipitation, and storms will cause sea levels to rise and contribute to storm surges. (The “surge” of the ocean onto land when there’s a storm can be much more destructive and far-reaching than the sea level rise itself.)

The way we’ve described it so far makes it sound like a linear, predictable set of effects. But a lot of people who study climate change are worried about “tipping points”—important thresholds in ecological or geophysical systems that, once we pass them, are irreversible and potentially quite damaging. Usually, we don’t know exactly when those tipping points will be crossed. Examples of irreversible events include:

* Extinctions of important species
* Collapse of the Greenland ice sheet
* Losses of entire ecosystems
* Dramatic changes in the existing flow of ocean currents (the “conveyer belt”)

(Source: Lenton et al., 2008, Nordhaus 2013)

1. **A Climate Change Ladder**

Climate change is influneced in a variety of ways. First, through the emissions that we produce as a functioning economy.

There are a variety of ways that we can respond to the emissions. These begin with efforts to mitigate the emissions. Such mitigation will lessen the severity of climate change and its accompanying effects – to be discsussed shortly.

We can adapt to the resulting clmate change. This means changing behavior so that the impact of climate change, the costs of climate change are less severe.

Or we can just live with the changes that come with climate change and continue emitting. As we will discsuss, this is a costly opton.

1. **Atmospheric CO2 Concentrations**

You’ve probably heard a lot about carbon dioxide emissions and how they’re causing climate change. We’re going to get into this in more detail in a minute, but let’s start by looking at what’s happened with these gases in the atmosphere in recent years and what’s predicted to happen. In this graph, the horizontal axis is the year, and the vertical axis is the concentration of carbon dioxide in the atmosphere in that year. You can see that human activity has, even since the year 1975, when this graph starts, increased the concentration of greenhouse gases in the atmosphere. Having increased from around 330 to 400, the abundance of carbon dioxide in the atmosphere increased by 20% over just these 43 years.

“Greenhouse gases,” abbreviated GHGs, include the most famous and in some ways most important gas, carbon dioxide, or CO2. But there are other gases that also act as greenhouse gases when they enter the atmosphere, including methane and nitrous oxides. You’ll often hear people refer to GHGs as carbon or CO2 as shorthand, but all greenhouse gases are important, and policy should address all of them. We measure them in a standardized unit called a “carbon dioxide equivalent.”

You may have noticed that I said we don’t know for certain how climate change will affect hurricanes, or when these tipping points will be triggered. I know that makes it sound as if the science

1. **Greenhouse Gas Emissions : 1990-2019**

Despite all of the efforts to reduce emissions, global greenhouse gas emissions have continued to increase. There was a decline during the Global Financial Crisis, but that’s not how we want to reduce emissions.

In particular, global emissiosn as a result of burning carbon based fuels continues to grow, contributing most of the increase since 2019.

The graph also shows other sources of greenhouse gases.

1. **Emissions Trajectories into the Future**

There are many forecasts of emissions. This graph presents a few, including business as usual and dramatic efforts to reduce greenhouse gas emissions. Under the worst case scenario, business as usual, emissions are forecast to increase dramatically.

There are also forecasts that suggest that it is indeed possible to reduce NET greenhouse gas emissions to zero. But this won’t happen without fairly significant climate change legislation and significant changes in how the economy functiuons.

Shortly, we will talk about whether or not it might be worth it.

1. **What Do Greenhouse Gas Emissionsn Do to the Planet ?**

The fundamental effect of GHG sis to increase global temperatures. With the major effect of rising sea levels – due to melting ice caps around the world. With rising sea levels, storm surges are likely to be more damaging.

Higher temperatures also bring about altered precitiation patterns, generally more variable weather, and more and more powerful storms. There is also more carbon available for the world’s oceans to absorb. This will alter sea life, reducing fish populations and killing coral reefs.

1. **These Changes Are Already Underway**

At just a superficial level, we can look at temperatures where you are. The red line is the 10 year average temperature. As you can see, this line has been trending upward over much of the last 100 years.

1. **How much pollution does society want? Analogy: How many oranges does society want?**

What I’ve talked to you about so far has mostly been about atmospheric science. Where does economics come in? In the context of climate change, economics suggests that without policy changes, people will continue to put out more greenhouse gases and deforest more land, accelerating climate change and thus hurting people. Let me explain why, starting with an example.

In an ideal world with a well-functioning market, like the market for oranges, prices reflect the true scarcity of a resource or the true social value of a resource, because prices are driven by the amount of money sellers are willing to accept and how much buyers are willing to pay. The way this works is that people who want to sell oranges will only sell them for a price that at least covers their costs, and people who want to buy oranges will only pay a price up to their personal value for oranges. Since people will act in their own self-interest, and all of the costs and benefits associated with oranges accrue to the buyer and the seller, supply and demand will automatically push the market to an equilibrium price where the costs and benefits of oranges are in balance: at this price, sellers want to sell the exact same number of oranges that buyers want to buy. This is the right number of oranges for society because society is getting as much value as it can from people buying and selling oranges.

1. **Pollution is different from oranges**

However, pollution (including the pollution that causes climate change) is different from oranges. When you turn on your light switch, that draw of electricity causes the power plant to burn more coal or natural gas; you are buying electricity from the power company. But another thing happens: pollution is generated, and that pollution contributes to climate change. Human activity in general causes some amount of pollution. The way economists think about it is not to try to get to zero pollution necessarily, but to find the right balance between the benefits from things like electricity and the harm that pollution causes to humans.

The fact that pollution affects everyone, not just the buyers and sellers of electricity, makes it an *externality*—a side effect, or an example of a market failure. A market failure occurs when people make decisions based on their own values don’t end up getting to the right balance of costs and benefits for society. With electricity, the externality of pollution is that some costs are borne by people other than the buyers and sellers: even if a person lives in an unelectrified yurt or has solar panels on their house, they are affected by the pollution from this electricity market they’re not part of.

The reason this is called a market failure is that a free market (people making decisions on their own) will in this case end up failing to reach the right balance of the costs and benefits of electricity: because there are some costs that the buyer and seller don’t bear, the price they negotiate is “wrong” in the sense that it doesn’t reflect all the costs. As a result, the price of electricity is too low and society consumes too much electricity relative to what would be the best balance. In this example, unlike our example of the orange market, society is not getting the maximum value it could get from buying and selling electricity because the costs are too great.

You can also think of the climate as a *common pool resource*: something we all benefit from but no one has an incentive to maintain and take care of. As a result, we all keep damaging the climate by pouring greenhouse gases into the atmosphere.

Sometimes people are surprised at economists’ approach to pollution. If we think about pollution as an externality from a transaction (e.g., the purchase of electricity), then we consider pollution an additional cost that needs to be taken into account. Thus, for economists, climate change per se isn’t a problem, but rather the lack of balance in the market; thus, the goal is to reduce pollution, not to eliminate it. If we don’t regulate greenhouse gas emissions, then the damages caused by climate change will be larger than what is efficient. Remember, those transactions are things that buyers and sellers get a lot of value from, so we want some of them to continue. The goal is to “fix” these externalities and do a kind of balancing act between the costs climate change will impose and the costs of fighting climate change. We’ll talk a lot about this in the rest of the presentation.

Economic analyses can help us quantify how much we’ll be affected by climate change, and they can help us find efficient ways to respond.

1. **Social Cost of Carbon**

When we think about all of these damages, we try to evaluate how much they cost in terms of the losses and suffering caused to human beings. We use these estimates to come up with something we call the social cost of carbon. This is the amount of damages to humans caused by each unit of greenhouse gas emissions. This is an important quantity; we’ll come back to it in a little bit.

Right now, the U.S. Environmental Protection Agency uses an estimate of around $40 per metric ton of CO2. But different models can estimate values less than $10 or above $100. More importantly, most models estimate that the social cost of carbon will increase as we move farther into the future, even if we take immediate action to fight climate change.

As discussed in the [2010 SC-CO2 TSD](https://19january2017snapshot.epa.gov/climatechange/social-cost-carbon-technical-documentation), estimates of the social cost of these greenhouse gases increase over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change, and because GDP is growing over time and many damage categories are modeled as proportional to gross GDP.

***The next 3 slides are perhaps most useful in a high school class.***

1. **Externalities**
2. **Examples of Externalities**
3. Heating your home – negative
4. Smoking – negative
5. Getting a dog – negative – they bark and poop
6. Pig farming – negative – they poop and spoil groundwater
7. Education – positive
8. Growing apples – positive – fosters bee populations
9. Getting a vaccination – positive
10. Basic scientific research – positive
11. **Addressing a Negative Externality**
12. Shows how decisions change in the face of price changes resulting from the internalization of an externality.
13. **Impacts of Climate Change**
14. **Global Warming Indicators**
15. **How these impacts affect humans**

This all sounds dramatic, but the reason that economists say that people should be worried about climate change is not because of the significant changes to the planet, but rather for how these changes will affect people—we call this the “damages” caused by climate change. There may be ethical reasons to care about the damage to the environment or other species beyond the outcome for humans, but economists focus on the damages that affect people.

Climate change has a physical impact on human life. For some people, the effects are positive, but the negative consequences are much larger and widespread. I’m going to talk about these effects in the future tense on this slide because the biggest repercussions are in the future, but many of these events are already happening.

Changes in temperature and precipitation will hurt agriculture because of the increase in heat, droughts, flooding, erosion, and water availability, as well as the potential for increased threats from pests. Places farther north will see improvements in agriculture (in the medium-term—eventually they will likely also suffer) because the warmer temperatures will lead to longer growing seasons, but most estimates for the world predict overall decreases in agricultural productivity.

Fisheries will be affected as oceans get warmer and become very slightly more acidic. Some species will move and some will become less able to survive, while others will do better. For example, there is evidence that the cod fishery on the east coast of the United States has started to migrate northward. Crustaceans will be hurt by acidification, as will animals at the bottom of the food chain. Animals that feed on them will likely be hurt, but we don’t know much about how these ecosystems will shift. Some studies suggest that jellyfish will do pretty well in the seas as climate change continues.

Fully 40% of the global human population lives within 100 km of the coast (UN, 2007). Sea level rise and storm surge, along with erosion, will lead to loss of coastal land and damage to coastal properties. Many populous urban areas across the world are vulnerable to flooding as a result of storms as well as “sunny day flooding” (tidal flooding in low-lying areas during full or new moons), and these floods will become more frequent and more intense over time.

High temperatures, combined with reduced availability of water, can cause heat stress, and people suffer further when heat aggravates other health conditions. In addition to the illnesses and deaths stemming from an increase in temperature, the pollutants released with greenhouse gases are directly dangerous to human health when they linger in the air around us; for example, an increase in particulate matter in the air is extremely harmful, especially for young children and the elderly. When people talk about the “co-benefits” of fighting climate change, they are in large part referring to the reduction in pollution-related deaths.

Moreover, the changes in the weather will make the climate more congenial to pests that carry diseases. For example, in the United States, deer ticks that in the past have lain dormant over the winter are now more active throughout the year, increasing the potential spread of Lyme disease. Malaria-carrying mosquitos are also increasing their ranges. Other effects of this type are hard to project; there may be vector risks that we can’t yet foresee.

Reduced fresh water availability will come about as precipitation patterns shift and sea levels rise; in addition to the stress added by droughts, there will also be incursions of sea water into fresh water aquifers that people depend on for water supplies. This can be harmful for human health and for many kinds of economic activity.

Wildfires are expected to become more common because of droughts; in addition, the lack of a hard freeze in winter allows pests that weaken forests to flourish.

As temperatures rise worldwide, the climatic zones of some species that we depend on, like fish, shift farther north. For plant and animal species in mountainous regions, climatic zones can shift up to higher elevations. These shifts, particularly combined with human use of the land, can cause previously fertile land to become a desert (this is desertification). These shifts may cause conflict between countries or societies as fisheries or grazing grounds that had belonged to one country or group physically move into the territory of another group.

There is increasing evidence that heat reduces worker productivity at a variety of tasks, including manual labor (Zivin and Neidell, 2012. The pollution that lingers in the air we breathe also reduces our productivity, and this has even been observed in test scores (Lavy, Ebenstein, and Roth, 2014) and other intellectual tasks (Heyes, Rivers, Schaufele, 2016).

There is some evidence that increased heat causes more violence by changing people’s behavior.

In addition, as resources become scarce or move around, or as people’s homes become unlivable because of flooding or other climate-related damages, people will themselves migrate in response to the climate threats they face. When this happens on a large scale, we call these migrants “climate refugees.” Conflict between groups can result from this kind of migration, or as groups fight over scarce and shifting resources.

1. **How Damages Will Vary Globally: Mortality as an Example**

Most of the discussion is of a warming globe. However, not all of the globe will warm. This map shows where changes in mortality, deaths, will occur. In the red regions, more deaths will happen while in the blue regions, fewer deaths. There will in fact be cooling over some parts of the globe, primarily the northern half of the northern hemisphere.

1. **How Damages Will Vary in the US**

Within the United States, the effects will vary. This graph provides estimates of changes in county level GDP across the country. Most of the deleterious effects will happen in the southeast region, from Kansas and Texas through southern Illinois, Maryland, and down through Florida.

Some of these changes will be quite significant. And some will be positive – again, in the northern part of the country.

1. **Adaptation reduces damages**

One reason it’s useful to think about climate change as an economist is because economists think about how humans respond to changes in the world. So, when we think about the human impacts of these changes in our natural world, we have to account for the fact that people change their behavior in ways that lessen those damages. *Adaptation* is the word used in climate policy to refer to these changes. People can find ways to avoid or minimize a harm, like flooding, or they can take advantage of a new opportunity, like a longer growing season. When we think about the net costs that climate change imposes on us, those costs include the costs of adaptation and any damages that remain after the adaptation.

We know that people will take many of these actions on their own, and some of them will not be very costly. But many actions are too costly for individuals, and in some cases adaptation is more efficient if it happens on a community scale. In some of these cases, governments should be involved to coordinate and help pay for these measures.

<red boxes are there because they are useful for SF Bay Area presentations, no other reason. Thought they might be useful to others as well.>

1. **Real Estate Markets**

Real estate markets in all of the affected regions will reflect the changes. Sea level rise, wildfire risk, and other changes in the local experience will cause some places to be less desirable as places to live and others to be more desirable.

1. **Individual-level adaptation examples**

It’s easy to envision adaptation at the individual level if you think about what you do on a hot day versus a cool day. On a hot day you may stay in the shade or indoors, while on a cool day you might behave very differently. That’s a form of adaptation. It’s costly because you’re giving up something that you would otherwise have done if it wasn’t so hot.

But some actions will take more investment from you. You may need to buy an air conditioner, or you may need to use the air conditioner that you own more often. Farmers and business owners may change their practices: if the growing season has changed, farmers may plant earlier or later; they might discover that different crops do better. These are decisions they make on their own.

Another element of adaptation is migration. It might be the case that if your house floods or burns down too many times, or if it’s just too hot, you might choose to move somewhere else.

1. **Public Adaptation**

You can see that some of these individual actions can get expensive. In some cases, it might be better for governments to take responsibility for adaptation. First, some adaptation investments are more cost-effective when they are undertaken as a group. Sea walls or other large-scale anti-flooding measures require city or regional planning. Many people benefit when ecosystems are developed to provide protection—wetlands can buffer communities against floods, and forests can reduce erosion and filter water supplies. These are investments that individuals would almost certainly not make on their own because everyone benefits; any person who provided a wetland would just get a tiny portion of the benefit the wetland provided.

Second, because adaptation can be very costly, low-income and vulnerable populations may not be able to afford measures that higher-income people can afford, like buying a new air conditioner. Society as a whole may decide to help people access these things if they become necessary for a reasonable standard of living.

Finally, we already mentioned climate refugees. Some people might move on their own accord as risks and damages mount, but the government might take an active part in helping people relocate. The U.S. Department of Housing and Urban Development has already funded a grant that aims to resettle a small number of climate refugees from Ile de Jean Charles, Louisiana, because of rising waters around this indigenous community.

1. **Market-Based Adaptation**

Another way in which the effects of climate change will be ameliorated is through price signals. Activities that today are cheap will become more expensive tomorrow. Living in warm climates will become more expensive as air conditioning has to run more often. Planting wine in certain regions will get harder and harder as the climate changes. Making it more expensive to grow wine where it has traditionally been found. Instead, the climate will become more favorable in other parts of the world – generally in areas to the north of existing wine growing regions.

There is a case to be made that these adjustments are not unlike other adjustments to changing circumstance. One important aspect is the sheer magnitude of the population and markets that will be affected.

Two other important aspect of these market adjustments are that:

1. There are a host of policies and programs that serve to mask their need. For instance, as more and more areas become flood prone, flood insurance will reduce the costs of continuing to build in these areas.
2. Their necessity can be mitigated. The only issue is whether the cost of mitigation exceeds the costs of the adjustment. Standard cost-benefit analysis can be used to evaluate the efficacy of mitigating the need for these adjustments.

The image reflects changes in the location of optimal climate conditions for wine growing. Napa valley will likely diminish as an attractive place to grow wine, while Oregon and Washington will become more attractive. Additionally, southern Europe (Spain, France, and Italy) will be less conducive to wine growing while northern parts of Europe will become more viable.

This is just one example of significant changes in the geography of agricultural production that will likely result from climate change.

Markets may not be our friend to the extent that there is no market in CO2 and market prices encourage CO2 production. But markets are our friend when it comes to adaptation. For example, in agriculture, in the face of a warmer climate and changes in the distributions of weather variables, market signals do and will encourage the planting of higher-yielding crops in newly appropriate locations. This is shown, in part, by the top-left map on slide 17. Also see the recent article on new cropping patterns – Wall Street Journal, November 25, 2018, “A Warming Climate Brings New Crops to Frigid Zone

Also relevant to a market adaptation theme are real estate markets and how they should discourage construction in newly flood-prone areas. A very real public policy issue is that federally subsidized flood insurance inhibits that response. (See, among others’, Kerry Smith’s recent work on this issue, which highlights the distributional consequences of insurance subsidy). Another is the debate over whether it is better to build sea walls and fortify in response to sea- level rise or better to encourage to relocation away from flood risk.

1. **Most vulnerable people and places**

The burdens of climate change are distributed unequally across the planet, mostly because of the geographic distribution of the physical impacts. Tropical areas are expected to see the greatest physical impacts in terms of temperature, precipitation, sea level rise, and storms. People who live in low-lying coastal areas are most exposed to sea level rise and storm surges. All over the world, low-income residents will have less capacity to adapt than those with higher incomes, since adaptation often requires investments or up-front costs.

(Barbier and Hochard 2018, and IPCC)

I mentioned that impacts will vary across the globe. The United States will not escape the effects of climate change. In fact, the U.S. Department of Defense considers climate change to be a serious threat, and it acknowledges that the U.S. is currently feeling the effects of climate change. This map shows how impacts will vary across the United States. The things that are blue are positive impacts—the benefits from climate change, such as improved agriculture in some northern regions and decreased cold-related deaths. But you see a lot of red spots on the map that show significant damages we expect from climate change. As you’d expect, the east coast will see a lot of coastal infrastructure damage. The south will experience an increase in heat-related deaths. Much of the country will see reduced agricultural yields.

You can also see that some of these effects represent adaptation. For example, the increased energy demand in the southwest is from increased use of air conditioners.

1. **Projected damages vary across the U.S. but are estimated at 1.2% of GDP per 1C increase**

These maps show in much finer detail how impacts will vary across the United States. This study compiled the expected effects from a 1 degree Celsius (1.8 degree F) temperature rise from many other studies. The net effect for the nation was predicted to be 1.2% of GDP per 1 degree Celsius of warming. Remember that we said that current estimates, if we don’t act on climate change, indicate an increase of 3.7 to 4.8 degrees Celsius by 2100. To put 1.2% of GDP in context, the U.S. GDP is $18.6 trillion, and we think of good growth for the U.S. GDP as being 3% per year, so a 1.2% reduction is the difference between a robustly growing economy and a relatively stagnant economy.

States in the far north may see net benefits, mostly because of agricultural gains, but the south, the southeast, and the mid-Atlantic region are expected to be hit hard because of agriculture, mortality (death), energy costs, coastal damages, and crime (Hsiang et al., 2017).

Another analysis has shown that the federal government has spent nearly $100 billion in a single year within the United States on the effects of climate change as a result of droughts, storms, floods, and forest fires, which is about one-sixth of the federal budget for non-defense discretionary programs (Lashof and Stevenson, 2013). Our definition of damages is broader and includes social costs, but these expenditures by the federal government are important to think about in the context of government budgets.

1. **Far Side cartoon**

So, this has all been pretty depressing! But let’s not forget: we have big brains and economic tools. We can use both to devise a pragmatic solution to climate change.

1. **Economics of Responding to Climate Change**

Now that we know how economic activity affects greenhouse gas emissions, we can start to understand possible steps to mitigate climate change.

1. **International Climate Policy Goals**

The international community has been concerned about climate change for decades, and has convened experts and policymakers through the Intergovernmental Panel on Climate Change (IPCC). This group produces reports on the consensus view of scientists about how climate change is progressing and what will continue to happen. Economists contribute to this work, particularly in thinking about the value of damages, the cost of fighting climate change, how adaptation will happen, and what policies are recommended.

Remember that we said that economists recommend balancing the costs and benefits of pollution rather than setting a goal of zero pollution? The IPCC’s Fourth Assessment Report (2007) recommended a goal not of zero temperature increase (which would be impossible at this point), but rather 2 degrees Celsius (3.6 degrees F). They calculated at that time that to reach this goal, industrialized countries would need to reduce emissions between 25% and 40% below 1990 levels by 2020.

In their Fifth Assessment Report (2014), the IPCC reported that temperatures had already increased by 0.85 degrees Celsius. The sea level has already risen by about seven inches in the last century.

In 2016, countries convened through the United Nations Framework Convention on Climate Change (UNFCCC) to form the Paris Agreement. In this agreement, countries agreed to the goal of limiting temperature increases to 2 degrees Celsius and to try to reach an even more difficult goal of a 1.5 degree increase. Given our current understanding and the technology we have and expect to become available, either goal will require dramatic reductions in emissions. It is not clear that the goal of a 1.5 degree Celsius increase is achievable with current technology, but this goal was chosen because, now that we have learned more about the science of climate change, we now understand that humanity will bear a lot of damages if we let warming get to 2 degrees.

1. **Recent Progress on Climate Goals**

IPCC’s Fifth Assessment Report (2014) indicates that the intermediate goals that were set in the previous (2007) Assessment Report were met by industrialized countries only because the Great Recession produced by the financial meltdown of 2008 significantly slowed down the economic growth of these countries; less economic activity always means less use of energy and thus less emissions. It’s probably obvious, but this is not a good thing: drastic cuts like this are very painful and do not achieve a good balance between fighting pollution and providing the material benefits people want.

There is still some debate over how to implement greenhouse gas reduction policies, and, in some places, even whether to act on climate change. Even so, nearly all economists believe that we should fight climate change, and economists have (what we think are) great ideas about how to fight it.

1. **How economists decide how much to fight climate change**

To determine whether and how much we should act, economists place the analysis of global climate change in the context of a cost-benefit analysis (CBA). A cost-benefit analysis weighs the expected consequences of the projected increase in carbon emissions versus the expected costs of policy actions to reduce emissions.

1. **Cost-Benefit Analysis of Fighting Climate Change**

Most of the economic models that have attempted to estimate the net costs of achieving a likely pathway toward a reduction of 2 degrees Celsius suggest that the costs are relatively small, amounting from 1% to 4% of GDP by 2030 (Rosen and Guenther, 2015). Studies show that these costs are almost certainly outweighed by the future economic damages associated with warming of more than 2 degrees Celsius that they would avoid. For example, the Stern Review calculates that the possible damage of climate inaction (or business-as-usual) could be as high at 20% of worldwide GDP (Stern, 2006). Since the expectedcosts of acting are less than what we expect the benefits of acting to be, the cost-benefit analysis for climate policy passes!

However, there are some caveats to CBA that we need to consider.

To do a CBA, we have to put a monetary value on all the costs of climate change. Critics say that the social, political, and ecological implications of climate change can’t be captured in a dollar value. For example, climate change can increase mortality, and those deaths have to be valued in a CBA. At the same time, if money spent to fight climate change comes from other human development uses (some of which are literally life-saving), the opportunity costs (i.e., what we have to give up) of fighting climate change could be very large. And indeed, some of the values that we want to incorporate are extremely hard to put dollar values on; economists have a lot of techniques to get at these numbers under the philosophy that some number is better than no number, but they are not uncontroversial.

The costs and benefits of fighting climate change are also uncertain, which makes the CBA harder. This uncertainty comes from a few things. First, as we have already discussed, the impacts of climate change can’t be precisely estimated yet. Second, unknown ecological tipping points might amplify the risks of not acting against climate change (Lenton et al., 2008). Third, technological change will reduce costs of fighting climate change in the future, but we don’t know how much because we don’t know what innovations will happen in the future. Fourth, we don’t know how human society will develop over the coming years: how rich people will be and where they will live. Again, these factors make it so we don’t have precise estimates of costs of fighting climate change or costs of climate change damages, but what we do know allows us to come up with expected ranges and average expected values of each.

For these reasons, we might think of CBA as a rough, back-of-the-envelope way to get general impressions; it can tell us whether action is a no-brainer one way or the other, but it would be hard to pretend we can be precise about the exact efficient degree to which we should fight climate change.

CBA has also been criticized because it does not inherently address inequality; a global CBA just tells us the comparison of the sum of total global costs to the sum of total global benefits, so is really a global average. Effects will vary from one place to another, as we discussed, and will fall most heavily upon the poor of the world. Regions such as Africa could face severely compromised food production and water shortages, while coastal areas in South, East, and Southeast Asia will be at great risk of flooding. Tropical Latin America will see damage to forests and agricultural areas due to drier climate, while in South America changes in precipitation patterns and the disappearance of glaciers will significantly affect water availability. While the richer countries may have the economic resources to adapt to many of the effects of climate change, poorer countries will be unable to implement preventative measures, especially those that rely on the newest technologies, and without financial help they will be unable to adapt and will thus face heftier damages.

The way in which economists incorporate inequality into their analyses can have a significant impact on their policy recommendations. If we think about costs in absolute amounts, then a cost of (say) $500 million is much more damaging to a country like the Maldives, which has a GDP of $3.6 billion, than to the United States, which has a GDP of $18.6 trillion. The Stern Review (the predecessor to the New Climate Economy Report) asserts that if we properly considered the disproportionate effects of climate change on the world’s poorest people, it would increase the estimated costs of climate change. Stern estimates that, without the effects of inequity, the costs of a business-as-usual (no climate policy) scenario will be 11% to 14% of global GDP annually.

1. **Roughly right vs precisely wrong**

Economic models can generate precise numbers—–for GDP growth, jobs, or emissions—but they can only ever offer approximations of the future. Too much is unknown about the course of technological and structural change, with the key processes difficult to capture formally. Too much that is of value—such as people’s health, the reduction of risk, the sustainability of the natural environment—is hard to quantify. But as John Maynard Keynes once said, “It is better to be roughly right than precisely wrong.”

Many climate experts, including those who contribute to the New Climate Economy report, recognize this point and warn against the search for false precision. We gather whatever evidence we can and make the best decision we can about what climate targets to set, informed by a range of perspectives and evidence; but since our knowledge is imperfect, we continue the scientific research that will help us refine our goals as we go forward.

In other words, while we may not know exactly what temperature rise or level of emissions reduction is precisely optimal, we know in general that we need to reduce emissions a lot, and soon.

1. **This is What Precisely Wrong Looks Like**

Red shows current wine growing regions that will not be able to produce wine in the year 2010.

Note how there will be no more Bordeaux, Burgundy, Tuscany, or Duoro wines. Instead in the year 2010, we’ll all be drinking Washington or Idaho Merlot, and a nice London Cab….

The costs of this migration are simply enormous.

1. **Economic Growth and Climate Action are Compatible**

What is the relationship between fighting climate change and economic growth? It’s complicated!

Economists like to say that there is no such thing as a free lunch. Reducing our greenhouse gas emissions (abatement) will have some real economic costs; we shouldn’t pretend that it won’t. But it’s worth doing because the costs of NOT fighting climate change are even worse.

The way we like to think about it is to acknowledge that economic growth has consequences, including climate change, and we have to be sophisticated and deal with those consequences. Economic growth will still continue with environmental regulations in place; as I said before, we don’t want or need to create a recession to address climate change. With smart regulations, we can have robust growth and an environment that’s healthy and promotes the human activities that depend on natural resources. It’s about balancing the different things we value.

Remember, one of economists’ special contributions to climate policy is that we create policies that achieve goals at the lowest possible cost. In the context of climate change, that means that we reach our climate goals with the lowest direct cost in terms of economic growth. This also makes policies more politically viable.

1. **Addressing the Sources of Our Emissions**

So, we know we need to reduce emissions; what are the best ways to do that? Let’s see where our emissions come from.

1. **Global Net Emissions Are What We Care About**

GHG emissions, regardless of where they originate, warm the entire planet. Therefore, we don’t care where they come from. There are environmental justice reasons to care locally, but it doesn’t matter whether emission originate in the United States or in China or in Europe.

We also care about NET emissions. There are plenty of naturally occurring phenomenon on the globe that reduce emission. And it is very important to recognize that economic activity can either add to the sinks or remove them. For instance, when forests are cleared in Brazil to accommodate cattle ranching, this is a reduction in our available carbon sinks and an INCREASE in our net GHG emissions.

1. **Sources of the Global Flow of Emissions**

The annual flow of GHG gas emissions is what is most often discussed. The origins of our emission are illustrated in this graph.

Historically, most emissions have come from the developed world, the United States and Europe, in particular. More recently, developing countries and regions are seeing very rapid growth in their GHG emissions.

Also worthy of note is that over the last decade or more, emission from the United States and Europe have been in decline.

1. **Sources of the Global Stock of Emissions**

In terms of addressing our emissions, it is important to look at the current flows.

However, it is also important to understand the sources of the global STOCK of GHG emissions. Historically, the United States has contributed about ¼ of all GHGes in the atmosphere today. 23 rich, developed countries are responsible for HALF of the stock of GHGes in the atmosphere.

1. **Sources of the Global Stock of Emissions**

150 countries together are responsible for the other half of the stock of gases in the atmosphere. China is the largest source, having contributed nearly 14%.

1. **How Does This Look Per Capita (Per Person)**

The U.S. doesn’t look particularly good….

Note the important role that land use can play.

1. **Total U.S. Greenhouse Gas Emissions by Economic Sector in 2020**

In the U.S., as in most of the world, most of our greenhouse gas emissions come from electricity, transportation, or industry. Some come from agriculture and commercial properties (like stores) and residential properties (homes).

The mix of activities that produce emissions that we’ve shown you so far are all for the United States; worldwide, land use may also play a big role. Deforestation releases carbon into the atmosphere, and agriculture releases methane (and often also carbon, though it need not always). Remember that these are sources of greenhouse gas emissions, but deforestation also reduces the forest “sink” for greenhouse gases, and so deforestation is both a source of GHGs and a reduction in a sink. Agriculture, forestry, and other land use (AFOLU) are responsible for a quarter of global GHG emissions due to deforestation and forest degradation, as well as emissions from methane (livestock), nitrous oxide (e.g., fertilizer), and carbon dioxide (e.g., tractors and fertilizer production).

1. **US Electricity Sources**

Here are the 4 major sources of electricity in the United States. The first 10 years or so represent the composition of sources over the last decade. As can be seen, in 2010, coal was the major source of supply, with the rest made up by nuclear, natural gas, and renewables. Over the course of just the last 10 years, the composition has changed dramatically. The change is primarily a switch from coal to natural gas, with also some significant increase in renewables.

Beyond the vertical line is the forecast composition through 2050. The major change in source is through an increase in the use of renewables and natural gas. Nuclear is not forecast to increase, natural gas will increase somewhat and coal will continue to recede into the background, but quite slowly.

1. **Which Emissions Should We Cut?**

At this point, we have a broad sense of the sources of GHG emissions. And that has often been used to direct reduction efforts: what are the major sources? Let’s address those.

Economists think about things a little bit differently.

Here is the way that economists think about targeting emissions for reduction and that is basically looking for the cheapest way to achieve our reduction goals.

Necessary for this is a list of all possible sources of emissions. We need to figure out how much emissions can be reduced from each source. Then it is important to figure out how much it costs to reduce emissions from each source.

The process is then to line them up and start reducing emissions with the cheapest source of reductions and work our way up to the more expensive sources.

Bottom line: TACKLE THE CHEAPEST SOURCES FIRST!

1. **Global GHG Abatement Cost Curve Beyond Business-as-usual, 2030**

Knowing where our emissions come from, we can start to think about how to reduce them. Remember, economists are concerned with the idea of doing this at the lowest cost. So, let’s think about the cost of each possible way to reduce emissions. We call reductions “abatement,” and we rank these abatement opportunities by their cost to create what we call a “marginal abatement cost curve.”

That’s what this graph is. It was made by McKinsey in 2009, itemizing GHG reduction opportunities and their associated costs. The width of each bar shows how much emissions could be reduced by it. We want to do things from the left to the right: from lowest cost to highest cost. Notice that some of the “costs” are negative—that means we can save money by doing them! This may only be true in theory; remember that these are all approximations.

Since this is several years old, the costs have changed some, and some things are not on here. Also, there’s a lot of debate about whether biofuels reduce greenhouse gas emissions when we think about them more holistically.

One really important thing to remember, too, is that these costs can change as we take actions. Technological advancements can bring down the costs of some of these abatement methods; we don’t yet know which ones! For this reason, governments invest in research and development to help spur these advancements. Private companies will do this, too, and will have more incentive to do so if we can fix the prices so that polluting is costly. But since society has a special interest in reducing emissions, governments can provide subsidies and grants for research into low-abatement, cost-saving technologies.

(If there’s time, spend more time talking about specific items in the graph here, pointing out low-cost and high-cost items.)

1. **Newer Estimated Abatement Cost Curve**

a

1. **Newer Estimated Abatement Cost Curve**

a

1. **Costs and Barriers Can Be Difficult to Assess**

a

1. **Geoenginerring and Carbon Capture**

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1. **Fossil Fuels Dominate U.S. Energy Production**

The burning of fossil fuels creates the great majority of our emissions. It is also the main way we get our energy in the modern world.

The chart on the right shows our energy sources, and you can see that the biggest sources of our energy by far are all fossil fuels: petroleum, natural gas, and coal.

The chart on the left shows the uses of energy today in the nation; since most of our emissions come from energy use, the mix is similar to what we showed on the last slide for emissions. Electricity (think: coal-fired power plants and natural gas-fired power plants) makes up the biggest portion of our energy use, followed by transportation (think: gasoline and diesel fuel in cars and trucks) and industrial or other uses. It is for this reason that people talk about how we need to reduce our use of fossil fuels to produce energy.

You may have heard that renewables (which are low- or no-carbon) are growing in huge percentage terms, and that’s true; you can see that the green line on the right slopes sharply upward. However, they’re still a very small part of the overall energy mix worldwide, just about 8%. Still, they’re expected to keep growing, and quite regularly they have outstripped predictions by leaps and bounds. Investment in renewables reflects this promise: global investment in renewable power and fuels in 2015 was $270 billion, a 17% increase from 2014.

Fossil fuels provide the bulk of our energy because they’re cheap. We’ve already told you that they are artificially cheap because the environmental costs are not being counted. You may not know that their prices are further lowered because governments all over the world subsidize fossil fuels in one way or another, whether it be in subsidies for fuel for citizens or in steeply discounted contracts that let fossil fuel companies extract fuels on government lands.

1. **Indicative Solar Costs Over Time**

Remember that we talked about how fossil fuel energy is “unfairly” cheap because of externality costs that aren’t reflected in the prices, and that fossil fuels dominate our energy because they are so cheap. However, costs of renewables have been falling for years, especially solar, and that’s promising—when they’re cheap enough, people will naturally switch over to them. The price of solar panels has fallen so dramatically that in some places they are cost competitive with fossil-fuel-based electricity from the grid.

1. **Wind Turbines Have 100 Times More Power generating capabilities than 30 years ago**

Wind energy is also becoming more advanced as the years go by, which reduces the cost per unit of wind energy.

1. **Challenges with Renewable Energy**

It’s easy to get excited about advances in renewable energy technology. However, we have to be realistic and remember that solar and wind power in particular have an important limitation. They are what we call *intermittent* sources: solar panels only work when the sun is shining, and wind power only works when the wind is blowing. Energy demand is strong all day and night, and there are peak surges at particular times of day, with bigger peaks on some days (e.g., hot days in summer) than others. Hence there’s a mismatch between the pattern of energy provided across the day by renewable sources, and the pattern of energy needed across the day. Energy needs to be supplied in the exact amount it is demanded at any minute.

As a result, it’s vital that we develop better energy storage technology that is low-cost and that loses as little energy as possible. No matter how good solar and wind power become, they will always be limited if we cannot store the energy. More research is underway in this area, which is very important.

The image is of a proposed storage facility. As energy is collected, a tower is created. This translates the energy that is generated into potential or gravitational energy in the blocks. During the day, the blocks are lifted and the tower is built. At night, the blocks are lowered back to the ground, generating energy that can be put out onto the grid.

1. **Climate Change Policy**

So, we’ve seen the sources of emissions, including energy, cities, and land use (agriculture and deforestation). Now let’s talk about how we can reduce those emissions through policies—through the actions governments take.

1. **Policies to fight climate change that directly reduce emissions**

Climate policies all try to find ways to reduce net greenhouse gas emissions. Remember that the basic problem is that all activities that produce greenhouse gas emissions, including burning fossil fuels, are “too cheap.” So, policies that push toward reductions in energy use overall, improvements in renewable energy technology, and greener use of land can fight climate change.

The way most pollution is regulated is that you see where the pollution is emitted and you try to get there to be less pollution coming out. The old-fashioned simple way of doing this for normal pollutants is that you go to the places where the emissions are coming out, like power plants, and you give them an emissions standard or limit that says they’re only allowed to put out so much pollution. But these policies are usually very inflexible in the sense that they may treat a pollution source that finds it really expensive to reduce emissions the same as one that finds it really cheap to reduce emissions.

Instead, to help increase reductions, economists put a price on emissions. The basic idea is that the root of the problem is the artificially low price of fossil fuels, which happens because the pollution creates a cost that’s external to the buyer and seller. This problem can be fixed by using policy tools to make the prices reflect the true costs to society. Increasing the relative prices of fossil fuels would essentially level the playing field.

One way to do this is to provide subsidies for green activities. We wouldn’t want to “pick a winner,” but instead subsidize any technology that seems to legitimately reduce emissions. One current method of subsidization for renewable electricity is called “feed-in tariffs.” A feed-in tariff is, essentially, a per megawatt-hour subsidy that is added on to green energy to let it compete with traditional energy sources on the grid.

Economists recommend instituting taxes as an even more powerful solution than green subsidies. These taxes are often called “carbon taxes,” or “cap and trade” programs (also known as pollution permits). The reason is that either of these methods help ensure that emissions reductions are accomplished with the lowest possible costs. This is good in its own right, because it means that meeting our environmental goals requires less sacrifice; but it’s also good because it makes implementing a policy more feasible (people object more strongly to a policy that involves more costs). We’ll explain this further in a moment.

1. **Command and Control vs. Incentive-Based Regulation**

a

1. **Efficiency: CAFÉ standards vs Carbon Tax**

<lifted directly from Metcalf (2019)>

Numerous papers have been written on the relative inefficiency of fuel economy regulation relative to a Pigouvian tax – see, for example, the recent review by Anderson and Sallee (2016). Whereas taxes on emissions – in transportation this can be translated into a tax on gasoline use – creates incentives for consumers to purchase more fuel‐efficient vehicles, drive fewer miles in aggregate, and scrap fuel inefficient vehicles sooner. A fuel economy standard mandating that an auto‐ maker’s vehicle fleet must meet minimum fuel economy standards in toto also incentivizes the purchase of more fuel‐efficient vehicles. But the higher fuel economy drives down the cost of driving per mile and so can lead to more driving – the rebound effect. Moreover, fuel economy standards only apply to new vehicles. This increases the value of fuel‐inefficient vehicles already on the road and delays their eventual scrappage, an effect first pointed out by Gruenspecht (1982). All in all, these factors lead to fuel economy standards being less cost effective than an emissions tax for achieving given emission reductions. Karplus et al. (2013), for example, find that fuel economy standards are six to fourteen times more expensive than a fuel tax to achieve the same emission reductions. Jacobsen (2013) finds CAFE is a little over three times the cost of a gasoline tax per ton of carbon dioxide avoided in a model where technology can respond to the mandate or higher fuel costs.

1. **How Does a Carbon Tax Work?**

**c**

1. **How Does Cap and Trade Work?**

b

1. **Putting a Price on Carbon**

Let’s demonstrate how carbon prices work. On the horizontal axis of this graph, we have amounts of emissions. On the vertical axis, we have costs of reducing emissions. The blue line is like an abstract version of that McKinsey curve we showed you before—these are all the ways to reduce emissions, some more costly, and some less so.

If everyone who emitted a unit of greenhouse gases had to pay some carbon price, they’d have to ask themselves for each unit: do I want to emit and pay that carbon price, or do I want to not emit (abate) and pay the abatement cost? In this way, all of the low-cost reduction opportunities will happen because it’s cheaper for the person to abate than to pay the carbon price.

Let’s suppose the we set the cost of emitting carbon at $50/ton. The all of the activities in blue, those where the bar is entirely below $50/ton would abate instead of paying the fee.

1. **Putting a Price on Carbon**

**<This slide works together with the previous slide to make the point described below>**

It’s easy to see how you can do this with a tax: you just set a tax equal to whatever price you want to set on carbon. A higher tax gets you more reductions. A carbon tax is a form of carbon pricing. In theory, this tax is levied on the carbon content of fuels (including fossil fuels such as coal, oil and natural gas, as well as biofuels) as well as on the greenhouse gas-producing effect of any other activity, such as deforestation and the raising of cattle. The carbon price is the social cost of avoiding an additional unit of CO2 equivalent emission. Such a tax fixes the crucial price signals to spur the right amount of carbon-reducing investment to balance costs of abatement with costs of damages.

With cap and trade, you set a limit for the amount of greenhouse gases that can be emitted in society—that’s the CAP. Then you create a permit for each unit of emissions you want to allow. You then get those out to the polluters (give them away, auction them, it actually doesn’t matter theoretically). Since you’re reducing your country’s emissions, you won’t have quite enough permits to go around for the amount of pollution generated! Perhaps two firms each have 10 permits, but one (Firm A) really wants 15 permits and would find it really expensive to cut emissions to 10. Say the other (Firm B) could relatively easily switch to another power source to reduce emissions to 5 units—not for free but relatively cheaply. Firm A then buys 5 permits from Firm B—that’s the TRADE. If a lot of these trades happen, then there’s a market price for permits. That acts like a carbon price just like a carbon tax would. If you know enough about how much it costs firms to reduce their emissions, then you can set a cap that would give a permit price equal to whatever level of tax you might have wanted to set—the tighter (lower) the cap, the higher the price (tax).

Notice that in each case, we get the amount of emissions we want, but we’re taking advantage of the lowest-cost opportunities to reduce emissions. To be clear, a tax or a cap and trade system will raise the prices of burning fossil fuels and other climate-harming activities. That’s the point of these systems. But people—people like us—will respond to those higher prices by shifting from dirtier to cleaner energy, buying more energy efficient products, and finding other ways to reduce our emissions.

Another thing to note here. If we design this system to get just the right balance of costs and benefits from fighting climate change, then the carbon tax or the price of emissions permits should be equal to the social cost of carbon. If you remember, we used this phrase to refer to the damages caused to humans by a unit of greenhouse gas emissions. The reason greenhouse gas emissions need to be controlled is that they cause costs that are externalities—they affect people other than the people who buy and sell the electricity (or whatever the item is that causes the pollution to be produced). When the price of carbon equals the social cost of carbon, the buyer and seller are now forced to reckon with the true costs of their decisions, and thus they’ll naturally come to the right balance of emission costs and benefits. Remember, too, that we said that the social cost of carbon is estimated to start at about $40 per metric ton of CO2 (though different people’s estimates vary) and should increase over time as we move into the future.

1. **Carbon Prices: The Good and Bad**

To economists, carbon taxes and cap and trade systems are likely to perform in ways that are mostly similar, by “fixing” the price problem and getting low-cost emissions reductions.

There are some potential concerns with pricing carbon, either through a tax, or through cap and trade.

It turns out that lower-income people spend a larger portion of their income on consumption items, including electricity, transportation, and goods produced using energy; as a result, any form of a price on carbon (either a tax or cap and trade) has a “regressive” impact, which means that low-income people pay a higher percentage of their income than do high-income people. This is easiest to see with a tax, but is also true of cap and trade, since greenhouse-gas intensive things will have higher prices to reflect pollution permit prices. Most countries, including the United States, prefer policies that are “progressive” in terms of their impact on income distribution, so that the proportion of income paid goes up with income. One way to fight this is to use any revenue the system generates to give families money back, and more money can be given back to lower-income families. (Taxes obviously generate revenue directly; cap and trade can be used to generate revenues if the permits are sold or auctioned to firms rather than given away.)

The subsequent revenue could be spent on public works, including environmental projects, but these tend to be less progressive or even regressive (benefiting high-income people more than low-income people). This is why current proposals (some of which we will discuss in a moment) call for returning the tax revenue generated from the carbon tax back to households. A system that returns carbon tax revenue to people is known as a carbon fee and dividend.

Additionally, if one area implements a carbon price and there are other areas that do not, some people fear that firms might flee for those less-regulated areas, thus taking away jobs. It has been argued, however, that carbon taxes are more efficient than direct regulation and may even lead to higher employment (Newell and Pizer, 2003). Recent careful estimates show that employment effects of greenhouse gas regulation are likely very small (Hafstead and Williams, 2018).

Both policies require close monitoring of greenhouse gas emissions, which might be costly and difficult in some situations.

1. **Revenue Dividend Eliminates Regressivity[[1]](#footnote-1)**

The easiest way to offset the potential regressivity of a carbon fee is to rebate the fee on a per capita basis. That is, to give each and every person in the United States an equal share of the revenues collected.

According to the U.S. Treasury, this would result in the tax in fact being progressive. Poor households would benefit the most after dividends from the carbon fee. Nearly 70% of U.S. households would break even or come out ahead under this scheme.

Makes it easier to pass, politically. Avoids the food fights associated with distributing the revenues and builds long term support from the public.

1. **Carbon Tax and Cap and trade: the differences**

**<click off the white rectangles and you get the next slide. Helpful to have both for creating pdfs – just click through to slide 50; first 3 clicks remove white rectangles and 4th goes to next slide>**

1. **Carbon Tax and Cap and trade: the differences**

There are some practical differences between taxes and cap and trade

Price and emissions: A carbon tax provides more certainty about the price firms face, but little certainty about the amount of emissions reduced. If the tax is set too low or too high, emissions will be too high or too low relative to the target. On the other hand, cap and trade provides more certainty about the amount of emissions reductions that will be achieved, and this might be important if we think that there’s an ecological threshold that we’re afraid of crossing if emissions turn out to be higher than expected. However, cap and trade has little certainty about the price of emissions, which is set by the emissions trading market (the number of permits on the market). Fluctuations in markets (e.g., a really hot day in summer causing a spike in demand for electricity) can cause permit prices to spike; this could cause blackouts and brownouts and high costs for firms and households to bear.

Ease of implementation: It may be easier and quicker for governments to implement a carbon tax. Governments already have systems set up to tax things, and often already have taxes on fuels that they can just add to. Therefore, a carbon tax may be able to be implemented in just a few months (voting aside). In theory, the same applies to cap and trade systems, but in practice they tend to be slightly more complex, requiring more time to develop the necessary regulations, since a cap and trade system is an entirely new institution and can’t piggyback on existing regulations in the way that new taxes can be piggybacked on and implemented by existing tax authorities.

Additional concerns: Because they require more new development, cap and trade systems may be susceptible to lobbying and loopholes. Also, tax systems always generate revenue that the government can use to reduce other taxes or redistribute back to people; cap and trade systems can generate revenue, but only if the permits are distributed by selling them to the firms initially, and the government may be tempted to give them away. Finally, cap and trade may be more flexible in the long run, though this depends on how the country’s regulations work. In the United States, a tax would probably require legislative approval to change the tax level, while a change in a cap and trade system could probably be adjusted by a regulatory agency like the EPA.

1. **One Other Thing: Cap and Trade vs. Carbon Tax**

narrative

1. **Implications of a $50/ton Price on Carbon**

Let’s talk just a little bit more concretely about the implications of a carbon tax. In particular, suppose there was a uniform carbon tax of $50/ton of emissions. One ton of coal results in almost 3 tons of emissions, so the cost of burning a single ton of coal would add about $140.

This has implications clearly for electricity, driving your gasoline-powered car, and for everything else, including banking services. The implications for some sectors are much bigger than for others.

This tax would roughly double the price of coal-fired electricity, making other cleaner sources much more attractive. This would shift the playing field for producing electricity in ways that significantly reduce emissions.

In terms of driving, it would add about $230/year to the average cost of driving your gasoline-powered car. This will help to get people out of their cars or to share them more actively, again, reducing emissions.

Other services, such as banking, will also be affected, but in a much smaller way. Estimates suggest that a $50 carbon fee would increase banking costs by about $1/year. An amount that would be scarcely felt. It may cause banks to make subtle changes, such as more efficient lighting, but will not affect customers significantly.

We have talked about a $50/ton fee, but the average fee is currently just $2/ton of emissions. This is an amount that is far too small to have any meaningful effect. Clearly, the price of carbon must be higher for this policy instrument to truly have an effect.

# Why Climate Policy Has Failed: And How Governments Can Do Better, By [William Nordhaus](https://www.foreignaffairs.com/articles/world/2021-10-12/why-climate-policy-has-failed?utm_medium=newsletters&utm_source=fatoday&utm_campaign=Why%20Climate%20Policy%20Has%20Failed&utm_content=20211012&utm_term=FA%20Today%20-%20112017#author-info), October 12, 2021, Foreign affairs

1. **Indirect Policies to fight climate change**

First, though, you may be thinking about other policies to fight climate change. Here are some of the policies that people tend to talk about. They can often help achieve climate goals and may have other benefits, even though, on their own, they generally will not solve climate change. This is because none of them fully solve the problem of the “unfair advantage” that fossil fuels have.

***Subsidizing R&D***

Promoting low-carbon or no-carbon technologies is a good idea. Research and development might be particularly in need of subsidies. The payoff for research is always uncertain and happens long in the future, so firms may be too cautious to invest heavily for unknown results.

***Grid/infrastructure***

As I’ve mentioned, infrastructure in general and the electrical grid in particular need investments, and low-carbon investments are a smart choice right now and heading into the future.

***Energy Efficiency Mandates & Subsidies***

A lot of attention is paid to energy efficiency, which governments can influence through mandates (e.g., California building codes) or subsidies for purchase of energy efficient alternatives (e.g., hybrid car subsidies). Energy efficiency is good because it lets people get more benefits from less energy. But most claims of energy reductions from energy efficiency investments have not proven to be very effective, either because efficiency improvements are less effective than expected or because people adjust their behavior to use efficient goods more often (e.g., you drive a hybrid more than you would drive a Hummer). Although society might want to encourage energy efficiency, economists don’t expect that these policies alone will solve climate change.

***Mandating Renewable Energy***

Many states in the U.S. have policies (“renewable portfolio standards”) that mandate that at least a certain percentage of the state’s electricity be from renewable energy sources, with the percentage growing larger over time. These standards have the potential to reduce emissions, but they do not guarantee low costs for doing so.

***Land use policies***

Land-use policies like smart city planning and policies for reducing deforestation and making agriculture less emissions-intensive could be low-cost ways of reducing emissions if pursued carefully. Some of these methods can fit into emissions pricing schemes, which we’ll talk about in a minute.

1. **Atlanta and Barcelona Have similar populations but very different carbon productivity**

Infrastructure can also be considered on a larger scale, such as the framework of cities. Cities are important because they are engines of economic growth. They generate around 80% of global economic output, and around 70% of global energy use and energy-related GHG emissions. Therefore, haphazard urban growth comes at a significant economic and environmental cost. This image of Atlanta and Barcelona show that these different patterns of urban sprawl are associated with very different carbon intensities. Carefully planned cities, such as Barcelona, demonstrate that compact urban development, connected with mass public transportation, sets the stage for healthy economies and citizens, and lower emissions. The New Climate Economy report estimates that such an approach to urbanization could reduce urban infrastructure capital requirements by more than US$ 3 trillion over the next 15 years.

1. **Compact and Connected Urban Pathways Can Go Hand-in-hand with economic growth**

As we see in this figure, economic growth can be very strong in cities that have compact and connected urban pathways. The dark blue line is basically a measure of economic performance, and you can see that for these cities (Stockholm, Copenhagen, and Hong Kong), there has been economic growth. The dark red line is a measure of per-person greenhouse gas emissions, and you can see that it is flat or declining in each city as economic growth continues. These are cities that are well known for being compact and dense. That allows transportation to be minimized, and contributes to dynamism as firms and workers can interact easily with each other.

1. **Land Use: Restoration is possible**

In addition to organizing our cities in a less resource-intensive way, we should also be attentive to the way land-use change affects the climate. This is especially true given that we need to balance the agricultural productivity that will let us feed a population projected to grow to over 8 billion by 2030 with sustaining our natural environments. Agriculture and forests are important parts of land-use change, especially in tropical countries that have substantial carbon-rich forests and in developing economies where 40% of the world’s degraded lands are found in areas with high poverty rates (FAO, 2011). The New Climate Economy report argues that food production can be increased, forests protected, and land-use emissions cut by raising crop and livestock productivity (through technology and R&D), using new technologies, and taking comprehensive approaches to soil and water management. Deforestation can be slowed through strong international support combined with strong domestic commitment to forest protection and rural income development.

Additionally, restoring just 12% of the world’s degraded agricultural land could feed 200 million people by 2030, while also strengthening climate resilience and reducing emissions. These images from South Korea show that kind of restoration.

1. **Climate Change Policy in Action**

I know I’ve introduced a lot of theory, but understanding the theory of carbon pricing is vital for appreciating and evaluating how we can apply it.

1. **Carbon Policies Across the World**

In fact, the application of pricing carbon is gaining traction throughout the world. As of April 2018, there were 51 carbon pricing initiatives across 45 countries (or about 26% of all countries). These initiatives account for 20% of global GHG emissions, and the implemented initiatives are valued at US$ 81.68 billion (or roughly 4% of annual U.S. GDP or 30% of the cash Apple has on hand). And while many large users of carbon resources in electricity generation, such as the United States, Russia, and China, have been slow to implement carbon prices, we are starting to see a break in this trend.

For example, at the state level, Oregon in 2016 had a carbon pricing initiative on their ballot, and it is likely to come up again this year. Regionally, nine states in the northeast U.S. participate in the Regional Greenhouse Gas Initiative (RGGI), which is the first mandatory market-based carbon pricing program in the United States. Federally, there is a bipartisan caucus (the Climate Solutions Caucus) in Congress that is currently evaluating possible federal carbon pricing models. One such example is the bipartisan carbon pricing system that was introduced as the Baker-Shultz Carbon Dividends Plan. Internationally, China, in December 2017, formally launched a national carbon market.

As you can see, carbon pricing is becoming more common and most likely will spread even further in the future. Let’s dive into more detail on current applications of carbon pricing, either through a tax or cap and trade.

Sources: https://carbonpricingdashboard.worldbank.org/map\_data

(ETS stands for emissions trading system, which is cap and trade)

1. **Cap and Trade**

Let’s begin with cap and trade programs, which you’ll remember means that a governing entity sets a limit on the amount of CO2 or CO2 equivalent emissions. I begin with the cap and trade programs because they currently make up the largest carbon pricing policy. As of April 2018, there are emissions trading systems at most levels of government: regional, national, and subnational (e.g., state or province).

1. **Cap and Trade Policies Around the World**

As this map shows, there are 25 emissions trading schemes implemented or scheduled, covering over 37 national jurisdictions and 15.1% of global greenhouse gas emissions.

1. **European Union’s Emissions Trading Scheme**

Let’s zoom in and talk about specific cap and trade programs. We’ll begin with perhaps the most well-known cap and trade market, and one you may have heard of before, which is the European Union’s Emissions Trading System (EU ETS). Having launched in 2005, the EU ETS is the largest and oldest major trading system, covering more than 11,000 facilities that collectively emit nearly half of the EU’s carbon emissions and accounting for roughly 4% of global emissions.

The EU ETS works by putting a limit on overall emissions from high-emitting industry sectors. That limit is reduced each year. Within the limit, companies can buy and sell emission allowances as needed.

1. **Progress towards meeting Europe 2020 and 2030 targets (EU Total GHG Emissions)**

The EU set a goal to reduce its emissions 20% from 1990 levels by 2010 using the ETS system. There were some initial hiccups with really low permit prices that weren’t reducing emissions much at the beginning. However, the EU refined the system, and since then, they have passed the 20% target and actually reduced emissions by 23% by 2016. You can see this reduction by the declining green line on this figure. How did they accomplish this goal? By gradually decreasing the allowed carbon emissions (the cap) each year.

They are not done, however! The EU now aims for a 40% emissions reduction compared to 1990 levels by 2030, as represented in the brown/tan dashed line in this figure. To achieve the new 2030 goal, the cap will start decreasing faster in 2020.

Another interesting fact about the system is that in the beginning, the ETS administrators gave out most of the permits for free to polluters. Over time, however, they have moved toward auctioning more and more of the permits. This is a common progression that is designed into most modern systems to ease the transition at first but eventually take advantage of the opportunity to raise revenue.

Source: [European](file:///Users/Jon/NEED%20Dropbox/Presentations/ClimateChange/Current/European) **Commission, 2013.**

1. **EU Has decoupled economic growth from greenhouse gas emissions**

You may be asking yourself, OK, how did this emissions reduction affect the EU economy? As I mentioned earlier, countries have implemented carbon pricing schemes without a loss of benefits to the economy. And the EU is no different. As you can see in this figure, as GHG emissions and intensity have fallen over time since the implementation of the EU ETS (see the red and green solid lines in the graph), GDP has actually increased by 50% as the solid blue line illustrates. Therefore, the EU been able to reduce GHG emissions without stopping growth. This means that growth has been decoupled from greenhouse gas emissions.

Source: [European](file:///Users/Jon/NEED%20Dropbox/Presentations/ClimateChange/Current/European) **Commission, 2013.**

1. **California’s Cap and Trade System**

California’s cap and trade program, which launched in 2013, is one of the largest programs in the United States. Over 450 companies, together responsible for 85% of California’s total GHG emissions, are regulated in this system. Because California is so big, that makes up 0.7% of global GHG emissions.

1. **California’s System is flexible**

California’s climate goal is to reduce regulated businesses’ GHG emissions to 1990 levels by 2020 and to 80% below 1990 levels by 2030. California’s program is a great example of the flexibility that cap and trade programs provide. For example, California’s program works in tandem with the Canadian provinces of Ontario and Quebec, which means that businesses can trade emission allowances across jurisdictions, leading to additional economic efficiencies. Their cap and trade program also works alongside other state climate policies, such as the

* Renewable Portfolio Standard, which requires all utilities in the state to source half of their electricity sales from renewable sources such as wind, solar, geothermal, and biopower by 2030.
* Clean Cars Program, which requires automakers to show a 30% overall reduction in GHG emissions on vehicles by 2016.
* Low Carbon Fuel Standard, which requires that all fuels sold in California by 2020 be 10% less carbon intensive than they were when the regulation was implemented in 2007.

1. **CA Relative to Goals: How Are We Doing?**
2. **Change in CA GDP, Pop, and GHG Emissions since 2000**

As you can see, California has implemented several policies that have decreased GHG emissions, as shown by the red, yellow, and orange lines on the graph. California has also shown that it can reduce emissions as the population grows. The blue line in the graph shows population growth, and the green line marks economic growth.

Source: https://ww3.arb.ca.gov/cc/inventory/pubs/reports/2000\_2019/ghg\_inventory\_trends\_00-19.pdf

1. **RGGI: The regional greenhouse gas initiative**

The Regional Greenhouse Gas Initiative (RGGI) was first implemented in 2009, and it has expanded and progressed since then. It covers the power generation sector of states in the northeastern United States. As of 2015, the RGGI states accounted for 7% of U.S. emissions. Murray and Maniloff (2015) estimate that RGGI caused emissions in RGGI states to be 24% lower than they would have been without RGGI.

1. **RGGI’s Effect on Emissions**

This picture shows that it’s not that simple to make that determination. As you can see, emissions were dropping in the region, but they were well below the overall cap. Emissions were also dropping in part because this system was implemented at the same time as the Great Recession. This may be why New Jersey left the trading system in 2011.

1. **Carbon Tax**

Now let’s talk about carbon taxes.

1. **Worldwide Carbon Taxes**

There are currently 26 carbon taxes across 24 nations regulating 5.3% of global GHG emissions. Even though carbon taxes are not quite as popular as emissions trading schemes, they have been used in many places and are gaining traction at the federal level. A carbon tax is generally priced per ton of C02 or C02 equivalent. As we said before, this should match, or ramp up to match, the social cost of carbon—the total cost of damages each unit of greenhouse gases causes to humans.

1. **British Columbia’s Carbon Tax Policy**

British Columbia, the third largest province in Canada, accounts for 0.1% of global GHG emissions. The province has had a carbon tax since 2008.

1. **“Tax the pollution we do not want….”**

The carbon tax was originally implemented by a relatively conservative government that wanted to ensure that the carbon tax was revenue neutral, so that the overall tax revenue would remain unchanged. To ensure revenue neutrality, every dollar the tax raises is returned to British Columbians through reductions in the income tax and corporate taxes.

1. **British Columbia’s Tax on Carbon**

So how does that tax work, exactly? Let’s look at this figure. In the early implementation period, British Columbia started off with a tax at CAD$ 5/ton of carbon dioxide equivalent in 2008, then increased it by CAD$ 5/year until the tax hit CAD$ 30/ton. In 2018, the government started increasing the tax again by CAD$ 5/year until it hits CAD$ 50/ton in 2021 as illustrated in the second half of the figure.

1. **Relative Greenhouse gas emissions, GPD, and pop size: British Columbia[[2]](#footnote-2)**

Let’s examine how British Columbia’s carbon tax has affected GHG emissions and economic growth. Remember the tax started in 2008. You can see a decline in the total GHG emissions (see the solid blue line in the figure), despite an increase in population (solid green line in the figure) and GDP (solid red line in the figure). More specifically, from 2007 to 2014, British Columbia saw an increase in population of 8.1%, an increase in real GDP of 12.4%, but a net emission decrease of 5.5%. In fact, since the tax, British Columbia’s GDP has grown faster than the rest of Canada but the province has not seen an increase in GHG emissions.

Recent research in fact indicates that the carbon tax generated a slight increase in overall employment. It also shifted employment from carbon intensive sectors, such as chemicals manufacturing to cleaner industries such as health care.[[3]](#footnote-3),[[4]](#footnote-4)

1. **Sweden’s Carbon Tax Policy**

Finally, let’s introduce the world’s oldest carbon tax, which is in Sweden. The tax was put alongside other fuel taxes. It was introduced primarily as a way to raise revenue, but it has become a cornerstone of Swedish climate policy.

1. **Sweden’s Carbon Tax Policy**

Sweden’s carbon tax began around $30/ton and was gradually increased to give businesses and households time to adapt. The tax currently sits around $140/ton. Sweden’s goal is to reach a point of no net emissions of greenhouse gasses by 2045.

1. **Real GDP and domestic co2eq emissions in Sweden, 1990, 2017[[5]](#footnote-5)**

Sweden, too, has been able to decrease their emissions (solid orange line in the figure) while growing their economy (solid yellow line in the figure).

1. **U.S. Carbon tax plans**

Finally, the United States is starting to recognize the ability to decrease GHG emissions while also growing the economy, which is why there are several bipartisan carbon tax agendas under consideration. Proposed policies in the U.S. suggest starting a carbon tax between $40/metric ton (Climate Leadership Council) and $15/metric ton (Citizens Climate Lobby) and increasing steadily over time.

Several states and municipalities have potential plans for carbon taxes in the works as well. These include Washington state, Oregon, and Washington, DC.

1. **Summary**

Climate change is real, is caused by human actions, and has impacts we’re already feeling. We need to reduce emissions to balance the costs of action against the costs of inaction. Scientists and the IPCC recommend that we work to keep warming below 2 degrees Celsius.

1. **Summary - Continued**

Thankfully, there are many ways to reduce emissions and economics-inspired policies can help us do this at the lowest cost. Taxes and cap and trade programs are proven, effective tools that we can use to fight climate change!

1. **“Economic Policies will be central to accomplishing the goals we choose”**

The next 10 to 15 years are crucial. In fact, the next 15 years of investment will determine the future of the world’s climate system. Climate change caused by past greenhouse gas emissions is already having serious economic consequences, especially in more exposed areas of the world. Without stronger action in the next 10 to 15 years, that is, without action that causes global emissions to stop climbing and actually start falling, global average warming will almost certainly exceed 2 degrees Celsius, the level the international community has agreed not to cross. According to current trends, warming could exceed 4 degrees Celsius by the end of the century, with extreme and potentially irreversible impacts. By building up greenhouse gas concentrations and locking in the stock of high-carbon assets, delay in reducing emissions makes it progressively more expensive to shift toward a low-carbon economy.

Climate change has costs. It’s better for us to tackle climate change in the lowest-cost way we can with smart policy, paying a moderate price now to create a future that lets the human race reap the benefits of a healthy planet.

1. **Questions?**

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3. Yamakazi (2017). [↑](#footnote-ref-3)
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