

THE POLICY CLIMATE



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Dear Reader,

We are pleased to present the inaugural edition of *The Policy Climate*. In this report, we offer an overview of policy issues relevant to climate change across the world that we hope will allow policymakers, analysts, advocates, and interested people of all stripes begin to see how the policy challenges of climate change fit together at the national and transnational level.

Climate change is a multi-faceted problem. It is the result of almost everything humans do, how we work, how we travel, how we feed ourselves, everywhere in the world. Similarly, policy of all kinds—including energy policy, land use and agriculture, industry, transport, urbanization and construction, and even economic development and fiscal policy—can have important consequences for climate change.

In this report, we focus on:

1. Brazil, China, India, Europe, and the United States—the regions we focus on in our work, which represent the majority of global greenhouse gas emissions;
2. The economic sectors that represent the greatest potential for greenhouse gas mitigation within each of these regions; and
3. A defined set of policy issues within these regions and key sectors that most affect climate change. In this first review, we have not yet explored the issues of climate change adaptation, although we expect more work in this area in future years.

For each of the sectors covered in these regions, we provide stylized facts and data about emissions trends, as well as a summary of drivers for those emissions over the last 20 to 30 years. Since institutional and political issues are such an important factor in the climate story, we also include a summary of the most important political considerations and policy directions for each of the geographies covered, as well as highlight important policy issues that cut across geographic boundaries. In so doing, *The Policy Climate* also highlights important issues that form the basis of CPI's work.

Please also visit the interactive version of this review at PolicyClimate.org.

We hope that you enjoy *The Policy Climate* and find it useful.

David Nelson

Senior Director, Climate Policy Initiative



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Climate Policy Initiative (CPI) is a global analysis and advisory organization focused on the effectiveness of climate and energy policy. Its mission is to assess, diagnose, and support nations' efforts to achieve low-carbon growth. An independent, not-for-profit organization led by Thomas C. Heller and supported by a grant from the Open Society Foundations, CPI's headquarters are in the U.S., with offices and programs in Brazil, China, Europe, India, and Indonesia.

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THE GLOBAL POLICY CLIMATE

BY THOMAS C. HELLER

More than two decades after the first Rio summit and the structuring of the United Nations Framework Convention on Climate Change (UNFCCC), global negotiations are stalled. That does not mean that nothing climate-related is happening. Even as greenhouse gas emissions rise year after year, climate friendly policies proliferate at national, provincial, and local levels in both developed and developing countries.

Energy efficiency, renewable energy, forest protection, biofuels, and carbon pricing are on the agenda of policymakers in many countries, sometimes for the express purpose of combating climate change, more often to achieve other goals such as energy security, economic efficiency, industrial and agricultural development or even improving a country's balance of payments. Yet we must ask: Are these the right policies? What has worked well, and what has not? Are these national and subnational policies, taken together, enough to address climate change?

This first edition of *The Policy Climate* is designed to provide a foundation for answering these questions. In it we focus on the evolution of climate policy in five major emitting regions: Brazil, China, Europe, India, and the U.S. With global negotiations stalled, we focus on national and subnational policy, because that is where the action is.

In this essay, however, I will begin with perspectives on the global negotiations. First, because a global agreement may still be essential, and would most certainly help tremendously, and more importantly, because the lessons that we learn from the national actions may themselves help inform the negotiations. Then, for those seeking to improve their own national policy, as well as to inform the global negotiations, I will summarize some of the key lessons that emerge from our review of the current state of climate policy, including the common, high-level policy issues that seem to cut across several countries and regions. Finally, I will reflect on what all of this means for the next decades of climate policy and for the work of Climate Policy Initiative.

STUCK IN THE PAST: GLOBAL CLIMATE NEGOTIATIONS

In 1995, for the Second Report of the Intergovernmental Panel on Climate Change (IPCC), the scientific community modeled global scenarios for future greenhouse gas emissions, including how fast emissions would grow and where the emissions would be produced.

We were way off. The IPCC predicted that the world would reach current emissions levels by 2030, at the earliest. Today, we are already far beyond what was the worst-case scenario. In the past 20 years, enormous political and economic shifts, reflecting changing development patterns, have altered the pace of emissions growth and its distribution. Growth in developed countries has neared zero, particularly in the face of successive financial crises, while capital and growth have moved to the developing world. The irony of climate risk is that it is driven by unimagined success across the developing world, where the middle class continues to grow, consuming more food and fuel.

That is a very different world than what we expected back in 1992. For better and worse, it has been turned upside down. However the ideas and assumptions that underlie the UNFCCC treaty remain consistent with the way the world looked in 1992, not with the way it looks in 2013. In many ways, global climate negotiations are stuck in the past, reflecting a world order that doesn't exist anymore.

In 1992, the United States had just won the Cold War, and leaders expected a large peace dividend. Money long devoted to the military budget could be freed up for other purposes. The economy was recovering from the recession of the late 1980s and growing fast. Europe was completing the integration of its markets and forming the European Union and the Single Market, which removed all barriers to capital movement and trade within the EU's growing borders. The developed countries were doing well, loaded with capital, budget surpluses, and optimism.

Meanwhile, the developing world was in bad shape, without sources of capital or revenues in their budgets. Countries that had relied on central planning had been severely shaken. Russia was abandoning communism and beginning its unsure turn to markets. China

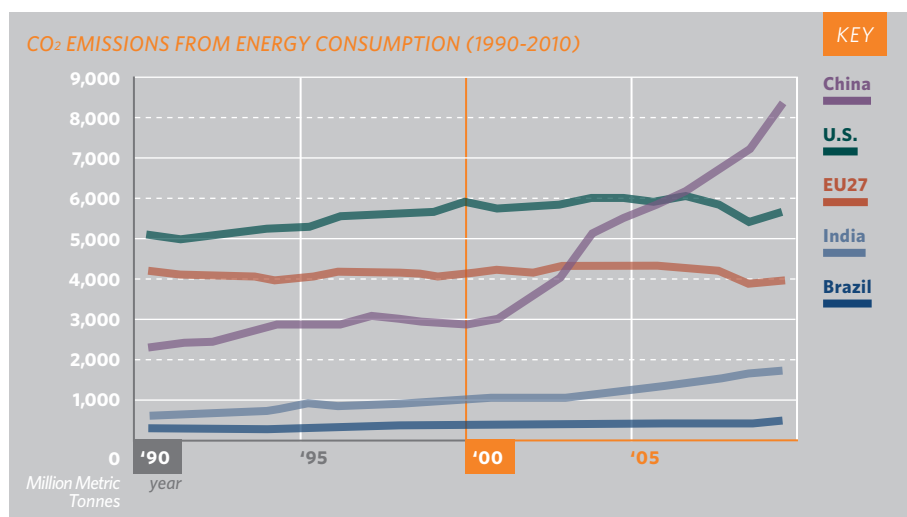
began to free up its market after Deng Xiaoping's South Integration Tour in 1992. Large nations, like India and Brazil, were literally broke, without reserves to pay for imports. Many were also undergoing major changes in their internal institutions.

Today China is the world's second largest economy behind the U.S. Capital stock is very high in the emerging markets, driven by the growth that is now concentrated in countries like China, India, and Brazil, with Turkey, Thailand, Chile and many others not so far behind them. At the same time, developed countries are fighting a recession and have had close to zero growth in many cases. China has long since become the world's largest emitter, and emissions growth continues across the developing world, even while emissions in the U.S. and Europe are flat or falling. This fall is partly due to policy, but also to flagging economies and the relative price of commodities, such as gas versus coal in the U.S. As in the chart below, between 2001 and 2010, fully 68% of the increase in global energy-related CO₂ emissions came from China and another 8% from India.

vailing markets where we thought emissions and emissions growth would occur, and then allow trading to find who could most cheaply avoid the potential losses climate change would impose. An international agreement would determine a cap or target emissions, issuing a limited number of permits in accordance with that target, and allowing supply and demand for those permits to discover the actual price.

Since the developed countries had put most of the existing carbon into the atmosphere during industrialization, the developing world argued that such a system should operate under a principle of common but differentiated responsibility—that is, at least for a while, only the developed countries would take emissions targets, and developing countries would receive some sort of fiscal or technology transfer to pay for the added costs of constraining their emissions.

In practice, the multilateral market system never yielded the potency and effectiveness for which we had hoped: Targets were never as tight as expected, no formula was accept-



When we developed the idea for a global cap and trade system, we conceived of climate change as an environmental problem that put a limitation on growth, which we assumed would be largely located in the developed market economies of the West. Once we framed climate risk as an environmental cost, we came up with a sensible market answer for it. We would create a proper price for the environmental damage, insert it into the pre-

ed as to how permits ought be distributed, the caps never deepened over time or spread across countries, the U.S. and later Japan and Canada opted out, and surplus permits from the economic collapse of the Soviet Union and dubious offset projects from China created price distortions.

Now, the geopolitical underpinnings of the international climate regime are out of line with

the inverted global political economy in which it is situated. While historical emissions may still lie more heavily in the developed world, the growth in the economies and emissions in places like China and India mean we can no longer conceive of meeting climate goals without serious actions across all economies. Meanwhile, the investment capital needed for new energy and food systems is now much less concentrated or available in the developed world and, indeed, may be more readily available in some places outside it.

The world has moved on from the expectations that underlie the ongoing climate negotiations, but the negotiations themselves have not. The 21st Conference of the Parties will be held in Paris in 2015, with the goal of setting a course for a new global agreement. There is very little reason to believe developing countries will be willing to take on targets in some sort of relatively uniform formula, and even less reason to believe very large amounts of money are going to be transferred from the troubled developed economies to the emergent developing nations.

WHAT'S HAPPENING IS HAPPENING AT THE REGIONAL AND NATIONAL LEVEL

While international climate negotiations may be currently trapped in an old paradigm, climate policy activity has moved forward at the national and subnational level in both the developed and the developing world, most often motivated by economic and other forms of national self-interest.

As many nations are aware, resource prices are rising. Development-driven demand and increasing costs of new sources of supply predict this trend will continue; the market response to rising resource prices is to invest in both efficiency and innovation. Reinforced by widespread concerns about energy and food security, forward looking governments in developed and developing countries are starting to fashion spending, regulatory, and public investment policies to anticipate where relative prices will go and build an infrastructure consistent with those changing markets.

There have been some real accomplishments, starting with the European Union, which complements its flagship Emissions Trading System with the 20-20-20 targets of the Climate

and Energy Package. The mandates set goals for 2020 to cut greenhouse gas emissions by at least 20%; meet 20% of EU energy consumption from renewable sources; and reduce primary energy use by 20% by improving energy efficiency.

Under the 20% renewable energy target, EU member states like Spain and Italy have invested taxpayer and ratepayer funds at scales that have driven down global costs for onshore wind and solar PV. The UK and Denmark are on the new frontier of off-shore wind. And Germany's Energiewende has implemented integrated policies to support innovative generation, transmission, storage, and market design to transform its entire energy system. In so doing, it seeks a prime place in a global low carbon energy industry and has already surpassed its EU renewables target for 2020.

In the United States, stable emissions are a result of both reduced demand caused by the recession and extensive private investment in shale fracking, which has driven the price of gas down to the point that firms aren't building or burning coal the way they once were, and gas appears to produce about half of the emissions of coal. At the same time, many states have instituted an array of policies, including renewable energy portfolios and energy efficiency targets, which create support for clean energy over and above federal tax incentives. Like Europe and Australia, California in 2012 inaugurated an inclusive cap and trade regime that overlaps its other measures.

While the world's top emitter of greenhouse gases, China also has a battery of national, provincial, and municipal targets and financial mechanisms for industrial energy efficiency, and imposes national quotas for renewable energy on state-owned generators. China's energy growth has become bimodal. While coal continues to dominate, last year a quarter of the new electricity generation capacity China built was onshore wind and solar PV, subsidized by local land grants and below market loans from state banks. In accord with a political tradition of learning about effective policy change through decentralized experimentation, China is exploring urban Low Carbon Development Pilots in five provinces and multiple cities and with a cap-and-trade

carbon market in two provinces and five cities. If successful, the intention is to launch a national market in 2016.

India, too, is testing market mechanisms with the Renewable Energy Credit market directed at incentivizing renewable energy and the Perform, Achieve and Trade market aimed at providing market incentives for industrial energy efficiency among the largest Indian industrial consumers. Each of these programs fit within the goal of meeting India's Copenhagen pledge to reduce its carbon intensity—that is the amount of carbon emitted per unit of economic output—by 20-25% from 2005 levels by 2020. However, these programs also serve other national goals such as energy security, economic efficiency, and balance of payments.

Brazil has had a great deal of success slowing deforestation through a policy push over the last decade. The deforestation rate in the Brazilian Amazon decreased from a peak of 27,000 square kilometers in 2004 to 7,000 square kilometers in 2009. That's partially due to lower agricultural and forest product prices, but a CPI study showed that in the absence of government conservation policies, total deforested area would have been twice as large as the observed 62,000 square kilometers. Done properly, Brazil can expand its agricultural yields in soy and cattle, while preserving its valued ecosystem services and the option to employ them as a hedge against uncertainty about their best future uses.

NATIONS FACE SOME COMMON CHALLENGES

We have established that the climate policy world of today is national and sub-national rather than global. It is also plural and not singular in policy design and type, composed of an overlapping and often inconsistent mix of mandates, standards, targets, regulations, voluntary codes of conduct, labels, incentives, taxes, fees, transfers, quotas, guaranties, insurances, public investments, and behavioral campaigns. And it is administered by various and competing ministries and special purpose agencies, with more or less judicial oversight in different polities.

In our work at Climate Policy Initiative, we examine these policies in all shapes and sizes,

across a range of industries and economic activities, in a variety of countries. *The Policy Climate* provides details about the proliferation of policies that has blossomed over the past twenty years. There are, however, some common challenges and questions policymakers around the world are grappling with. Moreover, some of these themes suggest areas where the world can build up from the seeming cacophony of the various policies in play toward the more interconnected transnational system that we started out to construct.

The first thing to realize is that climate policy is policy first and climate second. The design of policy, and how its implementation plays out in the real world, is most often determined by the policy architecture that typifies the political system and institutional powers in place in a nation. Chinese policy, for example, is more comfortable with administrative controls aimed at inducing compliance by provincial and local authorities. China relies on packages of financial incentives; investment controls; encouragement, monitoring, and evaluation of local experiments; and decentralized target responsibilities that are rewarded and punished through promotions and demotions of official careers. Market mechanisms, centralized regulators, and the data systems that support them have not, for the most part, been part of their political traditions.

At the same time, all of the countries or regions in which we work—Brazil, China, Europe, India, Indonesia and the U.S.—are large and diverse. With substantial economic, and often political, cultural, and even language differences between their component states or provinces, policy is normally balanced between the national and subnational governments to allow them to address very different circumstances. Thus, the first lesson for anyone looking at a global picture is that the local context drives policy design. Any overarching solutions must fit into this tangle, strive to create efficiency gains, and weave together existing policies rather than supersede them.

We see this in play in the U.S. and India, where renewable energy targets have been left to the states, even as the national governments develop policies to incentivize it. Europe experiments with a range of interconnected national and EU level policies, which

are often further targeted by economic sector, while China experiments with special economic zones, incentives, and regulation for its low carbon cities and low carbon provinces. These interactions between national and subnational levels carry lessons for any transnational solutions of the future.

Once the local context is established, the scale at which policy is implemented matters. For example, in Brazil, policies aimed at deforestation have been successful in addressing large-scale deforestation to the point where most of the remaining deforestation is smaller in scale. Now, the tools used for finding larger-scale deforestation become less useful, and more expensive, when addressing smaller players. Likewise, a key challenge for China is to expand its “Top 1000” energy efficiency program aimed at the largest 1000 industrial enterprises in China to a “Top 10,000” program. Some of the measures used in the Top 1000 program, including very detailed energy audits and intensive energy management programs employing teams of engineers for long periods of time, may not justify themselves when applied to the next 9000 smaller enterprises, where the value of energy savings for each will be smaller.

For these smaller-scale opportunities, where monitoring and enforcement must occur at the subnational level, governments may prefer producer subsidies rather than mandates. Higher enforcement costs, capacity issues, empowered interest groups, local protection of economic development, or gaming can shift the policy needle toward positive inducements to effect desired behavior.

Another issue is whether umbrella policies that cut across industries, such as the EU ETS, or targeted policies such as specific subsidies to one particular technology, are more effective. Economists might argue that by creating a general market price as an incentive to all, all actors can make decisions based on their own self interest that, nevertheless, together maximize overall efficiency. But can the political system tolerate the outcome of possible wealth transfer where some, especially those across a nation's borders with particularly low-cost carbon savings opportunities, might profit heavily as a result of nothing more than serendipity? The answer is probably a well-constructed combination of the two, but how?

Finally, policymakers often look to what works elsewhere. Borrowing and adapting policy solutions can provide a shortcut to policy development often consistent with the narrow time windows in which policy change is possible, but local context, and how that affects policy, varies from country to country. Therefore, using policies from other countries requires careful consideration and adaptation. For example, the Renewable Energy Certificate policy in India, which is adapted from policies like the Renewable Obligation Certificate market in the UK and the renewable portfolio standards in the U.S., is having, at best, mixed results. As another CPI report states, these poor results are not necessarily a reflection of the policy itself, but of weaknesses in India's financial systems and difficulties of the electricity industry itself, namely the state electricity boards. Thus, the reality on the ground may reduce the effectiveness of an imported policy. Similarly, we will be interested in the progress of the carbon market experiments in China, which are partially imported from Europe.

In addition to these common challenges, we must also go back to one of the questions I asked at the beginning: Are these national and subnational policies, taken together, enough to address climate change?

The answer is undoubtedly no, current policies are not enough, but they at least shine spotlights on what ought be the field into which better international cooperation must play. National initiatives are the result of the political balancing of local policy traditions, institutional powers, and country-specific political economic calculations. If international negotiations can focus not on overriding national initiatives, but on filling in some of the gaps and shortfalls that they reveal, they will reinforce and strengthen the policy directions that are finding a solid footing in the economic and environmental objectives of grounded political systems. As with all international regimes, effective management of climate risks is unlikely to be imposed from above. The contours of multilateral success normally lie in the codification and enhancement of national and regional common practices that define where cooperation can make improvements. I suspect climate change will be no different.

MOVING FORWARD: PRODUCTIVITY, INVESTMENT, AND INNOVATION

In light of all this, what's next for both national and transnational policy?

To move forward, we need to re-frame the problem. Much of the developed world continues to recover from a financial recession. At the same time, the developing world is not yet developed; it still needs to grow. Hundreds of millions of people live on less than two dollars a day in China and in India, as well as many other countries. And with these short-term pressures for survival, near-term development is going to trump longer-term environmental policy when they are seen as being in conflict.

We must learn that development is not the antithesis of climate success; it is its precondition. We must recognize that nations are looking for a pattern of development that also improves environmental quality—and that many understand the concept that high environmental quality can, in fact, promote more growth and more sustainable growth. Consequently, we must reconceive the climate problem as an aspect of a broader development problem. The question is not whether to grow, but how to grow.

INCREASED PRODUCTIVITY, THE UNION OF DEVELOPMENT AND CLIMATE POLICY

At its heart, climate policy is about resources, especially food and fuel. How we produce and combust fossil fuels for energy and how agriculture displaces stored carbon in our soils and forests are the key drivers of emissions. We need to increase the productivity of our stocks of natural resources, through innovative technology, organization, finance, market designs and policy to improve the yields from each unit of land we farm and energy that powers our industry, buildings, and transport. Our ability to maintain the ecosystems we value, including the stability of the climate, will come from getting more growth out of what we have been given. We can regulate and protect the physical world most effectively when we create the economic space in which to do so.

Economies that have increasing public budgets to subsidize transformative investment, yet are particularly sensitive to changing resource prices, may be most likely to focus on growth and climate strategies that both increase productivity and conserve resource stocks. Consider the surprising interest in climate policy in Brazil, which is essentially dependent on selling resources, and in China, which depends on consuming and transforming them.

In the northern region of Brazil, including the southern arc of the Amazon, cattle ranching is a key cause of deforestation, and land productivity is low (although new census data shows this may be changing); as in Indonesia, one of the other last remaining tropical forests in the world, growth has come not from more intensive, higher-productivity use of existing land, but extensively by clearing forests for more low-productivity farming and pasturage.

“DEVELOPMENT IS NOT THE ANTITHESIS OF CLIMATE SUCCESS; IT IS ITS PRECONDITION.”

Brazilian research indicates that by introducing simple practices like pasture rotation, ranchers could increase land productivity and double the number of cattle on only half the land. And what about the other half of this land? If we had an agricultural services market, land owners could lease it to agribusiness firms with the specialized capital, knowledge, and market information to improve yields and supply national and global markets in soy and other grains. In turn, with careful public policy, these practices can be transmitted to smaller farmers and embedded in landscapes where high-value environmental assets, including the remaining forests, are conserved because they need not be eaten away to meet growth, poverty reduction, and food security targets.

Brazilian governments, national and local, are moving to stimulate the policy, organizational and banking context to accelerate the

strategic shift to a low-carbon economy. Such larger systemic changes to extract greater productivity from existing resources, in part through the new applications of the revolutions in information science, biotechnology, and materials science already in evidence, will define the union of development, climate policy, and productivity that lies ahead of us.

WISE INVESTMENT, A CORNERSTONE OF MODERN POLICY

Once policy focuses on increased productivity, the climate problem is fundamentally about large scale and efficient investment. While such transformations in the past have usually involved public spending at increased scales (e.g. roads for the automobile; semiconductor research and the design of the Internet for information technology), the first step toward building a low carbon future is to spend the money we do have in the wisest way possible.

In the U.S., for example, recent CPI analysis shows that the government could save up to \$4.5 billion each year by simply adjusting how tax credits for wind energy are delivered.

Since most governments lack both the resources and the financial know-how to fund a transition to a low carbon economy through public money alone, a second step is to analyze and efficiently share the expected risks and returns with private capital in order to lower the cost of financing climate friendly infrastructure. The critical policy considerations for this step are in getting the highest possible private leverage for each class of assets in which public funds are placed and in finding an optimal mix of low and high risk investment bets. In particular, institutional investors with long-term investment horizons require a degree of policy certainty to invest. CPI analysis indicates that changes in policy

and industry practices can encourage additional investment from this investor group, as can new, low-cost pooled investment vehicles. Attracting these investors in a way that lowers the costs of financing renewable energy is an additional challenge.

Where the incremental costs of clean energy infrastructure relative to the costs of fossil energy that they would replace are small and local, the problems of attracting private equity and debt have often proved manageable. However, as costs rise with new and early vintage innovative technologies, like off-shore wind, solar thermal generation, carbon capture and use or sequestration, or new grids that manage large volumes of intermittent energy, the risks and costs of capital rise rapidly. Similarly, as private capital crosses more distant borders, particularly into developing countries, it shies away from the regulatory risks that come with reliance on public policies that enhance revenues or lower costs.

Against this background, there can be no one-size fits all solution that unlocks capital, innovation, and more efficient uses of resources in various parts of the world.

MOVING INNOVATION ALONG ITS CURVE

Increased productivity of our existing resources and technology, and wise investment, however, are not enough to address the climate problem. We also need to find ways to support innovation, which has the potential to redirect nations towards low-carbon development models.

To illustrate why, take this example: In the past twenty years of climate policy, we see that many regions—from Inner Mongolia to Texas—report climate gains, compared to their initial baselines, because of low-cost renewables, principally onshore wind installations. The main drivers of costs in the success of onshore wind have been learning and economies of scale. The general rule is the more you build, the more you lower costs. Using a combination of taxpayer subsidies (grants) and ratepayer mandates (feed-in tariffs), Northern Europe, led by Denmark and Germany, financed increasingly large vintages of new wind farms that produced larger and more efficient turbines at progressively lower

costs. The cost of wind-generated electricity has fallen to the point that in some parts of the day and in some parts of the load curve it is already competitive with coal and gas.

As the required subsidies decline, ratepayers are less prone to protest the smaller related electricity cost increases and financiers are more comfortable that the political support will be there to continue paying for the difference that assures their loans will be covered. With greater comfort, the risks perceived by the financiers go down, and with it, the cost of finance and the cost of the project. Basically, when installed within the margins of the existing power system, costs remain politically tolerable and a virtuous circle sets in.

What is more problematic are the technologies that are less mature, further from becoming competitive, and in need of more time and deployment to discover their ultimate economic potential. High cost support to these innovative technologies will cumulate over time and may bring about ratepayer unrest. Germany and Spain now experience such backlash in their solar politics. But, if backlash increases regulatory risk, financing costs will also rise or access will be cut off.

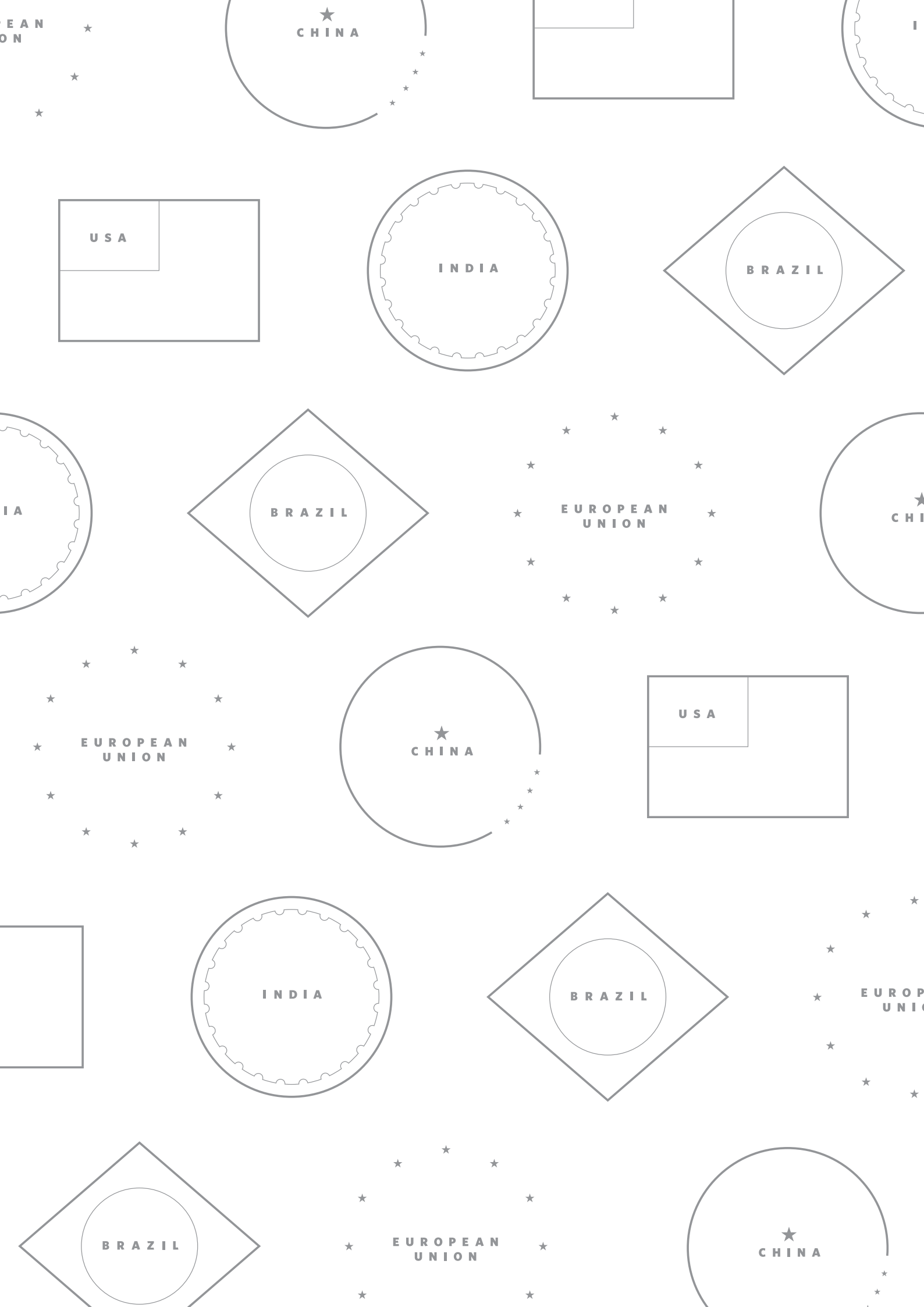
So, it's clear the world needs policies that can move innovative technologies from early stage to commercial stage because these policies can lower costs across the globe. However, which nations will assume the initial burden of funding the early high costs of innovation, and why should they bear the price for this public good? How can the risks of policy support be shared more equitably when incremental costs are far from commercial margins? How do nations ensure complementary investment in intelligent transmission and storage systems? Or address concerns where the political record of regulatory consistency is clouded or questionable? We explore some of these questions in the Innovation section (page 91) of this review.

The best policy anticipates the world that is coming more than it accommodates the world we now know. The great ice hockey star Wayne Gretzky put it very well: "I skate where the puck is going, not where it's been."

The future will be one where innovative technologies and wise investment lead to more

productive ways to provide food and fuel. This means that in practical politics, climate and development are one and the same. The sooner we realize it, the better the chance we will have to get both right.

At Climate Policy Initiative, and in particular in this review, we hope to lay the ground for what's to come. ■



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GUIDE TO THE POLICY CLIMATE

REGIONS

Climate Policy Initiative (CPI) has offices and programs in six regions: Brazil, China, Europe, India, Indonesia, and the United States. This report covers all of these regions except Indonesia, and thus represents slightly more than half of the world's population and close to two-thirds of global greenhouse gas emissions. These countries vary widely in terms of economic development, natural resource endowment, political system, and climate policy, and can offer different lessons to policymakers:

BRAZIL

Brazil has a vast natural resource endowment in the form of the largest tropical rainforest coverage in the world. This endowment creates one of the most important climate policy challenges facing the world: protecting that rainforest. At the same time, the size and natural resources of Brazil, including hydrological resources, have enabled the economy to grow rapidly while maintaining a low-carbon footprint compared to other countries.

CHINA

China's rapid economic growth fueled by abundant coal resources has led the country to become significantly wealthier and more industrialized as well as the world's largest greenhouse gas emitter. The challenge China faces is how to adjust the character of its economic growth to reduce its greenhouse gas impact without undermining longer-term economic prospects.

EUROPEAN UNION

Europe, an already mostly wealthy but slower-growing union of diverse sovereign nations, has, in many ways, sought to lead the world in terms of climate mitigation policy. The challenge in Europe is to continue providing leadership and to continue experimenting with new policy solutions, while maintaining wealth and public acceptance in the face of an economic crisis and while accounting for national differences in outlook and policy.

INDIA

India may be growing rapidly, but it lags well behind the other regions in our survey in terms of economic development. While the need to develop and alleviate poverty may seem to trump longer-term climate concerns, the challenge here is to build infrastructure and foster economic growth down paths which entail fewer greenhouse gas emissions.

UNITED STATES

The United States is a wealthy and slow-growing nation relatively well endowed with natural resources, but currently lacking political consensus or political will to pursue strong and dedicated climate policy action. Nevertheless, a range of policy, resource, and economic factors have led U.S. emissions to decline 13% over the last five years. The challenge in the U.S. is to weave together various state-level policies, energy efficiency, energy security, technology innovation, and economic policies to continue and accelerate the decline in carbon intensity of the U.S. economy.

ECONOMIC SECTORS

With a few notable exceptions, most climate-related policies address a particular economic sector. Even those policies that cut across sectors, like the European Emissions Trading System, will for the most part have effects that are expressed on a sectoral basis. Thus, the second organizing principle for our report is around sectors. Specifically, we group emissions and emissions reduction opportunities around seven sectors: Buildings, Power, Industry, Transport, Agriculture, Forestry, and Waste. The importance of these sectors varies from region to region. To restrict our discussion to the most important sectors for each region, we have ranked sectors by greenhouse gas mitigation potential, based on the greenhouse gas abatement curves produced by McKinsey and Company in its report “Pathways to a low carbon economy,” and identified the set of sectors that comprise at least 80% of the total greenhouse gas mitigation potential for each region.

In this review, 80% of national greenhouse gas reduction potential for each region lies in the following 17 sectors:



POLICY ISSUES

Policies can be categorized in any of a number of ways. In this review, and at CPI, we categorize policies into three types, based on the problems that the policy may be trying to address:

POLICIES THAT REMOVE BARRIERS address opportunities for greenhouse gas reduction that should make economic sense on their own terms, without incentives (or after

the appropriate level of incentive has been granted), but fail to get implemented for any of a number of market failures such as a lack of information, high transaction costs, regulatory constraints, or incentives directed to the wrong people. A typical example is energy efficiency actions that should pay for themselves, but do not get adopted. Policies that remove barriers can be directed to correcting these market failures.

POLICIES THAT PROVIDE INCENTIVES address opportunities for greenhouse gas reduction that may not make economic sense under the current market structure, but would do so with appropriate accounting for the value of associated environmental benefits (the environmental externality, in economist parlance). Policies that provide incentives could include directly pricing the externality, such as through carbon pricing, but can also include more targeted subsidies, tax breaks, or other incentive systems. Typical examples include protecting forests or supporting renewable energy.

POLICIES THAT SUPPORT INNOVATION are in a separate class of policy. Beyond barriers and incentives lie a series of technology or process improvements that may currently not exist or be too expensive to implement, but may become economically beneficial when the technology is developed and the costs come down. Many of these technologies could provide significant benefit, but might not get developed without policy support. Examples include cellulosic biofuels, carbon capture, nuclear fusion, or solar photovoltaic (PV) technology 10 years ago. Policies could include research and development, demonstration plants, or deployment policies (such as the case recently with PV).

In this report, we discuss policies that address barriers and incentives by region and sector. For innovation, where the potential is unknown in a more definitive sense, we have focused more on general policy lessons and their implications for climate policy in a separate section.

HOW TO READ THE POLICY CLIMATE

For each region we provide a brief overview of climate relevant policy and issues in each of the most important segments. In doing so we ask:

- In each region, how have key sectors and greenhouse gas emissions for these sectors evolved?
- Is policy hitting the most important targets?
- What are the issues we need to better understand in assessing the effectiveness of policies from a climate standpoint?

To answer these questions, each sector within each region presents three sets of charts:

1. **EMISSIONS** covers trends in greenhouse gas emissions—and related factors—over the last 30 years.
2. **EMISSIONS DRIVERS** looks at major factors contributing to these emission trends including technology, economic development, behavior, and others.
3. **POLICY** addresses representative trends in relevant policies.

The idea is to map the policy development trends against the greenhouse gas emission trends and their contributing factors to begin to identify where policy may have played an important part, or where there are gaps. However, we should warn that this is a starting point, aiming to frame the problem, as we cannot expect to evaluate policy effectiveness in each one of these areas rigorously within the wide scope of this report. Rather, the anecdotal evidence put forward establishes a reference frame against which we can begin more detailed effectiveness analysis. In so doing, this analysis helps set the stage for CPI analysis and climate policy effectiveness analysis in general.



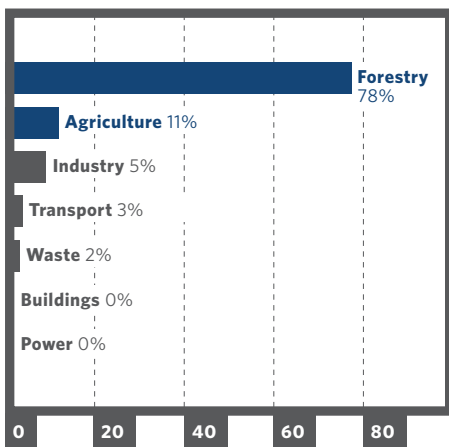


B R A Z I L

A minimalist geometric design on a white background. A large, light gray circle is partially visible on the left side. A large, light gray triangle is positioned on the right side, pointing towards the right. The two shapes overlap, with the circle's edge cutting through the triangle's left side. The text 'AZIL' is centered horizontally within the circle's area.

AZIL

PROTECTING FORESTS THROUGH POLICY



Percentage of Greenhouse Gas Mitigation Potential

In any discussion of Brazilian climate policy, the first topic is deforestation. Having greatly reduced large-scale deforestation, Brazil's challenge now is to address small-scale deforestation, which may require different policy approaches. Brazil also faces the challenge of meeting its growing energy demand with low-carbon energy sources.

The Amazon is the world's largest rainforest, stretching over an area of over five million square kilometers. Most of the forest is contained within Brazil, where the Amazon originally occupied over four million square kilometers of the country's territory—an area equivalent to almost half of continental Europe. The Brazilian Amazon holds unique biodiversity, 20% of the planet's fresh water, and substantial carbon stock.

In the early 2000s, the conversion of forest areas and land use change accounted for over 75% of Brazil's total net CO₂ emissions, and the agricultural sector contributed approximately 70% of methane emissions (Brazilian Ministry of Science and Technology 2010). By 2011, over 700,000 square kilometers of Brazilian Amazon forest had been cleared.

Yet controlling and combating deforestation has been one of Brazil's biggest climate policy successes in recent years. Since the mid-2000s, the deforestation rate in the Brazilian Amazon decreased by 82%—from a peak of 27,000 square kilometres in 2004 to 5,000 square kilometres in 2011 (see Emissions & Output, page 12). That's partially due to lower agricultural prices, but a CPI study showed that government conservation policies helped avoid the clearing of over 62,000 square kilometers of forest area (CPI 2011b). In the absence of such policies, total deforested area in the late 2000s would have been more than twice as large as the observed 57,000 square kilometres.

The Action Plan for the Prevention and Control of Deforestation in the Legal Amazon (PPCDAm) has served as the basis for national conservation policy efforts since the mid-2000s. Launched in 2004, the PPCDAm introduced a new mechanism to combat deforestation in the Brazilian Amazon. Through a combination of command and control policies, institutional changes,

and new technology to monitor deforestation and target law enforcement actions, the PPCDAm has had great success in reducing Amazon deforestation.

Yet, the character of deforestation has changed, and the policy tools Brazil employs to combat deforestation may need to change with it. The PPCDAm's measures have greatly reduced the problem of large-scale illegal deforestation in the Amazon. However, small-scale deforestation persists, possibly practiced by farmers who have some rights to clear forested land. Combating this small-scale deforestation may require a different mix of policies—for example, a greater reliance on incentives rather than command and control measures, or a greater role for local governments.

In addition, as deforestation declines and Brazil's economy grows, energy is contributing more to Brazil's overall emissions picture. While emissions from land use change decreased by 64% between 2005 and 2011, other sectors' emissions increased by 18%, led by a 33% increase in emissions from the energy sector (Azevedo 2012). Energy-related emissions are expected to grow further in both relative and absolute terms, as the country strives to meet a sustained rise in demand for electricity.

Beyond deforestation and the Amazon, Brazil is one of the world's least carbon-intensive economies. Currently, 45% of its primary energy originates from clean energy sources, compared with the 8% average for OECD countries. Brazil is also the world's second-largest producer of biofuels and the third-largest producer of hydropower, and it has recently sought to expand generation based on wind power and biomass.

With this combination of wealth in natural resources, experience with renewable energy generation, and innovative policies, Brazil's climate policy challenge is to continue combating deforestation in its diverse forms, while also restraining growth in energy-related emissions as demand for electricity rises.

BRAZIL'S CLIMATE POLICY LANDSCAPE

EARLY ENVIRONMENTAL POLICY

The development of Brazilian environmental policy dates back to the late 1960s and early 1970s, when Brazil first created federal governmental agencies that dealt specifically with environmental matters.

In 1988, Brazil's new constitution increased decentralization of environmental policy by enabling states and municipalities to formulate their own policies. One year later, the Brazilian Environment and Renewable Natural Resources Institute (Ibama) was established to formulate, coordinate, and execute national environmental policy. After the creation of the Ministry of the Environment (MMA) in 1992, Ibama shifted its focus to environmental monitoring and enforcement. Currently, Brazilian environmental policy is coordinated by the MMA, but both its implementation and execution are decentralized across several agencies at federal, state, and municipal levels.

The late 1990s and early 2000s witnessed the introduction of important policy instruments. The passing of the Law of Environmental Crimes in 1998 established the legal basis for the sanctioning of environmental infractions, and the creation of the National System of Nature's Conservation Units in 2000 strengthened environmental protection by establishing the directives for territorial protection. In spite of such efforts, external pressure regarding Brazil's rising greenhouse gas emissions at the time pressed the government for further action.

THE PPCDAm: AN INTEGRATED STRATEGY TO FIGHT DEFORESTATION

In the early 2000s, Brazil adopted a novel approach to environmental policy, seeking to incorporate the environmental discussion in the agenda of other ministries and sectors of government. In particular, the launch of the PPCDAm in 2004 introduced an integrated approach towards combating deforestation in the Brazilian Amazon. A new tactical-operational plan encompassed a large set of strategic conservation measures to be implemented and executed as part of a collaborative effort between federal, state, and

municipal governments, alongside specialized organizations and civil society. It focused on three main areas: territorial management and land use, with particular attention to land tenure disputes; environmental monitoring and control; and the promotion of sustainable production practices.

With the PPCDAm, Brazil moved toward a more integrated approach to combating deforestation, coordinating activities across the different levels of government. For the first time, numerous ministries were simultaneously involved with combating deforestation, an issue previously restricted to the MMA and Ibama. Moreover, the mobilization of key organizations—particularly the National Institute of Space Research (INPE), the Federal Police, the Federal Highway Police, and the Brazilian Army, whose joint efforts were orchestrated by the Presidency's Chief of Staff—allowed for the implementation of innovative procedures for monitoring, environmental control, and territorial management.

This integrated effort has had a dramatic impact on deforestation. Work conducted by CPI has shown that conservation policies introduced within the PPCDAm framework were effective in combating deforestation in the Brazilian Amazon, including during periods of high agricultural output prices. CPI estimates that, in the late 2000s, over 62,000 square kilometers of forest area were preserved by such policies. A large fraction of this is attributed to the deterrent effect of command and control efforts, which contributed an estimated 53,000 square kilometers of avoided forest clearings from 2007 to 2011.

The PPCDAm promoted institutional changes that enhanced command and control capabilities in the Amazon. These changes resulted in an increase in the number and qualification of law enforcement personnel, and brought greater regulatory stability to the investigation of environmental crimes and application of sanctions. Moreover, they established the legal basis for singling out municipalities with very high deforestation rates and taking differentiated action towards them.

Parallel to the PPCDAm's command and control efforts, the creation of protected areas gained momentum in the mid-2000s. In addition to preserving biodiversity and

natural vegetation, protected areas served to shield deeper areas of the Amazon from the advances of deforesters.

Brazil also introduced a novel rural credit policy to provide rural producers an incentive against deforestation. In 2008, the National Monetary Council approved Resolution 3,545, which hinged credit, an important source of financing for rural producers, on proof of compliance with environmental regulations. The conditions established in Resolution 3,545 affected mostly mid to large-scale producers, as small-scale producers benefitted from a series of exemptions.

In its first few years of implementation, the rural credit policy has already had an impact on deforestation. CPI estimates that approximately BRL 2.9 billion (USD 1.4 billion) in rural credit was not loaned from 2008 to 2011 because of restrictions imposed by Resolution 3,545 (CPI 2013). This reduction in credit prevented over 2,700 square kilometers of forest area from being cleared. Had the resolution not been implemented, deforestation would have been 17% greater.

An important contributor to the PPCDAm's success was the government's ability to access timely, detailed information on deforestation. One of the key changes introduced by the PPCDAm was the use of the Real Time System for Detection of Deforestation (DETER), a significant leap forward in remote sensing-based monitoring capacity in the Brazilian Amazon. Developed by INPE, DETER is a satellite-based system that captures and processes georeferenced imagery on forest cover in 15-day intervals. The images are used to identify deforestation hotspots and target law enforcement activities. Prior to the activation of DETER, Amazon monitoring relied strictly on ad hoc reports of illegal deforestation. With the adoption of the new remote sensing system, however, Ibama was given speedier access to recent georeferenced data and was thus able to better identify, more closely monitor, and more quickly act upon areas with illegal deforestation activity.

Moving forward, land use issues are still paramount in Brazil; the country's primary climate policy challenge is developing an integrated approach that allows agricultural productivity to grow while conserving forest land.

Brazil also faces the challenge of meeting its growing energy demand with low-carbon energy sources.

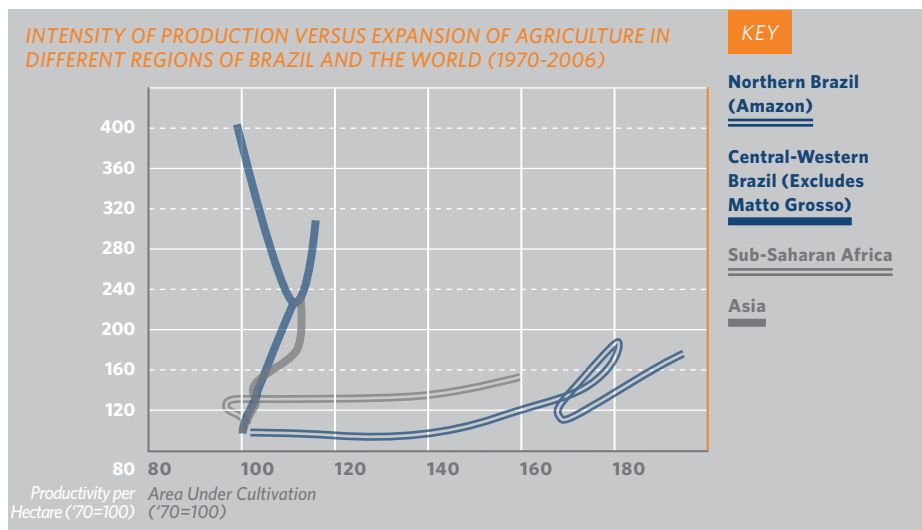
ADDRESSING SMALL-SCALE DEFORESTATION AND AGRICULTURAL PRODUCTIVITY WITH AN INTEGRATED LAND USE APPROACH

Having greatly reduced large-scale deforestation through the PPCDAm, Brazil's next challenge is to address small-scale deforestation, which may require different policy approaches—approaches which take into account the relationship between deforestation and agriculture in Brazil.

Land is an asset that grants two types of dividends, both of which are significant in Brazil's economy: environmental dividends

capacity to extract agricultural value from this land is also substantial. With 60 million hectares of land dedicated to the production of crops, fruits, and planted forests, plus almost 200 million hectares of pasture, Brazil stands as a relevant player in the market for agricultural commodities. Promoting efficient land use can not only contribute to the mitigation of climate change risks and protection of natural resources, but also help meet rising food demand.

Agricultural productivity has been increasing steadily in Brazil (see Emissions Drivers, page 14), but that increase has not been spread evenly across the country. From 1970 through the mid-2000s, the Center-West region increased productivity while bringing relatively little new land under cultivation. However, in the North region the pattern was



and, given Brazil's role as an important player in the market for agricultural commodities, agricultural dividends. Since both are important in the country's political environment, an integrated land use approach that combines the provision of ecosystem services with high-productivity, sustainable growth has a higher chance of being successfully implemented. Preliminary evidence suggests that Brazil has potential to significantly improve its performance in both areas.

In 2011, native vegetation covered over 550 million hectares of the country's total 850 million hectares, offering enormous environmental value (ICONE 2012). Yet, Brazil's

the opposite, with only a small rise in productivity accompanied by a large increase in area used for agriculture. Indeed, low productivity dominates Brazil's vast pasture area. In fact, the expansion of agriculture in Brazil's Center-West follows patterns similar to Asia's, while agricultural expansion in the North is similar to that of sub-Saharan Africa.*

There is clear potential for increasing agricultural output growth via the adoption of intensive, high-productivity techniques rather than deforestation. Yet higher productiv-

*Source: CPI analysis based on data from FAO and Agricultural Census

ity gives producers stronger incentives to clear more land. Without effective policy measures in place to protect natural vegetation, gains in agricultural productivity can exacerbate deforestation pressures, rather than alleviate them.

Increasing clearing costs is one mechanism for ensuring that natural vegetation is preserved. This could be achieved through the implementation of more stringent conservation policies like the PPCDAm and the associated rural credit, command and control, and protected territory policies.

A better understanding of agricultural productivity could also provide critical input to support Brazil in its effort to both reduce the pressure on areas covered by natural vegetation and deal with food security while pursuing rural development in poor areas of the country. Currently, Brazil faces substantial dispersion in productivity, particularly among cattle ranchers and small farmers. This is the case even within areas with very similar geographical characteristics. Such variation points to a pervasive and substantial problem of misallocated resources. In-depth knowledge about rural technology adoption behavior and market failures affecting agricultural production is therefore essential to steer agricultural policy towards setting effective incentives to high-productivity agricultural production.

Although conservation policies have been effective in curbing deforestation in the second half of the 2000s, recent changes in the dynamics of deforestation within Brazil present new challenges for further reducing forest clearings. Deforestation is currently being driven mostly by the cutting down of forest in small increments, instead of following the early 2000s pattern of large, contiguous areas of cleared land. Whether this is the result of a change in behavior of large-scale deforesters or the increased relative participation of small-scale deforesters is unclear. Such changing patterns indicate that the very nature of deforestation in Brazil is changing over time, and conservation policy must evolve along with it.

To deal with small-scale deforestation, Brazil may need to rely more on local governments, who can tailor policy and enforcement to

meet local circumstances. In addition, part of the success of the PPCDAm has been in cracking down on illegal deforestation. But the remaining small-scale deforestation may not be illegal—under Brazil's laws, farmers have some rights to clear land for agriculture. If much of the remaining small-scale deforestation is legal, it may require greater use of incentives rather than command and control policies.

“SINCE THE MID-2000S, THE DEFORESTATION RATE IN THE BRAZILIAN AMAZON DECREASED BY 82%.”

While it is clear that reducing forest clearings also reduces emissions from the forestry sector, no obvious change in the pattern of emissions is expected from increasing agricultural productivity. Total emissions may either increase or decrease as agricultural production rises, depending on the type of technology adopted to boost productivity. Although the large volume of emitted methane is likely associated with low-productivity cattle ranching in Brazil, overall, the rising total emission pattern shown is inconclusive (Emissions & Output, page 14).

MEETING GROWING ENERGY DEMAND

In addition to protecting forests, meeting increasing energy demand is also on Brazil's climate policy agenda. Brazil's current Ten-Year Energy Expansion Plan foresees the addition of 69 GW of installed generation capacity (an additional 58%) from 2011 through 2020. A key concern for the country is how to procure new generation capacity in a reliable, secure, and cost-effective way that minimizes socio-environmental damage. Brazil has a diversified portfolio of potential resources for generation expansion, including hydropower, biomass cogeneration (mainly from sugarcane), and wind power.

The National Bank for Economic and Social Development, the major provider of long-

term credit to the energy sector in Brazil and the world's second largest development lender, has recently shown an inclination towards favoring clean energies, including run-of-the-river hydropower and on-shore wind.

Yet, Brazil's energy portfolio also has significant volumes of oil and associated natural gas from recent deepwater offshore discoveries, as well as large coal reserves and proven

uranium reserves. The International Energy Agency (IEA) projects that, over the next 10 years, installed new capacity additions in Brazil will be provided mainly through hydropower and natural gas, and only to a lesser extent by biomass and wind (IEA 2012). As a result, greenhouse gas emissions from electricity generation are expected to increase from 30 to 65 Mt CO₂ between 2009 and 2020. Opportunities to explore clean energy developments will thus be of great importance over the next decade, contributing to greater capacity without significantly increasing the CO₂ intensity of the energy sector.

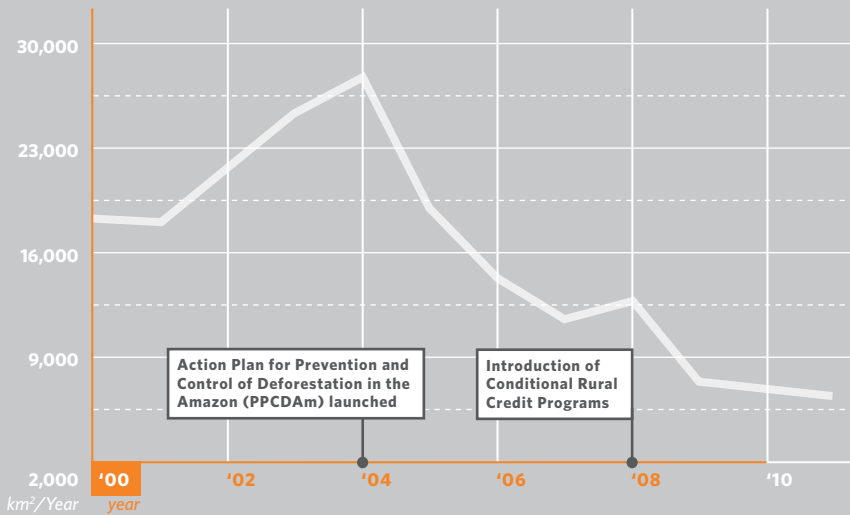
Brazil now faces a twofold challenge: to ensure that deforestation levels are kept low using a combination of conservation efforts, policies that combat forest clearings, and large-scale development of sustainable, high-productivity agriculture; and to meet its growing electricity demand using reliable, safe and cost-effective techniques with little social and environmental impact. Addressing both aspects of this challenge is currently a priority in the Brazilian environmental policy scenario. ■

EMISSIONS & OUTPUT

ANNUAL AREA DEFORESTED IN AMAZON REGION IN BRAZIL (2000-2011)

KEY

NOTES



Deforestation Rate

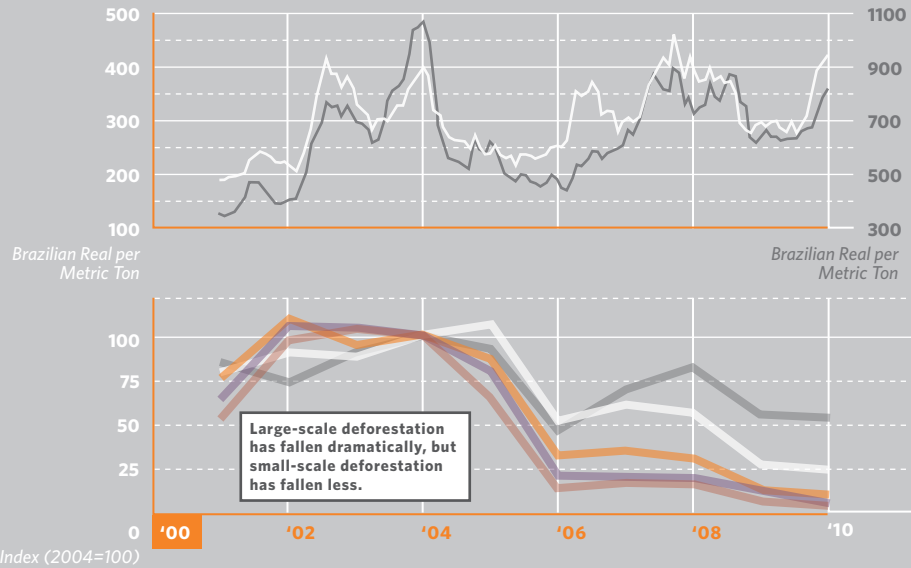
Deforestation declined rapidly, particularly after major policy changes in 2004 and again in 2008.

EMISSIONS DRIVERS

COMMODITY PRICES (2001-2010) / INDEX OF CHANGE IN DEFORESTATION ACTIVITY BY SIZE OF DEFORESTED TRACTS (2001-2010)

KEY

NOTES



TOP

Corn Prices

Soybean Prices

Common drivers of deforestation, such as commodity prices (Soybean and corn prices on top chart), and land protection (see policy chart below) appear to have changed deforestation patterns, with large scale deforestation declining much more rapidly than small scale (e.g. tracts of less than 25 hectares on bottom chart).

BOTTOM

<25 Hectares

25-100 Hectares

100-500 Hectares

500-1,000 Hectares

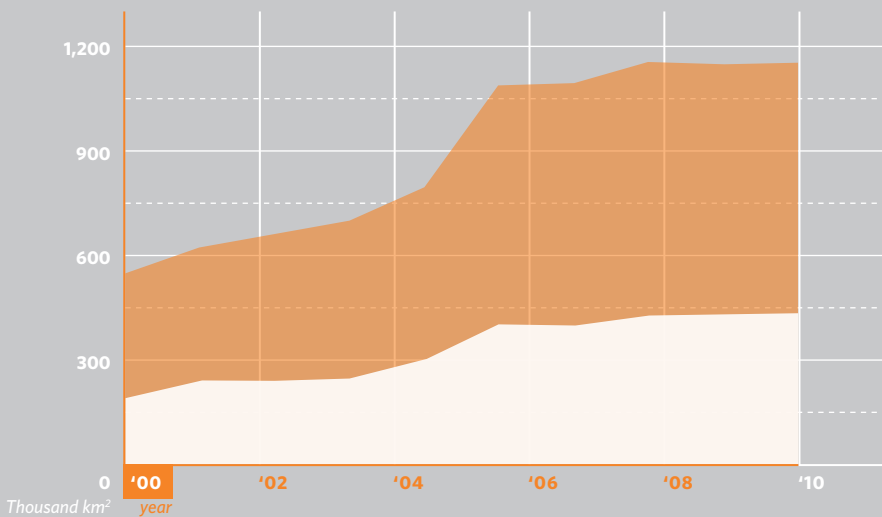
>1,000 Hectares

POLICY

AREA OF LAND UNDER GOVERNMENT PROTECTION (2000-2010)

KEY

NOTES



GOVERNMENT LAND PROTECTION PROGRAMS

Sustainable Use

Integral Protection

As an example of increased Brazilian policy efforts, Brazil has increased efforts to reduce deforestation, and the amount of land under government protection has increased significantly since 2001.



1980-1990

Brazil was embroiled in a long economic crisis throughout the 1980s and ended military dictatorship in 1985. Forestry and environmental policy began to receive very limited attention at the end of the decade.

1990-2000

As the economy moved towards stabilization, Brazil established key institutions to execute environmental policy and made environmental infractions penal. The start of the decade saw lower deforestation rates than the late 1980s, but rates had risen again by the end of the decade. (INPE 2012)

2000-2010

Environmental awareness, and conservation policy and enforcement, increased across the decade. Deforestation rates dropped significantly in the second half of the 2000s.

POLICY

Forest Code of 1965 continued, requiring that a proportion of rural land remain forested

New 1988 Constitution increased decentralized environmental policy

National Policy of the Environment created key execution instruments, 1981

- National Environmental System
- National Environmental Council

Brazilian Environment and Renewable Natural Resources Institute (Ibama) established, 1989

Ministry of the Environment established, 1992

Law of Environmental Crimes made environmental infractions penal rather than civil, 1998

National System of Nature's Conservation Units established, 2000

Action Plan for Prevention and Control of Deforestation in the Amazon (PPCDAm) launched, 2004

- Coordinated efforts among federal, state, and municipal governments, and civil organizations
- Territorial and land use management
- Real Time Deforestation Detection System (DETER) remote sensing system used to implement and enforce command and control policies
- Improved qualification of Brazilian Environment Institute (Ibama) personnel
- Prioritized municipalities with high deforestation rates for differentiated action (Presidential Decree 6.321, 2008)
- National Monetary Council Resolution 3.545, 2008
 - Introduced conditional rural credit policies
- Credit contingent on compliance with environmental requirements and legitimacy of land claims
- Strengthened legal support for environmental infractions and sanctions (Presidential Decree 6.514, 2008)

UNDERLYING CHANGES

Democratization

Hyperinflation

Failed economic reforms

Restructuring of economy

- Broad trade liberalization reforms
- Hyperinflation ended in mid-1990s

Mexican, Asian, and Russian financial crises led to Brazilian financial crisis in late 1990s

Commodity prices relatively low

Rio Summit 1992

1997 Kyoto Protocol included seeds of UN-REDD

Early 2000s surge in exports due to growth in China and significant appreciation of Real

Increasing pressure for expansion of agricultural frontier

Global recession 2008-2009

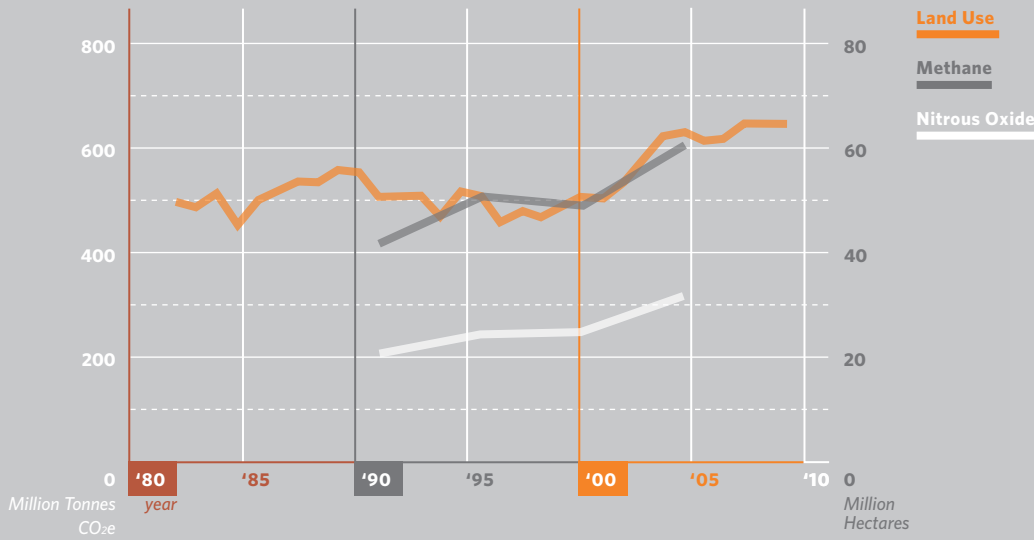
REDD under active discussion in the UNFCCC negotiations

EMISSIONS & OUTPUT

NON-CO₂ GREENHOUSE GAS EMISSIONS AND LAND USE (1980-2009)

KEY

NOTES



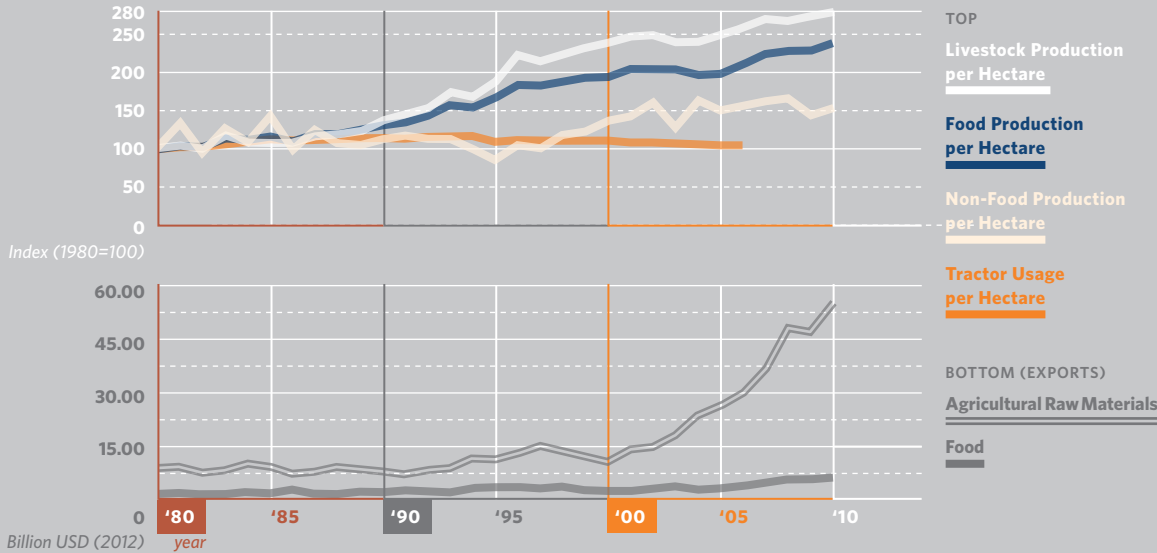
Both land under cultivation (right axis) and non-CO₂ emissions increased (left axis).

EMISSIONS DRIVERS

AGRICULTURAL PRODUCTION INTENSITY (1980-2010) / AGRICULTURAL NET EXPORTS (1980-2010)

KEY

NOTES



TOP
Livestock Production per Hectare

Food Production per Hectare

Non-Food Production per Hectare

Tractor Usage per Hectare

BOTTOM (EXPORTS)
Agricultural Raw Materials

Food

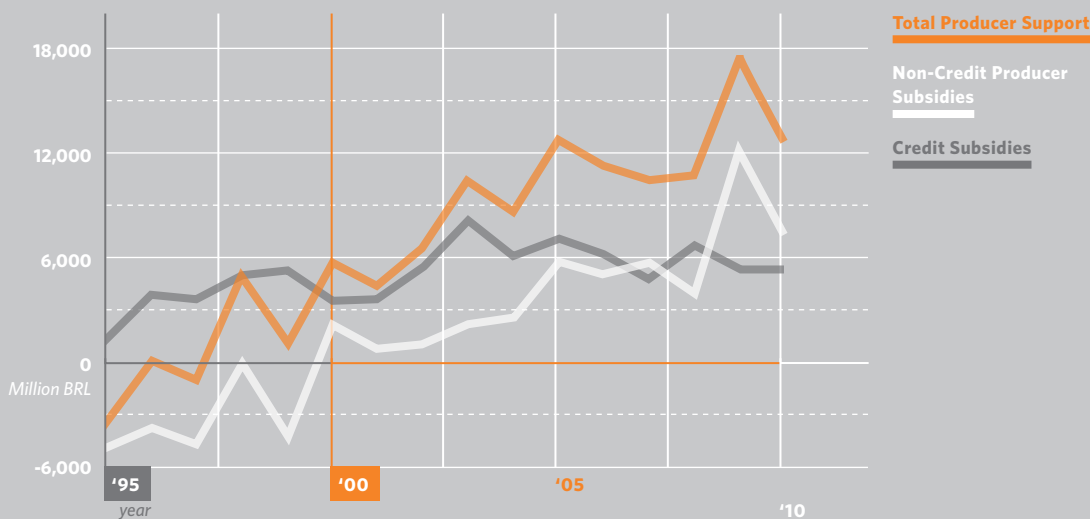
Although the intensity of food production per hectare increased, mechanization did not increase (top chart). Instead, increasing land use, some of which satisfied export growth (bottom chart), and some of which satisfied population growth (not shown), was a major driver of growing emissions.

POLICY

SUBSIDIES TO AGRICULTURAL PRODUCERS (1995-2010)

KEY

NOTES



Total Producer Support

Non-Credit Producer Subsidies

Credit Subsidies

Brazil made increasing the productivity of agricultural land a priority as a means to reduce expansion into new land and deforestation. Subsidies to producers, in part to modernize their operations, steadily increased over time. In the 1990s, credit subsidies were offset by price controls set below market prices; as these price controls rose above market prices, they became additional effective subsidies.



AGRICULTURE

BRAZIL

1980-1990

The 1980s saw a major economic crisis, political disruptions, then political stabilization.

1990-2000

In the 1990s, the economy stabilized and Brazil liberalized trade. The agricultural sector made advances in professional, technological, and operational modernization.

2000-2010

Rising prices and yields in the 2000s accompanied increasing rural credit.

POLICY

Embrapa continues research efforts (initiated in 1970s) to advance technological development for agriculture

Mercosur common trade policy established, 1991

Development of family production programs in mid-1990s

- National Program for Strengthening Family Farming (PRONAF)

The Land Reform political attention implementation waned due to increased mechanization in agriculture

Significant increase in planned rural credit under subsidized rates

Conditional rural credit policies (National Monetary Council Resolution 3,545), 2008

- Credit contingent on compliance with environmental requirements and legitimacy of land claims

UNDERLYING CHANGES

Democratization

Persistence (since 1970s) of oil shocks consequences, prompting development of biofuels

Hyperinflation

Failed economic reforms

Savings freeze in 1991 leading to major recession

Restructuring of economy

- Broad trade liberalization reforms
- Hyperinflation ended in mid-1990s
- Significant increase in Brazilian tax burden

Mexican, Asian, and Russian financial crises led to Brazilian financial crisis in late 1990s

Professionalization, mechanization, and decreasing labor-intensity of agriculture

Early 2000s surge in exports due to growth in China and significant appreciation of Real

2007-2008 global food price crisis

Expansion of agricultural frontier

Middle-class significantly expanded

Increase in tax burden until 2003

Global recession 2008-2009





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C H I N A

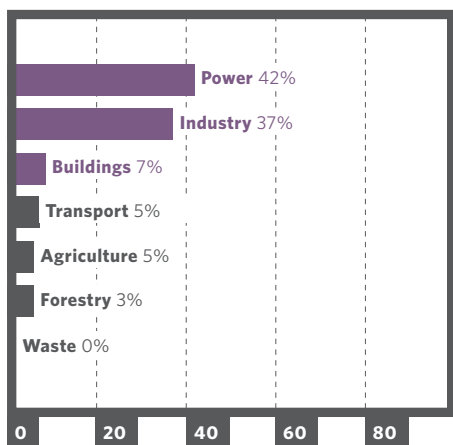




CHINA



PURSUING LOW-CARBON GROWTH POLICY AT UNPRECEDENTED SCALE



Percentage of Greenhouse Gas Mitigation Potential

The statistics boggle the mind. Between 2001 and 2010, China accounted for 68% of the world's growth in energy related carbon emissions. Between 2005 and 2010 China represented 82% and 87% of the world's growth in the consumption of oil and coal respectively.

But these startling figures do not mean that China is doing nothing with respect to climate change. China has the world's largest installed capacity of wind turbines; by 2012, 27% of the world's wind generation capacity was in China. China has also implemented a number of programs to increase energy efficiency and to phase out old, inefficient equipment. Since 2004, China's carbon intensity has fallen faster than any of the other countries in this survey, but China's carbon intensity still remains high. Going forward, the new party leadership has signaled its interest in promoting a low-carbon green economy. China's, and the world's, challenge is to balance these emerging environmental concerns with intense demand for continued economic growth.

Between 2005 and 2010 China represented almost a quarter of the world's economic growth. This unprecedented growth and its share of the world economy have changed the way the Chinese think about energy and energy security. Where once the country had coal reserves to satisfy demand into the 23rd century, at current, higher, consumption rates, this coal will be exhausted in a few decades, and coal no longer seems so abundant; China has long since moved from exporting coal to importing it. This growing demand pushes energy and commodity prices up and the Chinese sense of vulnerability grows.

Statistics tell us how closely economic growth has been correlated to energy related greenhouse gas emissions, which account for 75% of Chinese greenhouse gas emissions and 90% of Chinese CO₂ emissions. China avoided the worst of the global recession by using cash reserves for stimulus and by turning to internal, rather than export driven, growth. When the global economy crashed in 2008, the government had to choose between economic growth and curtailing emissions. In 2009 it chose the former with a \$4 trillion yuan (\$700 billion) stimulus package that protected China against some of the economic woes other countries faced but

took a severe toll on its environmental health. Predictably, emissions rose, and China didn't come close to meeting its energy intensity targets in 2009.

Meanwhile 30% of China's population still lives on less than \$2 a day, while local environmental issues, such as air pollution levels, which recently hit more than 20 times World Health Organization guidelines in Beijing, remind the Chinese that factors like poverty reduction, environmental quality, and social stability may be as important as economic growth. Thereby lies the dilemma: How can such a large country grow fast without overly straining the world's resources, while maintaining social stability and, to the climate change point, how can China do so in a carbon constrained world?

But grow the middle kingdom must. Unlike many other developing countries, China's population is aging rapidly, with a demographic profile closer to that of the developed world. With abundant cheap labor having been an important driver of growth, China must now face a time where the working age population begins to shrink. China's struggle is to become wealthy before it becomes old.

In this struggle, China has many advantages. Growth has generated massive cash reserves. Meanwhile, the scale of Chinese growth and its internal demand has created many scale advantages for the country. Building new infrastructure in China can cost much less than elsewhere, partly because China builds so much, has teams and standard designs waiting, and has accumulated so much experience.

All this happens at a historic time of leadership change. Ten years ago new leadership saw a singular focus on growth and a shift to a capital intensive growth model, accompanied with decreased focus on energy efficiency. This shift led to phenomenal growth in both the economy and energy demand. Five years ago under that same leadership, China adjusted course, re-emphasizing energy efficiency and adding some additional environmental and social constraints to the mix. In the 12th Five-Year Plan (FYP), which sets the national agenda for 2011-2015, China made climate change an explicit component of national legislation for the first time. With a focus on sustainability and "higher quality"

growth, the 12th FYP outlined specific targets: 16% reduction in energy intensity, 17% reduction in carbon intensity, and an 11.4% share of total primary energy consumption from non-fossil sources like hydropower, solar, wind, and nuclear.

Today, with the 12th FYP and new leadership, China can look back to the successes and issues of its recent past to help to move forward toward a lower carbon economy. In particular, China can learn from the vast assortment of policy it directed towards increasing the energy and carbon efficiency of the economy; from the experience of giving targets the central role in policy; from the results of policy experiments taking place at the local and provincial level; and from issues related to dealing with the Chinese bureaucracy.

IMPROVING THE CARBON EFFICIENCY OF ENERGY USE AND PRODUCTION THROUGH POLICY

Addressing greenhouse gas emissions means addressing energy. China has implemented many policies targeting improvements in energy efficiency, with a combination of mandates and incentives.

A particularly successful element of Chinese policy has been the closure of old or less efficient industrial plants, including coal fired power plants. In the 11th FYP (2006-2010), China beat its target of 50GW (50,000 MW) of coal power plant retirements by more than 50%, closing almost 77 GW. The electricity output from the retired plants is being replaced by newer, larger power plants. China has dramatically improved the efficiency of the new power plants it is building, and now builds plants that are as efficient as any other coal fired power plants in the world. We estimate that the CO₂ emissions savings from closing these power plants alone is well over 100 million tonnes per year.

While these closures were made using command and control policies that dictated their closure, our analysis suggests that most of the closures were well justified on economic grounds. While coal prices have risen, the cost of building new coal fired power plants in China can be as little as one-third to one-half as much as similar plants in Europe or the

U.S. As a result, the money saved by reducing coal consumption more than offset the cost of building the new plant. However, after years of closing plants, the remaining plants are newer and more efficient, so the amount of carbon emissions and energy that can be saved as a result is falling and the economics of retiring the plant no longer looks as attractive. Improving efficiency will get more difficult as these easy wins are used up.

Another important policy has been the "Top 1000" program. The Top 1000 program was directed at the 1000 or so largest industrial enterprises in China. These enterprises were required to have energy audits, retire inefficient plants, and undergo a number of reporting and management changes designed to improve energy efficiency and attention to efficiency. The cost and administrative burden of the Top 1000 program was not insubstantial, either for the enterprises themselves or the central and provincial governments that needed to administer and verify the programs. Yet from a carbon savings standpoint they appear to have been successful. The Chinese National Development and Reform Council (NDRC) estimates that 165 million tonnes of coal equivalent—China's preferred measure of energy—were saved.

In 2011, with the 12th FYP, China has rolled out this program to the Top 10,000 enterprises. However the challenges and economics will be different as the enterprises get smaller and their sectors change. In the next set there are fewer large state-owned companies, and more commercial enterprises such as hospitals. Further, the administrative and monitoring costs that were associated with the large enterprises will not shrink proportionally to the size of the enterprise. With smaller enterprises the potential savings will shrink faster than the cost of running the program. So China will need to think of new ways to administer the program, new incentives, and may need to accept smaller efficiency returns on the effort expended.

China is also diversifying its energy mix away from coal, with renewable energy, nuclear energy, and hydroelectric power high on the list. China hopes to achieve energy security and environmental goals even while creating new industries such as the manufacture of wind turbines and solar modules. To that end,

in 2005, the national government passed the Renewable Energy Law, which encouraged the use of renewable energy for power generation, buildings, and transport through mandates and financial incentives.

Major power generation companies were given quotas for renewable power similar to the Renewable Portfolio Standards (RPS) in the U.S., and the feed-in tariff to power grids was carefully set to guarantee a profit. Wind power installation capacity increased by more than 40-fold in the five years from 2005 to 2010—four times the national target.

Yet even with the energy efficiency and renewable energy achievements, carbon emissions inexorably rise, as efficiency and renewable achievements get buried in the onslaught of economic growth, rising energy demand, and the use of coal as the mainstay of the energy supply.

USING TARGETS AS POLICY

China's main umbrella climate policy is the Target Responsibility System for Energy Savings, a 2006 mandate requiring all provinces to reduce their energy intensity reduction by a specific target in order to achieve a national target of 20% for the 11th FYP and 16% for the 12th FYP. Distributed among China's 33 provinces, the target is then disaggregated among cities, and in cities among industries.

The results have been mixed. By the end of 2010, China reduced its energy intensity by 19%, but emissions rose 33.6%. Some provinces and municipalities—most notably Beijing, Shandong, Shanghai, Guizhou and Guangdong—achieved their targets with little fuss. Other provinces were stymied by a lack of money or monitoring capability to keep industries in check, while still others found energy intensity targets difficult to achieve under the greater pressure to meet GDP targets.

In recent years the Chinese government has realized that previous mandates were ineffective in part because they were unfunded. In 2005 the country began offering tax incentives, monitoring programs, and a lot of money. Over the next five years, the government poured \$2.59 trillion yuan (USD 399 billion) into energy efficiency and renewable energy programs.

Target-setting as a policy tool has both advantages and disadvantages. Having a clearly defined target can streamline the decision-making process. A singular focus on specific targets enables quick adjustment and rapid action. On the other hand, overly prescriptive targets don't allow for reasonable tradeoffs. And setting the right targets can be challenging; if targets are set incorrectly, or defined too simply or imprecisely, they can lead to perverse outcomes.

In China examples of the inefficiencies of targets are common, from the shutting down of some very expensive industries one or two days a week to meet energy intensity targets, at significant cost to the economy, but with no real long-term efficiency benefit, to the building of wind turbines and other equipment that don't get connected to the grid, but help meet investment and renewable energy capacity targets.

However, after verifying the data, the national government recognized an average of 2.01%. China's tracking systems need greater transparency, a quicker turnaround, and more expert and public review of data and methods.

One way or another, each of these challenges will become more difficult, as multiple objectives require more data, and provide more opportunity for conflict between targets and perverse outcomes.

EXPERIMENTS AT THE LOCAL AND PROVINCIAL LEVEL

As a very large and populous country, China has long needed to rely upon local and provincial governments for some policymaking and enforcement, much more than might meet the eye to the casual external observer. Over the years, the national government has sought to exploit the policy making and inno-

“WE ESTIMATE THAT THE CO₂ EMISSIONS SAVINGS FROM CLOSING THESE POWER PLANTS ALONE IS WELL OVER 100 MILLION TONNES PER YEAR.”

Another issue with targets is that their use increases the importance of reliable data, but also increases the incentive to provide overly rosy data. In other words, using targets can lead to less accurate data, precisely when more accurate data is needed. Making sure these targets are being met is a significant challenge. China needs better systems for measurement, reporting, and verification. While the emissions data captured by the national monitoring system seems reliable, and has matched data from the Lawrence Berkeley National Laboratory and the World Resources Institute, provincial and local monitoring is far less reliable. In 2011 the provinces reported an average energy intensity reduction of 3.6%.

vation capability of local governments, for example through special economic zones, even while fighting to keep most policy control at the national level. Carbon policy has been no exception.

China is now experimenting with additional policies—encouraging local innovation and trying approaches that have not been used widely in China, including emissions trading through energy and carbon markets.

The Low Carbon Development Pilot Program started in 2010 in five provinces and eight cities. Through a mix of emissions and policy targets for energy, construction, and public

transport, these cities are attempting to re-think the urban environment. Since then it has become a national program, and 29 cities recently signed on for the second round of the pilot program. The key to these programs has been to devolve some policy-making and spending authority to the local governments. This authority can be used in many ways, for efficiency and urban development, or to create new, low-carbon based manufacturing industries.

Another pilot program involves carbon markets, where design and initial implementation was launched in 2011 in two provinces and five cities. (Two of these provinces, Guangdong and Hubei, also participate in the Low Carbon Program.) Still in their infancy, these markets will experiment with different designs and parameters for markets and may demonstrate how a national carbon market might work, which is planned for 2016.

MANAGING CHINA'S BUREAUCRACY

China is now a middle income country, or, rather a middle income country of about 600 million, mixed with a poor country of about the same size. As such, the country and its people now have a lot to lose as well as opportunity to gain. Different groups within China have become more wealthy and have gained power. The state-owned enterprises—the industrial companies owned by the government—including especially the energy companies have become very powerful, sometimes bringing them into conflict with the central government and in so doing reducing the efficiency of the Chinese economy. The company that owns the transmission grid is a prime example; battles have severely hampered Chinese energy system goals. Financial sector analysts report that a lack of transmission capacity caused curtailments that reduced the average profit of wind generation by half in 2012. Partly as a result, new wind turbine build was lower in 2011 than 2010, and lower still in 2012.

Early in 2013, the Chinese government announced a series of measures to both reduce the power of the state-owned enterprises, such as forcing them to pay dividends, and to resolve some of the issues that were stalling transmission system build. They also announced new, higher wind turbine build

targets. Time will tell whether these reforms will be successful.

Beyond the state-owned enterprises, policy must fit within the landscape of the Chinese bureaucracy itself. The importance of the bureaucracy was demonstrated during the 10th FYP, when a bureaucratic reorganization left energy efficiency without a high-level official responsible for it. From the late 1970s through the late 1990s, national industrial ministries were responsible for energy policy implementation: the Metallurgical Ministry oversaw iron and steel, the Ministry of Electric Power monitored power plants, and so on. However, as market reform continued throughout the 90s, many industries were privatized, the ministries were eliminated and oversight shifted to local governments. However, the local governments weren't required to have an energy policy or oversight, and few had the capacity. During the 10th FYP, there was an administrative vacuum in energy policy implementation. Once again energy intensity shot up and energy efficiency went down, reversing a 22-year trend.

That reversal triggered the target responsibility system, through which the central government is essentially forcing local government to take responsibility for meeting national energy targets within their borders. That means they're now the main instruments for instituting and enforcing national energy policy.

This new system seems to be working. Shandong province, for example, took the nationwide energy reduction target of 20% during the 11th FYP and aimed higher, for 22%. The provincial government disaggregated this 22% amongst all the cities and provided funding to supplement central government funding. If facilities did not meet the energy efficiency standard, they were asked to replace the facility with higher efficiency technology or were compensated for closing.

ENCOURAGING BOTTOM-UP INNOVATION

Traditional programs will not be enough for China to meet its climate needs. It will need to encourage innovative and bottom-up programs, but it will also need to develop more robust mechanisms to monitor the impact of such experiments.

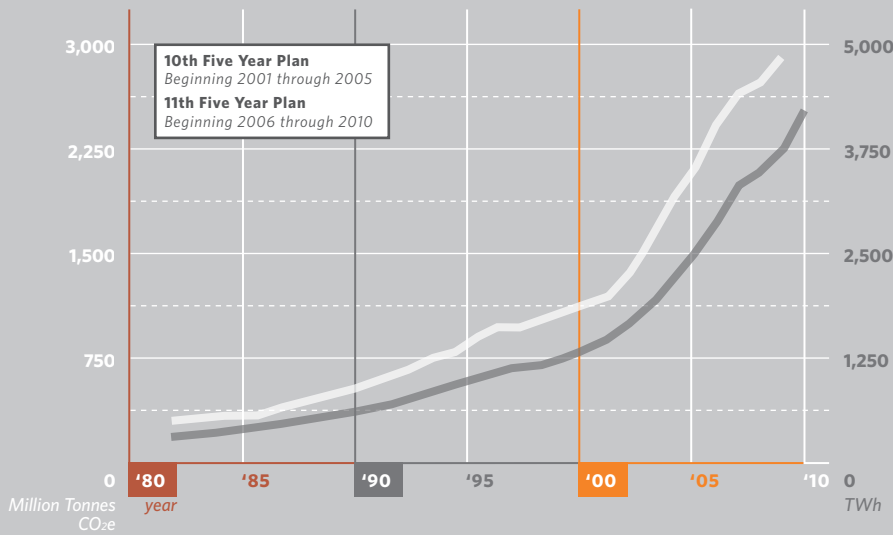
Moreover, with the global economy still weak, China's ability to invest in energy efficiency, low-carbon initiatives, and clean technology faces significant hurdles. But the new party leadership, which took the helm in November 2012, has signaled its interest in promoting a low-carbon green economy. At the most recent National Party Congress in October 2012, this emerging leadership put out an ambitious call for China to create an "ecological civilization." To do so it must weigh intense pressure for economic growth against an equally intense push to address its environmental ills. This balancing act remains one of the world's biggest climate challenges. ■

EMISSIONS & OUTPUT

GREENHOUSE GAS EMISSIONS AND GENERATION (1982-2010)

KEY

NOTES



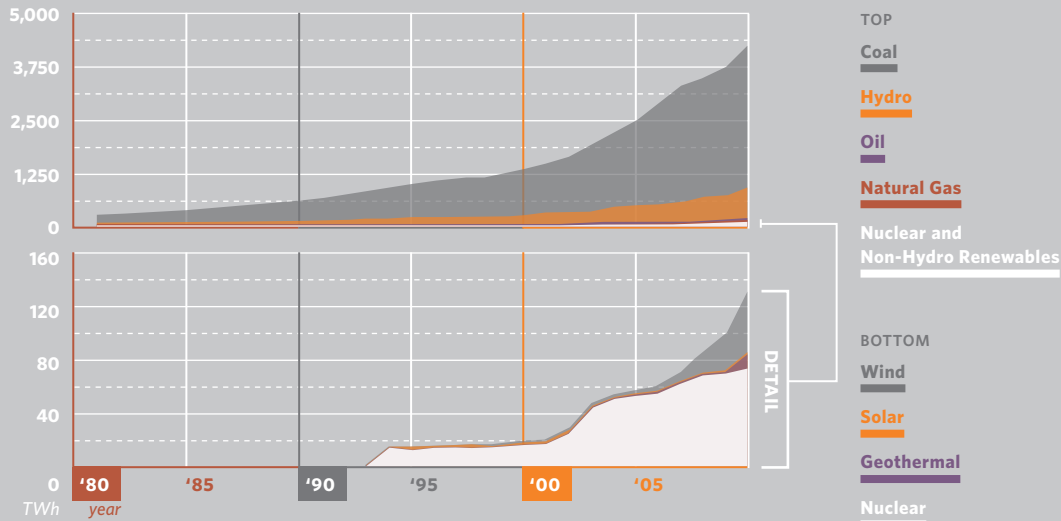
Electricity generation and the associated CO₂ emissions increased significantly in the past three decades, with generation growth accelerating significantly in the tenth Five Year Plan (2001-2005). Since 2006, the growth in power demand has slowed slightly with CO₂ emissions following suit.

EMISSIONS DRIVERS

FUEL SOURCES FOR POWER GENERATION (1981-2010) / LOW CARBON FUEL SOURCES (1992-2010)

KEY

NOTES



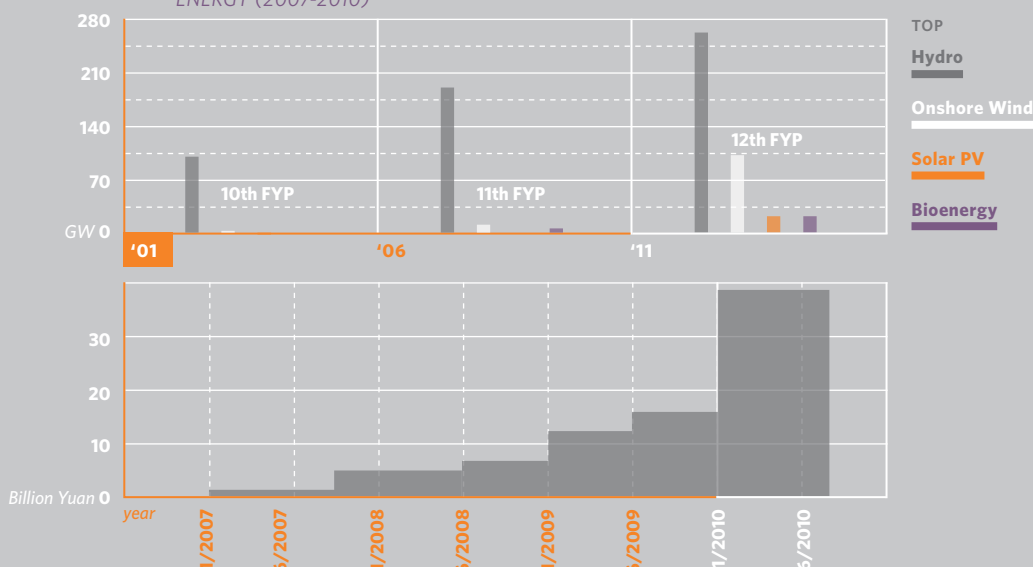
The vast majority of increased generation came from conventional sources, primarily coal. However, the past decade saw exponential growth in low-carbon fuel sources, such as renewable energy, although this energy represented a very small portion of overall electricity production.

POLICY

TOTAL INSTALLED CAPACITY TARGETS (2001-2015) / INCENTIVES DELIVERED TO TRANSMISSION OPERATORS TO INCREASE GRID ACCESS TO RENEWABLE ENERGY (2007-2010)

KEY

NOTES



Policy encouraged increased renewable energy deployment through a mix of generation targets (top chart). Total incentives to transmission operators to connect and carry renewable electricity increased more than 25-fold between 2007 and 2010 (bottom chart). China maintained reasonably high, but slowly declining, feed-in tariffs for wind and solar (not shown).



1980-1990

China increased and diversified its power supply in the 1980s while focusing on energy efficiency improvements. China took first steps towards building an initial institutional framework for environmental protection.

1990-2000

As China's power supply grew and diversified, the government began programs to close small coal-fired power plants, but coal continued to dominate the energy supply. The corporatization of state power-related assets began.

2000-2010

China continued its corporatization of state assets. Balancing demand and supply became a key challenge as economic growth continually outpaced expectations. After marked increases in carbon intensity in the early 2000s, the late 2000s brought new emphasis on renewable energy and re-emphasis on energy conservation, along with a rapid improvement in the average efficiency of coal fired power plants.

POLICY

State Council announced Promotion of Small Hydro Power for Rural Electrification Policy, 1983

Nuclear licensing and regulatory body National Nuclear Safety Administration (NNSA) established, 1984

Electricity sector reforms in mid-1980s (Qui 2012)

- Opened up non-government investment in power plants
- Government maintained full control of transmission

Small Coal-Fired Plants Development Interim Provisions, 1986

Energy Ministries' assets corporatized to state-owned enterprises

- Ministry of Petroleum Industry converted to China Petroleum and Gas Corporation (1988)
- Established China National Offshore Oil Corporation (CNOOC) (1982)

Air Pollution Prevention and Control Law of 1987 laid broad framework for regulation of air pollution (Alford 2001)

National Environmental Protection Agency established, 1984

Government-set coal price transitioned to government guidance on coal price, 1993

National Electric Power Law of 1995 reiterated encouragement for private and foreign investment in the power sector

State Planning Council supported domestic/foreign joint venture to develop wind power technology, 1996

Energy ministries' assets corporatized to state-owned enterprises

- Ministry of Electric Power converted to State Power Corporation, 1997
- China Petroleum and Gas Corporation converted to Sinopec and China National Petroleum Corporation (CNPC), 1998

Closure of Small Coal-Fired Power Plants, 1999

Air Pollution Prevention and Control Law amended, 1995

National Environmental Protection Agency upgraded to State Environmental Protection Administration (SEPA), 1998

Air Pollution Prevention and Control Law amended, 2000

Electricity System Reform to introduce competition, 2002

- State Power Corporation split into several companies
- State Electricity Regulatory Commission established, 2003

Major coal and power corporations allowed to spin off publicly listed subsidiaries

Electricity Price Reform Plan of 2003 deregulated generation and sales prices

Established Coal and Electricity Price Linkage Mechanism, 2004

Coal price liberalization, 2006

Renewable energy promotion

- Government financed wide range of renewable energy projects
- Renewable Energy Law, 2006
- Wind, solar PV, and bioenergy feed-in tariffs established in late 2000s

11th Five-Year Plan, 2006-2010

- Small coal-fired power plant closure program, including new large plant construction contingent on small plant closures
- 10% SO_x emissions reduction target, including mandatory installation of scrubbers in many new plants

SEPA elevated to Ministry of Environmental Protection, 2008

UNDERLYING CHANGES

Reform and Opening Up Policy of 1978 introduced economic incentives and some competition

Domestic market began to open to global competition and imported technologies (Rosen 2007)

Increased railway construction between western coal production provinces and coastal areas

Nuclear power generation began

Three Gorges Dam hydroelectric project (22GW) began construction, 1992

Became net importer of oil, 1993

Energy shortage early 1990s: small self-use industrial power generators boomed

1997 Asian financial crisis contributed to small coal-fired plant closures in late 1990s

Power shortages

- 2004-2005: power production capacity increase unable to meet surging demand
- Rail and port constraints became a major issue for supplying coal to generators
- Late 2000s: market coal prices higher than controlled electricity tariff

Became net importer of coal

Coal-fired generator efficiency saw constant improvement throughout the decade, energy intensity decrease

Increasing residential electricity demand

Rapid increase in global coal prices

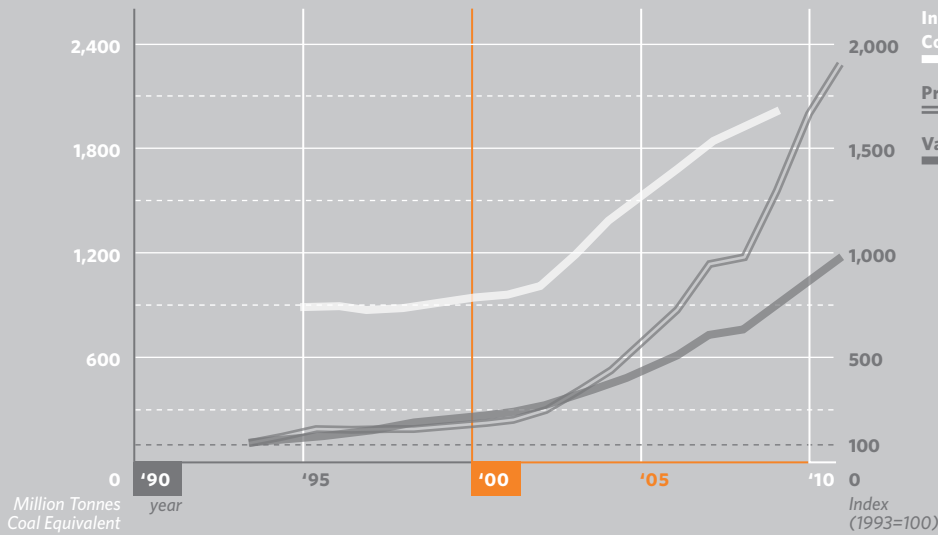
Beijing Olympics 2008

EMISSIONS & OUTPUT

ENERGY CONSUMPTION BY INDUSTRY AND INDUSTRIAL OUTPUT (1993-2011)

KEY

NOTES



Industrial Energy Consumption
Production Index
Value-Added Index

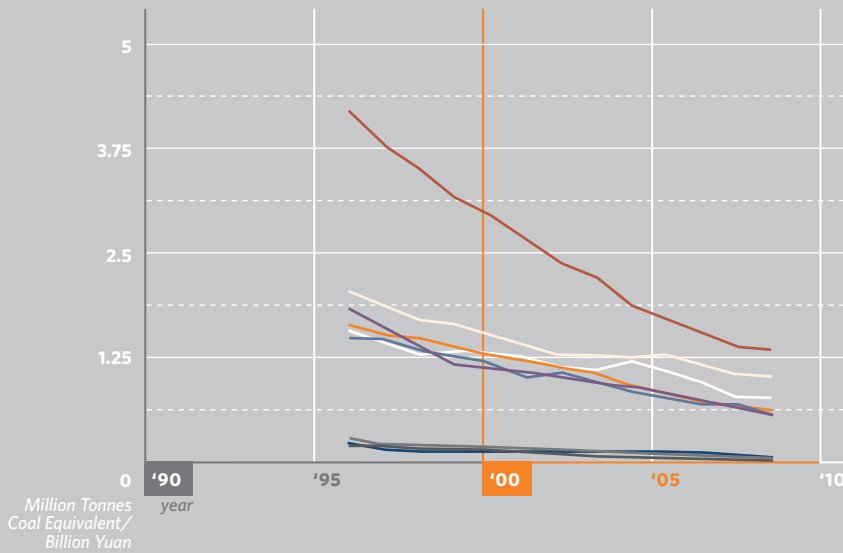
By some measures, industrial production output rose almost 20-fold since 1993 (right axis). China did not report greenhouse gas emissions from industry, but they were very closely related to energy consumption, which more than doubled since 2002 (left axis).

EMISSIONS DRIVERS

SECTOR ENERGY INTENSITY: MANUFACTURING, METALS & MINERALS, CHEMICAL (1996-2008)

KEY

NOTES



Paper, Pulp & Printing
Iron & steel
Non-metallic Minerals
Textile & leather
Chemical & Petrochemical
Non-ferrous metals
Wood & wood products
Food and tobacco
Transport equipment

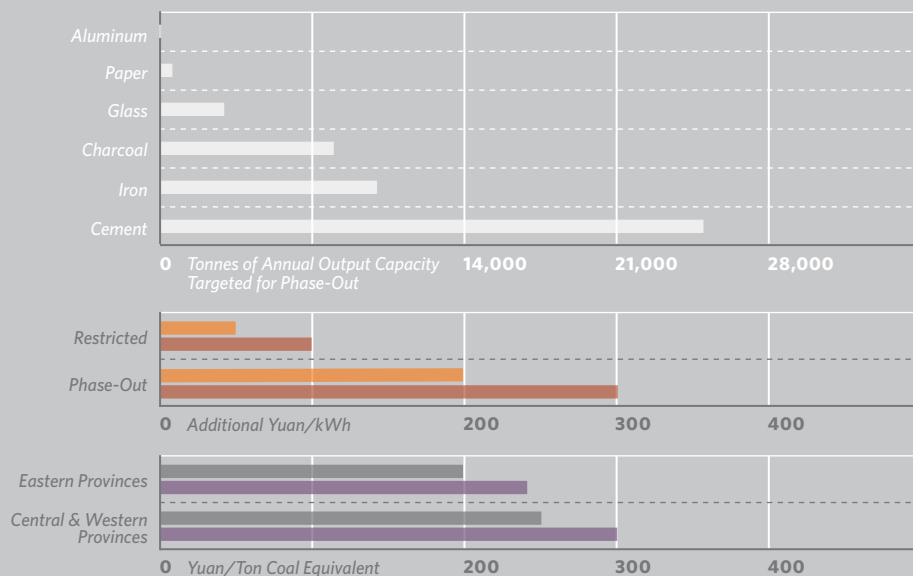
Industrial emissions intensity improved dramatically across all sectors, although from a generally high starting point.

POLICY

PHASE OUT TARGETS - STANDARD SCALE (2007-2009) / ENERGY CONSUMPTION REDUCTION INCENTIVES AND PUNITIVE PRICING

KEY

NOTES



2007-2009

The government set specific targets for many large industries regarding how much capacity was to be phased out or retired (top chart). Industrial plant designated for phase out - or restricted production - paid higher prices for electricity, as penalties were added onto the price for electricity (middle chart in orange). Additionally, industries were given incentives to reduce energy consumption that varied depending on the region (bottom chart).



1980-1990

Starting from a very high energy intensity level, China initiated two decades of energy efficiency investment and improvement. GDP grew faster than energy demand. China also began some market reforms and took first steps towards building an initial institutional framework for environmental protection.

1990-2000

GDP continued to rise faster than energy demand with energy efficiency still improving at a notable pace. Institutional infrastructure and funding for energy conservation was weakening by the end of the decade.

2000-2010

China saw a sudden decline in the emphasis on energy conservation from 2002-2005, accompanied by a stronger focus on capital-intensive economic growth. Energy demand grew dramatically. China returned to a strong focus on energy intensity reduction in the second half of the decade.

POLICY

Energy Efficiency Target: quadruple GDP and only double energy consumption 1980-2000 (Levin 2009)

- Energy efficiency investment 12% of total energy investment in first years
- Energy efficiency improvement via low-hanging fruit fixes and practices
- Established new institutions:
 - China Energy Conservation Investment Corporation, 1988
 - Bureau of Energy-Saving and Comprehensive Energy Utilization under State Planning Commission

Market price reform, 1988

- Dual pricing system (state-owned enterprises permitted to sell commodities at market prices outside planned quota)

Institutional structure for environmental protection grew (Qui 2009)

- Environmental Protection Commission established under State Council, 1984
- National Environmental Protection Agency established, 1984

Energy efficiency action continued over the decade; however, funding and institutional infrastructure weakened by end of the 1990s (Levine 2009, Price 2001)

- Ministry of Energy created in 1988 but abolished in 1993
- Industrial ministries demoted to bureaus in 1998 resulting in weakened state control over enterprises (Price 2001)

State Council stipulated closures of small facilities in 15 high polluting industries, (e.g. small coal mines, paper), 1996

Energy Conservation Law, 1997

In early 1990s, adoption of UN Agenda 21 led to incorporation of sustainable development as national strategy in China Agenda 21

National Environmental Protection Agency upgraded to State Environmental Protection Administration (SEPA), 1998

Acceded to WTO, 2001

Marked de-emphasis on energy conservation in first half of decade

- 10th FYP emphasized economic growth and infrastructure investment

Developed the West Policy of 2000, including investment in infrastructure

Return to energy conservation, 2005

- 2005 target to reduce energy intensity by 20% by 2010 (Zhou 2010)
- NDRC focus on efficiency revived (Zhou 2010)
- 11th FYP EE Programs targeted major efficiency opportunities
 - Top 1,000 Industrial Enterprises energy saving targets
 - Phasing-Out of Outdated Capacity Project
 - Ten Key Energy-Saving Technology Improvement Projects

Energy Conservation Law amended 2007

- Mainstreamed Energy Conservation as a fundamental national strategy
- Announced Target Responsibility System and evaluation measures

Differential electricity pricing, late 2000s

NDRC set energy policy and prices, but energy management still spread across agencies

Rhetoric changed: Chinese Communist Party 17th National Congress raised "ecological civilization" for first time

11th FYP set first air quality targets

SEPA elevated to Ministry of Environmental Protection, 2008

UNDERLYING CHANGES

Reform and Opening Up Policy of 1978 introduced economic incentives and some competition

Domestic market began to open to global competition and imported technologies (Rosen 2007)

Became net importer of oil, 1993

Asian financial crisis, 1997

Rising labor costs and commodity prices

Dramatic build-out of infrastructure and generation capacity

Energy use per GDP unit increased by 3.8% annually from 2002-2005 and then began to decrease in 2006 (Zhou 2010)

China demand driving global prices

Industrial production moved up value chain

Accelerated export and increasing industry energy intensity

Chinese economic growth contributed to global commodity shortage in mid-2000s

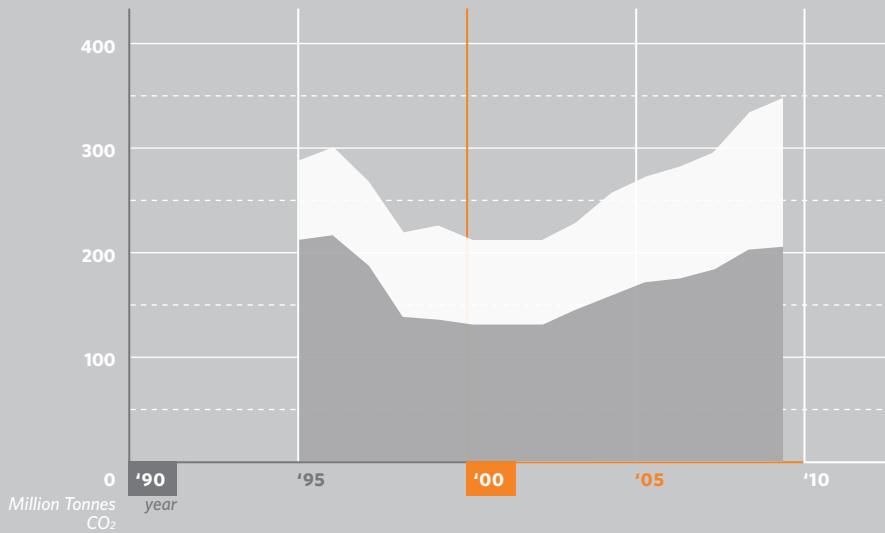
Became net importer of coal

EMISSIONS & OUTPUT

BUILDING SECTOR EMISSIONS (1995-2009)

KEY

NOTES



Commercial
Residential

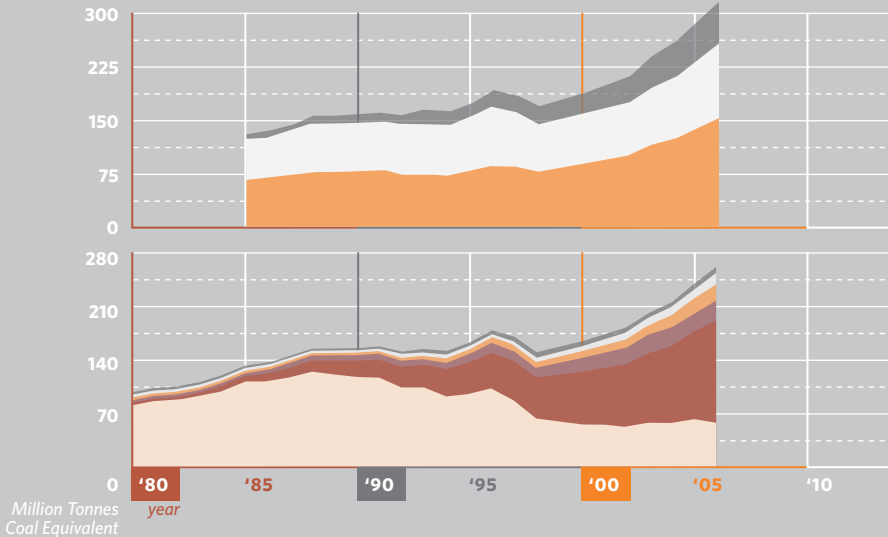
Reported buildings-related emissions fell during the 1990s, possibly due to district heating improvements, but more likely due to underreporting of coal use and measurement issues. Since 2002, emissions have been rising steadily due to growing energy use in buildings.

EMISSIONS DRIVERS

ENERGY CONSUMPTION BY FUEL SOURCE / ENERGY CONSUMPTION BY SECTOR AND GEOGRAPHY (1980-2006)

KEY

NOTES



TOP
Commercial
Rural Residential
Urban Residential

BOTTOM
Other
Natural Gas
Heat
Liquid Petroleum Gas
Electricity
Total Coal

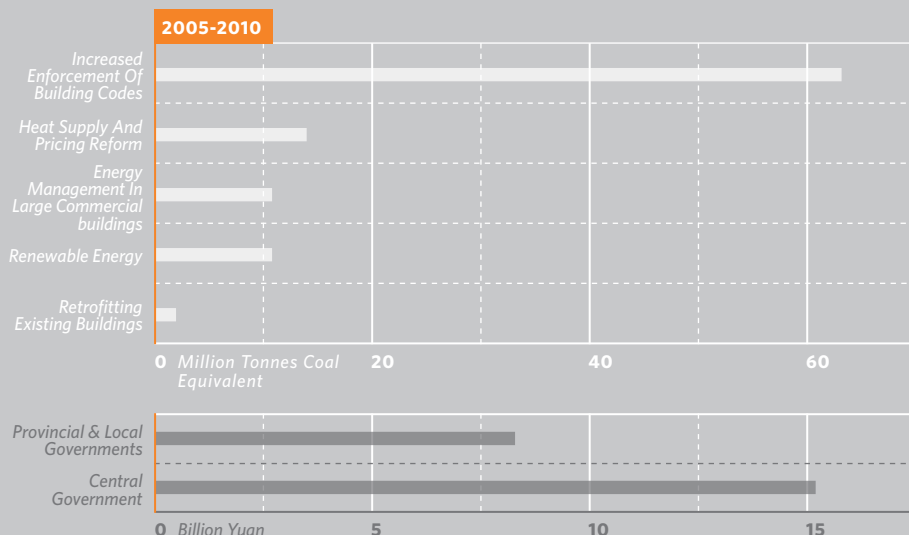
Urban residential growth was the primary driver of growth in energy usage, which in turn was the primary cause of increasing emissions, with commercial building energy use contributing a small increase (top chart). Particularly in urban residences, electronics and appliances became a significant end use, more than offsetting efficiency improvements in heating. Appliance use contributed to the increase in share of electricity in energy, as did the shift away from coal use (bottom chart).

POLICY

ESTIMATED IMPACT OF POLICIES TARGETING ENERGY USE REDUCTION (2005-2010) / FUNDING FOR ENERGY MONITORING, CAPACITY BUILDING, AND EQUIPMENT REPLACEMENT (2005-2010)

KEY

NOTES



Energy Reduction Targets

Increased enforcement of energy building codes saved an estimated 60 million tonnes of coal equivalent per year, more than all other targeted policies combined (top chart). Meanwhile, both the provincial and central governments provided substantial funding for energy efficiency monitoring and improvements (bottom chart).

Funding for Energy Efficiency Programs



1980–1990

Urbanization and rapid building were already underway in the 1980s. China initiated building energy conservation policies, primarily focused on district heating in the colder regions of the country.

1990–2000

China moved into its pattern of build and rebuild, demolishing older buildings but building new buildings at a faster pace. In concert, China focused on new building energy efficiency standards and continued heating policies.

2000–2010

Total building floorspace increased rapidly as new construction outpaced continued demolition of older buildings. Lifestyle energy intensity and rural building energy consumption increased. China increased the number and ambition of energy-saving standards for new buildings and retrofits.

POLICY

Residential Building Energy Conservation Design Standard targeted coldest regions, 1986

State Planning Commission Announcement on Enforcing Urban District Heating, 1986

First Appliance Energy Efficiency Standards introduced, 1989

Urban District Heating Industrial Policy Measures of 1992 stated district heating as important target for pollution reduction and energy conservation

9th Five-Year Plan, 1996-2000

- 30% efficiency improvement targets for new residential buildings with moving baseline year
- Phased-in 50% and additional 30% efficiency improvement targets for new commercial buildings
- Guidelines for building retrofits
- Heat metering pilots

Energy Conservation Law of 1997 stipulated energy conservation principles for building design and construction

Residential building efficiency

- Technical standard for retrofit of district heated buildings, 2000
- New building efficiency targets ratcheted up throughout decade—65% improvements by late 2000s
- Energy Conservation Design Standard extended to entire country
- State Council Announcement on Re-enforcing Residential Building Energy Conservation Auditing, 2004

Commercial building efficiency

- Increased new commercial building efficiency target to 50%
- 11th FYP required large commercial and government buildings to lead retrofiting

Energy Conservation Medium-Long Term Plan, 2004

- Building retrofits requirements tiered according to municipality size
- Established energy efficiency labeling for appliances

Tax incentives for heat providers, 2004, 2006

Ten Key Energy-Saving Technology Improvement Projects (e.g. District Heating and CHP, Building Energy-Saving, Green Lighting)

2007 Energy Conservation Law set standards for air-conditioned buildings and required meters for district-heated buildings

Promoting Building-Integrated Renewable Energy policy, 2009

Energy-Saving Appliance Subsidies, 2009

UNDERLYING CHANGES

Urbanization led to new building construction
Rapid increase in total building area

Fuel switching from coal to electricity in heating and cooking

Increase in energy use from household appliances

Increase in district heating energy efficiency (late 1990s)

Continued rapid increase in total building area

Continued fuel switching from coal to electricity in heating and cooking

Continued increase in energy use from household appliances

Increasing rural building energy consumption (CPI, unpublished data)

Significant demolition of older buildings

Rapid total building area increase continued—commercial building floor space tripled from 2000-2008 (CPI, unpublished data)

THE DILEMMA OF CARBON INTENSITY TARGETS

Two realities of climate change policy stand out in apparent conflict. First, strong economic growth and higher emissions tend to go hand in hand. Second, development needs and political realities mean that many nations prioritize economic growth over greenhouse gas emissions limits and targets. This conflict means that as long as unfettered economic development is a priority over emissions limits, emissions will likely go up. In response, some nations have put forward a potential solution: to replace absolute emissions targets with carbon intensity targets—that is, to attempt to decrease greenhouse gas emissions per unit of economic output.

The solution makes sense in that it encourages using a limited budget for emissions in the ways that generate the most economic value. It also provides more flexibility than fixed emissions caps, allowing or even encouraging more economic growth as long as that growth is less carbon intensive. Indeed, the additional wealth created could be used to invest in greater carbon reduction in the future. Such is the theory.

For analysis, carbon intensity is an attractive metric in that it should strip out some of the effects of economic growth to isolate the impact of actions that are improving the carbon efficiency of a country or industry. We include carbon and energy intensity as metrics in several of our charts in this review.

Unfortunately, our use of intensity metrics highlights the practical difficulties involved. Assuming accurate emissions data, the difficulties lie in the denominator; that is, measuring the relevant change in economic output. The first question is what currency to use. If the Euro, say, were to appreciate 20% against the dollar overnight, carbon intensity in dollars would fall close to 20% as economic output expressed in dollar terms would have risen 20%, all with no real action or change on emissions.

Purchasing Power Parity and value added as metrics

A logical response is to use purchasing power parity (PPP)—adjusting the currency for what it can buy, including lower or higher priced local goods. However, measuring and comparing PPP is notoriously difficult, particularly since relative prices tend to move in ways that can create large distortions. For example, a rising cost of wages and labor could drive down the PPP-driven carbon intensity, even if nothing else changes in the economy, including output. Furthermore, economic output from many segments of the economy can go unreported, making the economy seem less efficient. Simply improving reporting and accounting can drive down reported carbon intensity.

Even with a perfect PPP adjustment, problems would arise on a number of levels, but most particularly on value added. Imagine a manufacturer that runs a successful marketing campaign, elevating standard goods into the luxury market, where the price doubles. By virtue of the price doubling, the carbon intensity of the product halves, with no other change. A country as a whole could also enjoy this, for example as risk falls or they build a reputation for quality, or as they produce higher end products.

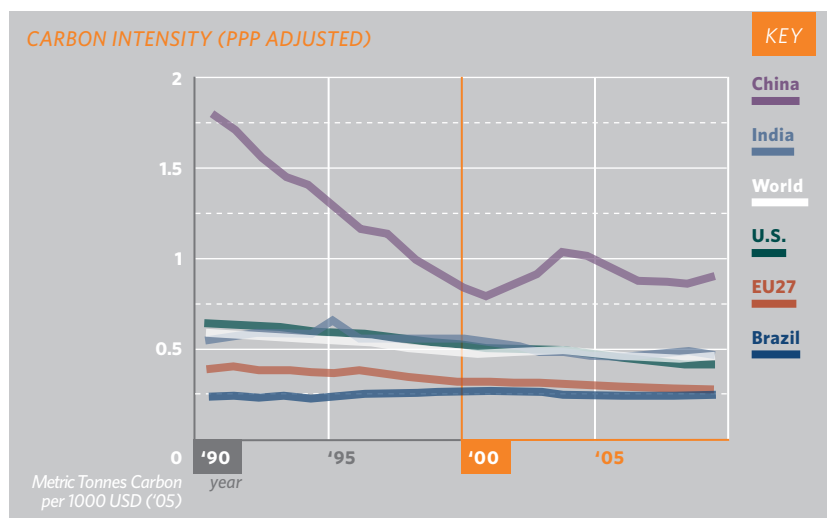
We have seen each of these factors in play in our analysis. The relative change in value added between the U.S. and Europe over the last 10 years looks remarkably like the movement of the dollar against the Euro. We conjecture that the improvement of relative value added in the U.S. is mainly a factor of lower labor and other local costs driven by a cheaper dollar. Meanwhile, Chinese relative value added in the industrial sector declined rapidly, which may be a function of increased competition, higher labor costs, and a rising currency more than offsetting a move toward higher value added products. But we cannot be sure, and this uncertainty comes even before we attempt to analyze carbon intensity.

Different starting points: Countries have different sets of efficiency opportunities

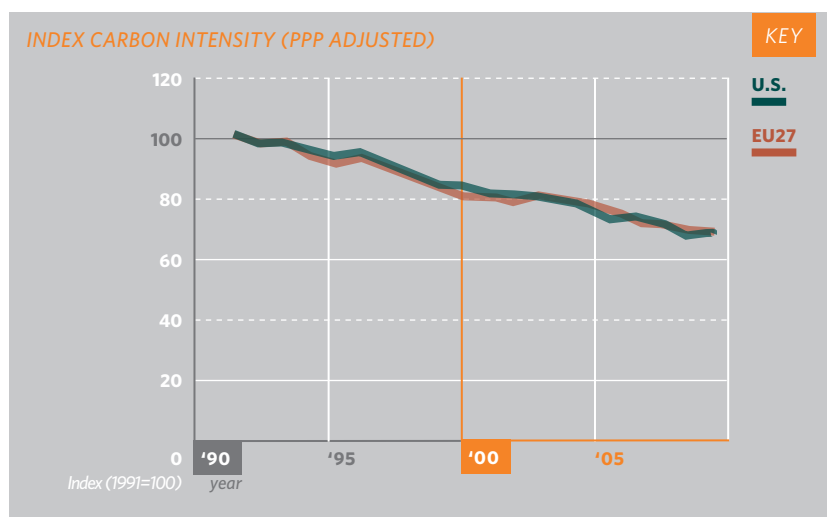
Differences between the starting points of industries or economies further limit the usefulness and veracity of carbon intensity metrics for use in comparison. Less carbon efficient economies will find it easier to increase carbon efficiency as they catch up to other countries in carbon (and energy) efficiency. Thus, as in the chart below, China has been the most effective country in terms of improving carbon intensity of the economy, particularly between 1990 and 2001, and again from 2004 to 2008. But has its accomplishment been exceptional, or exceptionally easy? We do not know, since we cannot say how quickly a country should catch up. China targeted, and just about made, a 20%

reduction in carbon intensity between 2007 and 2012, and is targeting a further 16% reduction by 2017. Meanwhile, India has targeted a 20-25% reduction over the 15 years from 2005 to 2020, but given India's lower starting point, is that more or less impressive than China?

In the next chart, improvements in U.S. and EU27 carbon efficiency over the last 20 years look remarkably similar. But does that mean that this is the rate at which any wealthy, relatively slow-growing developed nation can improve carbon efficiency, or does it reflect the lower carbon intensity starting point of the EU, offset by a relatively stronger EU policy environment? How much improvement should we attribute to the policy environment, and how much more difficult is efficiency improvement when carbon intensity is already low?



The answer is that at this point, we cannot know for sure. As such, energy and carbon intensity metrics can only be a part of the analysis. They can give us some guidance as to the effectiveness of policies, but they must be complemented with other analyses and metrics.



The same must go for using intensity targets as a replacement for absolute emissions targets. Carbon intensity targets can provide some value, but only if used in conjunction with other metrics or targets.





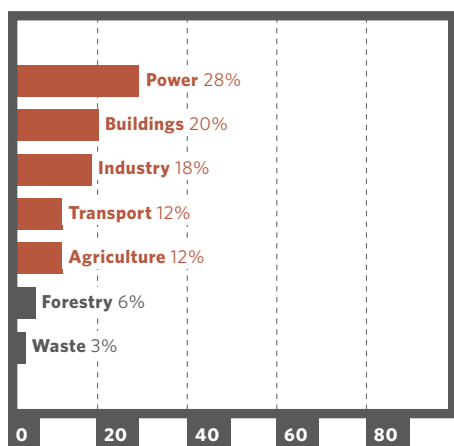
**EUROPEAN
UNION**



ROPEAN
NION



MAKING POLICY FOR CLIMATE'S SAKE



Percentage of Greenhouse Gas Mitigation Potential

Europe is the land where climate policy has been explicit. Seeking to lead the world in terms of climate mitigation policy, it has integrated policy across many, varied states, and its nations have developed and implemented ambitious policies of their own. The challenge in Europe is to continue providing leadership in the face of an economic crisis, while accounting for national differences in outlook and policy.

In other regions and countries, a collection of energy efficiency, renewable energy, land use, transport, industry, finance, and technology policies add up to climate policy. Europe has woven these policies together, beginning with the world's largest carbon market and the binding targets that the European Union (EU) and its member states accepted as part of the Kyoto Protocol. What's more, Europe has ambitious plans for 2020—the so-called 20-20-20 plan—even while it seeks to use its experience and negotiating power to encourage other countries to go further.

In many senses, Europe has had advantages in pursuing climate change policy. In Europe there is more—albeit not complete—consensus that something must be done about climate change, making the politics easier. Further, although there are wide variations within Europe, the region is relatively wealthy, slow-growing, and resource-poor, and thus already has a relatively carbon-efficient economy, driven by years of pursuing energy efficiency, energy security, efficient transport, and working within land use constraints.

Yet the EU is also struggling through a financial recession, and governments are putting a strong focus on spending public money more wisely. Meanwhile, the benefit of a carbon-efficient economy may also be a curse, for it may be harder to make an efficient economy more efficient than to make an inefficient one efficient. And, like all of the other regions and countries in this survey, Europe has to work with several levels of government—its 27 member states, and often their regions, provinces, counties, or Länder. So in the context of flat or declining emissions, Europe's challenge is to maintain its own momentum for climate and energy policy action, despite its financial difficulties, while continuing to push for greater action internationally.

What European countries have learned through many years of climate policy is that no single policy can do everything; rather, a mix of regulation, market-based instruments, and targeted, information-driven policies has proven most effective at addressing climate and energy issues. But there are other lessons to learn from Europe. These include the challenges of developing and implementing an integrated climate policy across several states; the challenge of implementing policy within the constraints of the EU's enshrined principle of "subsidiarity," or devolving power to the lowest level of government possible; the important role of finance; and lessons on how countries and regions can cooperate with their neighbors to improve climate policy abroad.

BUILDING AN INTEGRATED CLIMATE POLICY ACROSS MANY, VARIED STATES

Europe's geopolitical landscape continues to shift as new member states are added to the European Union. From its origins in post-World War II Europe in 1958 as an economic alliance of a few Western European states, today the 27-member EU now includes states with highly different circumstances. Despite these states' varying commitments to and experiences with meaningful environmental measures, and the range of sectors they cover, the EU has been successful in achieving an integrated approach to energy and climate policy. This makes it a useful laboratory for climate policy.

INTEGRATED CLIMATE AND ENERGY POLICY

At the core of Europe's Climate and Energy Package is the European Union Emissions Trading System (EU ETS), the world's largest and most comprehensive greenhouse gas emissions trading system. Created in 2005, this cap-and-trade system covers more than 11,000 power stations and industrial plants as well as airlines in 31 countries (including non-member European states Iceland, Norway, Croatia and Liechtenstein). The target is to lower emissions by 21% below 2005 levels by 2020 in sectors covered by the EU ETS.

As in other regions, some policies that work for large sophisticated players are more difficult to apply to smaller players and other sectors. Thus, many of the sectors not

covered by the EU ETS are addressed by a set of sector- and product-specific policies. These range from the Ecodesign Directive, which sets performance standards for energy consuming products, to the Energy Labelling Directive, to various instruments targeting transport emissions. EU-wide energy labeling standards have become increasingly more stringent over the last 17 years (see Policy, page 42), with the energy efficiency index for both the worst and best possible labels falling by about half over that time.

A major shift in EU policy was achieved through the Climate and Energy Package, or 20-20-20 targets. Set in 2007, this trio of EU-wide targets aims to cut greenhouse gas emissions by at least 20%; meet 20% of EU energy consumption from renewable sources; and reduce primary energy use by 20% by improving energy efficiency, all by 2020. While the tightened ETS-target is EU-wide, the energy efficiency and renewable energy targets are translated into national targets, implemented and enforced at the member state level.

But this integrated policy has not been without its hiccups. Carbon prices have dropped to levels that provide only weak support for low carbon investment. At first they dropped because too many free allocations may have been granted to many ETS participants. The free allocations were made to smooth the transition to an economy where carbon emissions had a price and to protect some industries against foreign competition where carbon is not priced. However, calculating how many emissions permits were needed to do this turned out to be even more difficult than anticipated, due to a lack of data, and some member states were overcautious in their allocation of permits. At the same time, over the first 18 months of the EU ETS, prices were on average higher than 15 euros—triggering abatement and behavioral changes of market participants, which in turn may have contributed to the price drop.

More recently carbon prices have fallen with the weakness of the economy. Industrial production, transport, and power consumption have all fallen with the downturn, leading to lower carbon emissions. Some suggest that other low carbon policies beyond the ETS, driven by more aggressive carbon cutting

governments like Germany, may have further lowered emissions and thus weakened ETS prices. But we must ask, what was the objective of the ETS in the first place? If it was to achieve emissions targets at the lowest cost, surely it has achieved its goal and has been wildly successful. If it was to encourage more investment in low carbon infrastructure and technology, it may have been less successful. For those who believe the latter, the lesson here is that regions must be sure that policy and implementation are aligned with their true objectives. One way or another, the ETS has been remarkably successful in establishing a market mechanism and a price for carbon and in creating an umbrella policy to tie other policies together.

COMPLEMENTARY POLICIES

There are also policies that don't target climate change directly but have reduced emissions as a byproduct. One good example is the Nitrates Directive, which was established in 1991 to protect water quality across Europe. Through reduced fertilizer use, it has led to reduced nitrous oxide emissions, and the European Commission estimates that if fully implemented, the Nitrates Directive could cut nitrous oxide emissions by 6% from 2000 levels by 2020. Another example is the Common Agricultural Policy, and specifically, a set of recent reforms which have led to fewer cattle, reducing methane emissions. Nitrous oxide and methane emissions are especially significant in that they represent around 85% of the EU's agricultural greenhouse gas emissions (EEA 2012). Different from any other sector of the economy, only a small share of emissions—15%—are related to energy consumption, and hence CO₂ emissions.

Another is the Large Combustion Plant Directive. Designed to reduce sulfur emissions and other air pollutants from large power plants and other combustion facilities, the Large Combustion Plant Directive has forced owners of these plants to choose between retrofitting the plants with pollution control equipment or retiring the plants after a limited number of operating hours without control equipment. Many inefficient plants have been retired as a result, reducing carbon emissions, although operation of the pollution control equipment reduces the efficiency of the plants that are not retired, so the carbon outcome is not completely straightforward.

BELOW THE UMBRELLA: POLICIES AT THE STATE LEVEL

Thanks to the principle of subsidiarity, EU policy is only a small part of the overall climate policy landscape in Europe. In general, most EU countries have imposed comparatively high fuel taxes for many years that have led to a relatively fuel efficient vehicle fleet (see Policy, page 46). Different EU countries have experimented with various incentive mechanisms for renewable energy, from feed-in tariffs and feed-in premia in places like Germany, Spain, or the UK, to bidding for the right to sell energy under contract in Denmark, to renewable obligation certificate markets in the UK. Energy efficiency programs also abound at the national level, including in Germany and the UK. Overall, while some member states, notably coal-rich Poland, have been somewhat resistant to climate policy, other states have enacted policies that are even more stringent than required under current agreements.

An example is Germany, one of the world's leaders in renewable energy manufacturing and deployment. In order to promote its *Energiewende*, or energy transition, to a low-carbon, nuclear-free economy, in 2000 Germany strengthened its earlier clean energy policies through the Renewable Energy Act. The Act uses feed-in tariffs to incentivize investment in renewable energy generation. Importantly, it also obliges energy network operators to connect renewable energy sources to the grid, and feed in the resulting energy generated. It aims to produce 35% of its energy from renewable sources by 2020, and 80% by 2050. By the end of 2011, Germany had met over 12% of its total energy demand from renewable energy. The country also aims to generate 35% of its electricity from renewable sources by 2020, and 80% by 2050. Notably, in the first half of 2012, renewable sources such as wind and solar generated over a quarter of Germany's electricity. At the same time, Germany also moved up its goal to phase out nuclear energy by 14 years, from 2036 to 2022, and closed eight of 17 nuclear power plants.

Because costs to support renewable energy and transition to a low-carbon economy will eventually be borne by energy bill rate-payers, the feed-in tariff system has become a

topic of heated political debate as Germany approaches the next federal election in 2013. The growing use of wind and solar projects has reduced system prices as experience in scale and number of projects increases. However, years of political action to support renewable energy mean the cumulative cost in Germany and other leading countries has become larger than in others, and so have weighed more heavily on consumers and taxpayers.

Like Germany, the United Kingdom has set an ambitious target to produce 80% of its energy from renewables by 2050 (its 2020 target is 15%). An innovative policy is the UK's Renewables Obligation Certificate system, established in 2002. The Renewables Obligation Certificate system creates a market mechanism to set a premium that should encourage renewable energy build. The system is designed such that if the renewable energy capacity is insufficient to meet targets, the price will increase in response to the shortfall in order to raise the incentive to build more renewable energy.

“NO SINGLE POLICY CAN DO EVERYTHING.”

Some elements of the Renewables Obligation Certificate market's design have drawn criticism. Some suggest that prices were high early on not because more incentive was needed, but rather because there was a shortage of projects that could be approved and built in time. The desire to encourage different technologies which have different economics led the system to be modified by “Renewables Obligation Certificate banding,” that is, granting a different number of credits to different technologies. For example, onshore wind will receive 0.9 Renewables Obligation Certificates per MWh, while many emerging technologies will receive 2.0. While banding can support multiple technologies, it may also undermine the rationale for the Renewables Obligation Certificate system in the first place—that is, to provide a competitive market that encourages the market to choose the lowest-cost technology. Plus, further dis-

tortions are possible where the bands are set too high or low. Finally, some complain that offering an incentive where the price can vary each year might introduce too much risk for a 20-year project, although innovative financing techniques (see the Walney example on page 38) have reduced this problem.

Spain was an early leader in renewable energy, offering generous incentives for wind, solar PV and the emerging technology of concentrating solar power. However, when the incentives proved to be too attractive, and thus encouraged much more build than planned, the incentives added to the budget problems in Spain. In response, Spain surprised investors in late 2010 by announcing retroactive cuts to feed-in tariffs for solar energy: a 30% cut for all payments made to existing projects for a period of three years until the end of 2013, when rates are planned to return to original levels, and 10% cuts for new installations (Royal Decree Law 14/10). Recently, Spain suspended the scheme for new installations with no re-opening date yet set (Res Legal 2012). CPI has found that the

most significant risk for investors consists in policy changes. Spain's decision led to uncertainties and concerns of similar moves in other European countries to alter renewable support policies.

Other countries have also cut tariffs for new facilities to reflect the reality of rapidly falling solar energy investment costs, but usually in a more orderly fashion, maintaining tariffs for already-built facilities. Nevertheless, the confluence of demand for low-carbon infrastructure capital, budgetary constraints, weakness in capital markets, and retrospective policy changes have generated new and strengthened risks in Europe, and notably increased policy and financing risks. These risks hamper the scale-up of green investments and call for a new suite of innovative risk-mitigation instruments.

MAKING POLICY AND FINANCE WORK TOGETHER

While the ROC market has had some design issues, the UK's Walney Offshore Wind Farm demonstrates how financing and contracting solutions can help improve the policy outcomes. The developer, the Danish company DONG Energy, entered into long term energy sales contracts that reduced the cash flow volatility associated with reliance on ROC market revenues. These contracts enabled DONG Energy to engineer an innovative financing structure for the Walney project that attracted institutional investors, who have traditionally been put off by green energy's lower rate of return (CPI 2012f).

In Germany, at least EUR 37 billion, or 1.5% of GDP, was invested in 2010 to support the German transition to a low-carbon economy, with more than 95% coming from the private sector. The high share of private investment coincides with significant public incentives such as concessionary loans and the feed-in tariff. During 2010—when the private sector channeled more than 70% of its climate-specific investments into renewable energy generation—corporations, households, and farmers had access to EUR 11.3 billion of concessionary loans to support their renewable energy investments. In 2010, the feed-in tariff paid to household and corporate renewable energy generators amounted to approximately EUR 13.1 billion. While this latter amount reflects payments for all renewable electricity fed into the grid in 2010 (not just capacity built or financed in 2010), the magnitude of the feed-in tariff related finance flow underlines the importance of this instrument for private renewable energy investments. The tariff is funded by the private sector via a premium on electricity bills. Industry is largely exempt from this, leaving the bulk of the cost to households and small and medium-sized enterprises.

DRIVING CLIMATE POLICY GLOBALLY

Europe is also driving technology, policy, and investment in other parts of the world. One way it does this is by setting an example for the global negotiations and offering to lower its emissions targets further as an inducement to other players. Another way is by investing in projects outside of Europe—for example,

in North Africa, where there are hopes to export renewable energy to EU member-state countries to support Europe's low-carbon transition.

Backed by ongoing financial support from the Clean Technology Fund, Morocco is constructing a large-scale concentrating solar power (CSP) plant called Ouarzazate 1. It's the first step in the ambitious Moroccan Solar Plan (2009), which aims to install 2,000 MW of CSP capacity by 2020 and export power to Europe. CSP is an early-stage technology with high upfront costs, and Morocco aims to be-

ministries have become active as well, which is changing the approaches of some member states.

As governments shy away from spending public money, it's becoming even more important to highlight that climate policy, if designed appropriately, does not need to hinder economic development. In fact it may promote economic development by providing new opportunities for growth and unlocking new sources of private capital. In 2010 greenhouse gas emissions in Europe were 15.5% below 1990 levels, while EU GDP grew by

“IN 2010 GREENHOUSE GAS EMISSIONS IN EUROPE WERE 15.5% BELOW 1990 LEVELS, WHILE EU GDP GREW BY MORE THAN 40% DURING THE SAME TIME!”

come a regional leader in its production with Ouarzazate 1, which when operational in 2014 will be one of the largest CSP arrays in the world. The case of Ouarzazate 1 shows that subsidies combined with competitive tenders, although expensive for public budgets, have the potential to stimulate competition and drive prices down (CPI 2012e). However, which policy instruments are best suited to promote early vintage technologies while driving down costs requires more analysis.

ECONOMIC GROWTH AND CLIMATE POLICY GO HAND IN HAND

One key lesson is that in the ongoing financial crisis, there is a very strong focus by governments on how to spend their public money wisely—a shift away from the prior focus on crafting the right mix of portfolio instruments. While targeted policies remain very important and have proven to be especially effective, environmental ministries are no longer the sole overseers of climate policy. Finance

more than 40% during the same time (EEA 2012).

BUILDING ON EUROPE'S EXPERIENCE

A key lesson of the European experience, with all its successes and drawbacks, is that well-articulated public policies are necessary to move toward low-emissions systems. These policies have been able to do this even across a large variety of countries, cultures, languages, levels of development, and economic structures. Public resource injections, conscientiously designed, can in fact alter investment risks and change private behaviors at an acceptable cost.

However, these public policies can be delivered through multiple, varied instruments—there is no single solution to ensure climate policy success. Going forward, expect to see more policy and financing experimentation in Europe, as well as continued leadership in climate and energy policy, which will

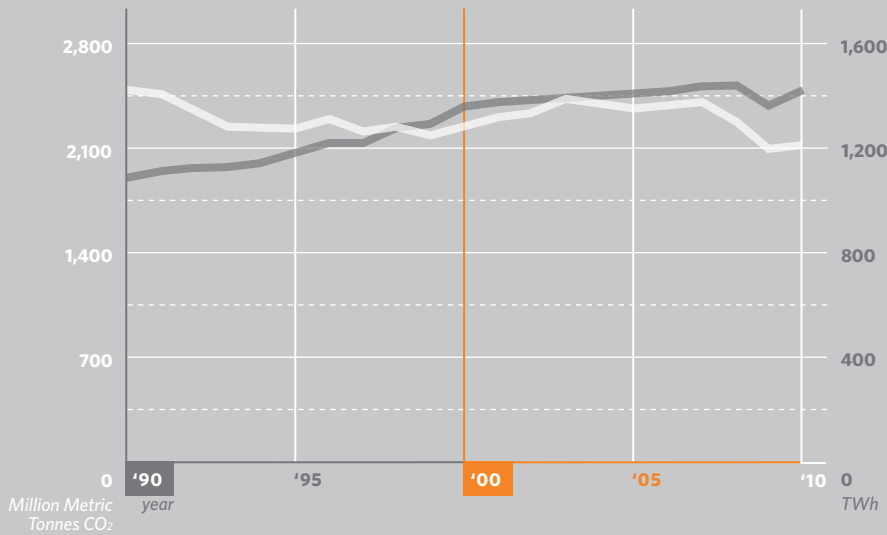
drive smart-grid technology and innovative financial instruments to lure investors across borders. The debut of the single energy market, expected in 2014, will provide a dynamic context for this work in progress. ■

EMISSIONS & OUTPUT

EMISSIONS AND GENERATION IN THE EU27 (1990-2010)

KEY

NOTES



Emissions
Generation

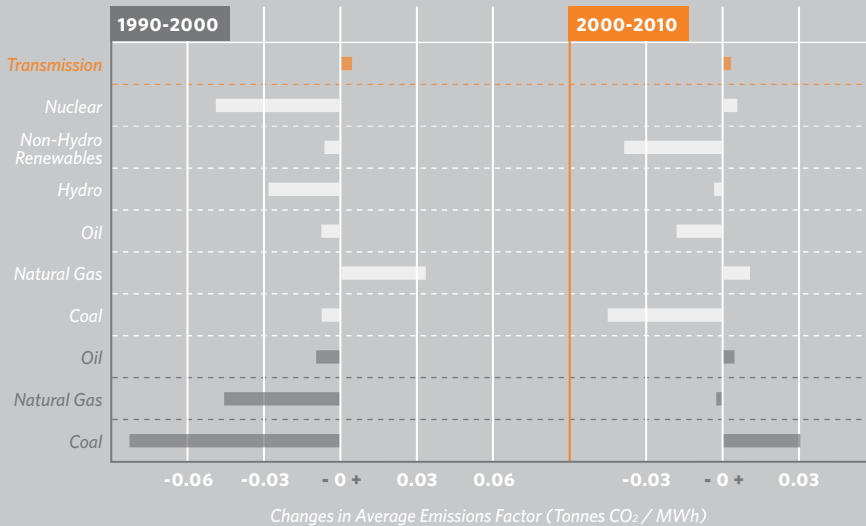
Emissions intensity fell fast enough that emissions declined overall (left axis), even though electricity generation grew (right axis).

EMISSIONS DRIVERS

POWER SECTOR VARIABLES AND IMPACT ON AVERAGE EMISSIONS FACTOR IN THE EU27 (1990-2010)

KEY

NOTES



Transmission
Generation Output
Power Plant Efficiency

During the 1990s, increases in coal and natural gas efficiency and growing nuclear output drove down grid emissions intensity. In the 2000s, the fuel mix shifted away from coal and toward other sources, especially renewable energy. The efficiency of coal plants fell in the 2000s, possibly due to increased sulfur and other pollution controls.

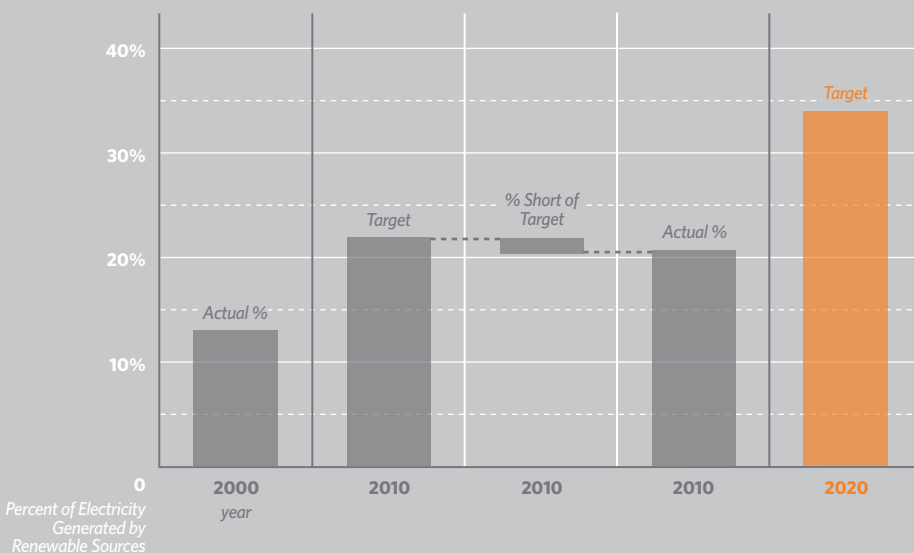
X-AXIS KEY
- Negative
Contributed to decrease in Average Emissions Factor
+ Positive
Contributed to increase in Average Emissions Factor

POLICY

TARGET VERSUS ACTUAL RENEWABLE ENERGY GENERATION (2000-2020)

KEY

NOTES



EU15
EU27

The EU set, and narrowly missed, ambitious renewable energy targets for 2010 for the EU15. For 2020, the EU has set an even more ambitious renewable energy target for the expanded EU27 of 20% of total energy consumption, which translates to 34% of electricity generation from renewable sources.



1990–2000

As EU began to liberalize and integrate its energy market, low gas prices drove switching from coal generation to gas generation. EU emissions limits were established for industry and energy facilities. EU renewable energy leadership grew while nuclear power and hydro generation increased across the decade.

POLICY

Liberalization and integration of EU's internal energy market commenced in second half of decade with First Energy Package (96/92/EC—electricity; 98/30/EC—gas)

Regulation of pollution from power plants increased

- Large Combustion Plant Directive (88/609/EEC) limits on CO₂, NO_x, and SO_x.
- 1996 Integrated Pollution Prevention and Control (IPPC) Directive (96/61/EC) instituted a comprehensive permitting regime for power plants to cover all types of pollution

UNDERLYING CHANGES

Restructuring of eastern European economies closed inefficient coal-fired power plants in the early 1990s (EEA 2011)

Low gas prices drove switch from coal- and oil-generation to gas-generation (EEA 2011)

Efficiency increased across all types of fossil fuel generation (EEA 2011)

Increase in generation from nuclear and hydro generation despite rapid slow-down in capacity deployment (Eurostat)

Europe became a significant source of early (non-hydro) renewable energy development

2000–2010

Continued energy market liberalization coupled neighboring energy markets and unbundled the power sector as EU aimed for a Single Market by 2014. The EU took global leadership in policy to reduce greenhouse gas emissions, establishing an Emissions Trading System, setting renewable energy targets, and taking a market lead in renewable energy sources. At same time, several Member States faced difficulties setting renewable support levels.

Energy market liberalization continued, targeting a Single Energy Market for electricity and gas by 2014

- Second Energy Package (2003/54/EC; 2003/55/EC) furthered competition and gave consumers choice of energy supplier
- Third Energy Package (2009/72/EC; 2009/73/EC) required separation of ownership in generation and transmission network assets

Under Renewable Energy Sources Directive (2001/77/EC), Member States set renewable electricity targets. Member states required to submit plans on how targets would be met

Emission Trading Scheme commenced in 2005 (2003/87/EC, amended 2009/29/EC)

- First Phase (2005-2007)
 - Allowance prices crashed in 2006 due to oversupply as allowances were non-transferable to Second Phase
- Second Phase (2008-2012)
 - Allowance prices fell and remained low as a response to the economic recession driven fall in emissions
 - Norway, Iceland, and Liechtenstein joined the ETS

Combined Heat and Power Directive (2004/8/EC) for promotion of cogeneration took effect in late 2000s

Regulation of pollution continued under the Large Combustion Plant Directive (2001/80/EC) and the IPPC (2008/1/EC)

Recession 2008-2009

Continued increase in electricity demand across EU (EEA 2011)

Energy security increased in political importance in some Member States

Gas given more attention as potential key role in energy future in many Member States due to cheaper fuel and more accessible technologies—e.g., Liquefied Natural Gas (LNG) in late 2000s and a possible shale gas revolution in next decade

Europe a leader in renewable energy development and deployment

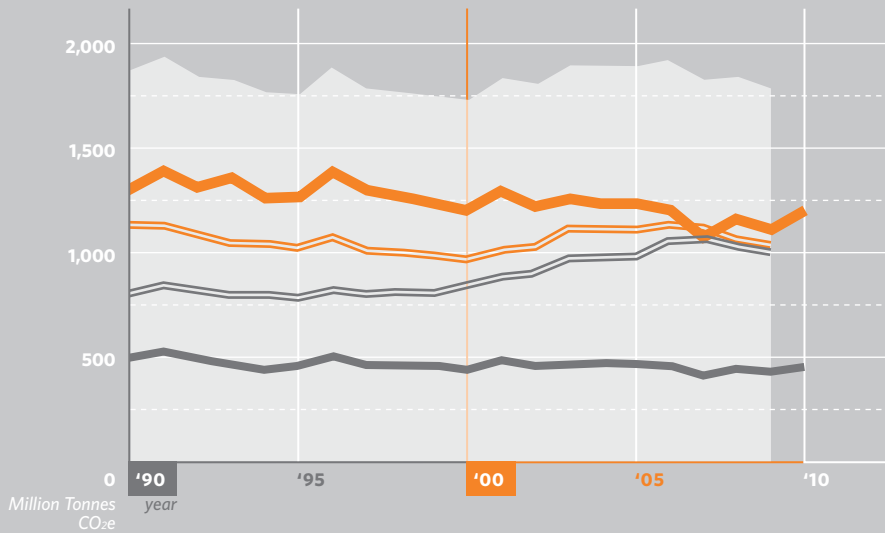
- Wind deployment far exceeded deployment of other technologies due to existing expertise, technology maturity and resource availability
- Rapid price reductions in wind and solar systems

EMISSIONS & OUTPUT

BUILDING EMISSIONS IN THE EU27 (1990-2010)

KEY

NOTES



- Direct - Residential**
- Direct - Tertiary**
- Indirect - Residential**
- Indirect - Tertiary**
- Total**

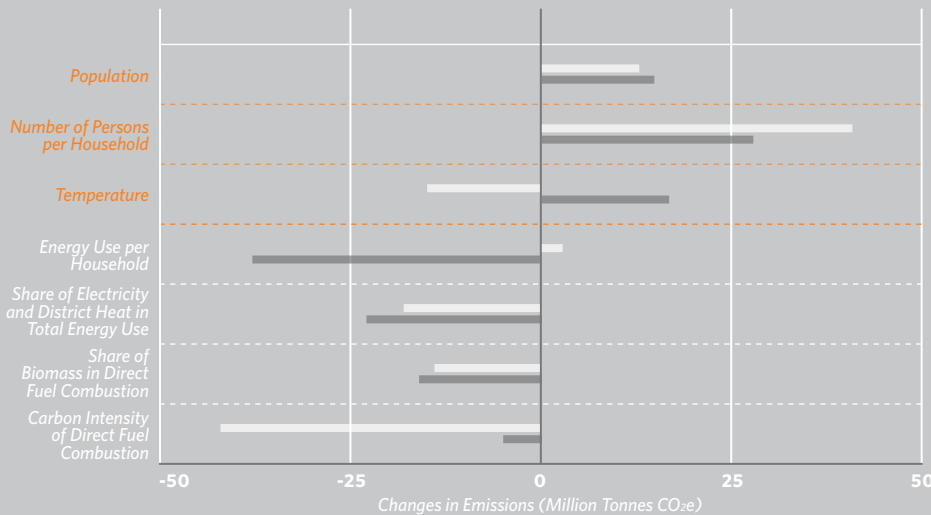
Emissions associated with direct fuel combustion in the buildings sector fell, but were offset by a shift from direct to indirect emissions due to a rise in electricity consumption.

EMISSIONS DRIVERS

IMPACTS OF DRIVERS ON RESIDENTIAL EMISSIONS (1990-2008)

KEY

NOTES



- 1990-2000**
- 2000-2008**

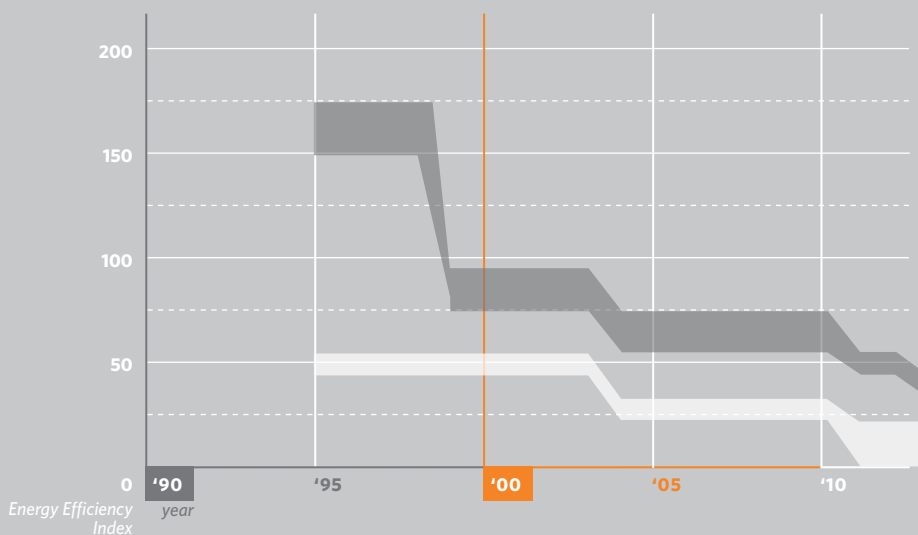
Population increase and smaller households—which led to more buildings and total floorspace—increased residential emissions. However, these factors were more than offset by increases in energy efficiency and renewable energy and a shift to electricity from other fuel sources.

POLICY

EU POLICY TOWARDS HOUSEHOLD REFRIGERATING APPLIANCES IN EU27 (1995-2013)

KEY

NOTES



- Range for Best Label**
- Range for Worst Permissible Label**

The increasing strictness of labeling standards for refrigerators, introduced in 1995 and updated regularly, demonstrated how EU efficiency standards ratcheted up over the last several years. The efficiency of the worst permissible label now exceeds the top category from 1995.



1990–2000

Energy policies emphasized building sector energy efficiency in the 1990s. Europe also harmonized energy efficiency labeling for appliances. Building sector efficiency steadily improved, leading to modest declines in direct greenhouse gas emissions from the sector. However, growing electricity consumption in the sector, partially driven by increasing appliance use, more than offset declining emissions, particularly in commercial buildings.

POLICY

Shift in EU-wide policy targeting buildings in 1990s

- EU-wide climate and energy strategies were introduced, but had limited reach as compared to national policies
- End-use issues became an integral part of energy policies: buildings sector recognized for significant potential for energy efficiency improvement

THERMIE Programme (1989) to support energy innovation

- Supported demonstration projects across EU, including energy efficiency technologies for building sector

SAVE Directive (93/76/EEC)

- Required Member States to introduce a range of policies to encourage energy efficiency in buildings

Boiler Efficiency Directive (92/42/EEC)

- Established minimum efficiency requirements with rated output for water boilers fired by liquid or gaseous fuels

Energy Labeling Directive 92/75/EEC and subsidiary directives established harmonized energy efficiency labeling of household appliances

UNDERLYING CHANGES

Moderate EU-wide population growth and growth in number of households

Steady growth in electricity consumption in buildings sector, especially in commercial and public buildings (ODYSSEE-MURE 2009)

Heating fuels shifted from coal and oil toward lower carbon gas and biomass (EEA 2011)

Improved efficiency of building shells, space heating units, and appliances

IT build-out and increased use of electronics and appliances across commercial and residential buildings

2000–2010

Energy performance standards in building codes and for products and appliances grew in importance in EU policy over the decade. Direct emissions continued to decline, partly offset by climbing electricity demand from appliances and electronics use. Electricity emissions offset direct emissions by the end of the decade, but overall emissions began to decline.

Increasing role of EU-wide policy targeting buildings in 2000s

- A set of EU-wide framework directives introduced to address different segments of building energy consumption
- Trickle-down effect to regional and municipal policy

Energy end-use efficiency and Energy Service Directive (2006/32/EC)

- Required Member States to realize 9% energy savings—largely in buildings and industry—from 2008 to 2016
- Required the Member States to draw up National Energy Efficiency Action Plans on how they meet this target
- Uptick in required implementation of performance standards
- Energy Performance of Buildings Directive (2002/91/EC) required Member States to introduce energy efficiency building codes and energy performance certificates for buildings
- Eco-design Directive (2005/32/EC; 2009/125/EC) required improving environmental performance of energy related products and energy efficiency performance standards for products
- 2000/55/EC set energy efficiency requirements for fluorescent lighting ballasts

Moderate EU-wide population growth and growth in number of households

Continued growth in electricity consumption in building sector, especially in commercial and public buildings (ODYSSEE-MURE 2009)

Efficiency of building shells, space heating units, and appliances continued to improve

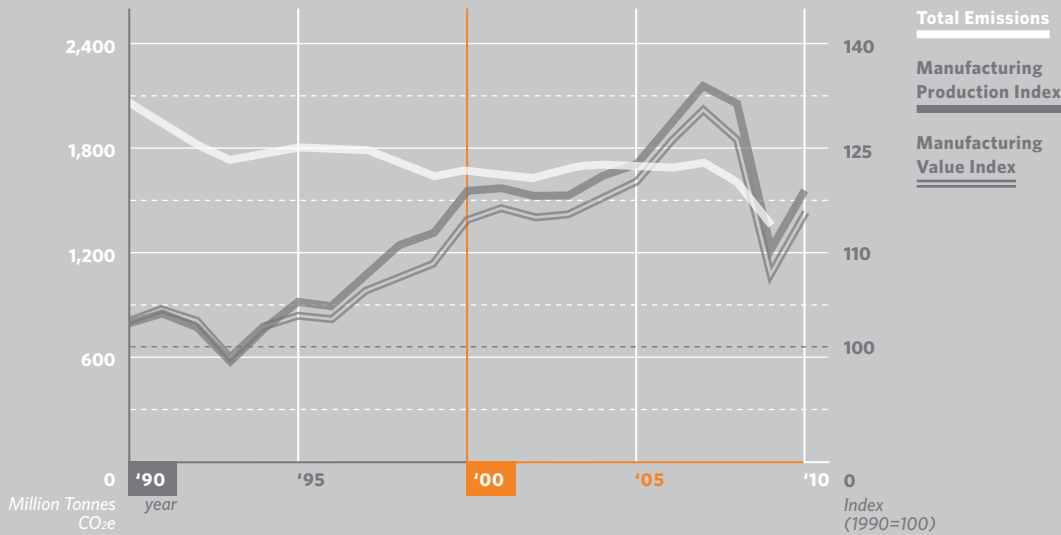
Growing IT-build out and household electronics and appliance uptake

EMISSIONS & OUTPUT

INDUSTRIAL EMISSIONS AND ELECTRICITY CONSUMPTION IN THE EU27 / VALUE-ADDED FROM INDUSTRY (1990-2010)

KEY

NOTES



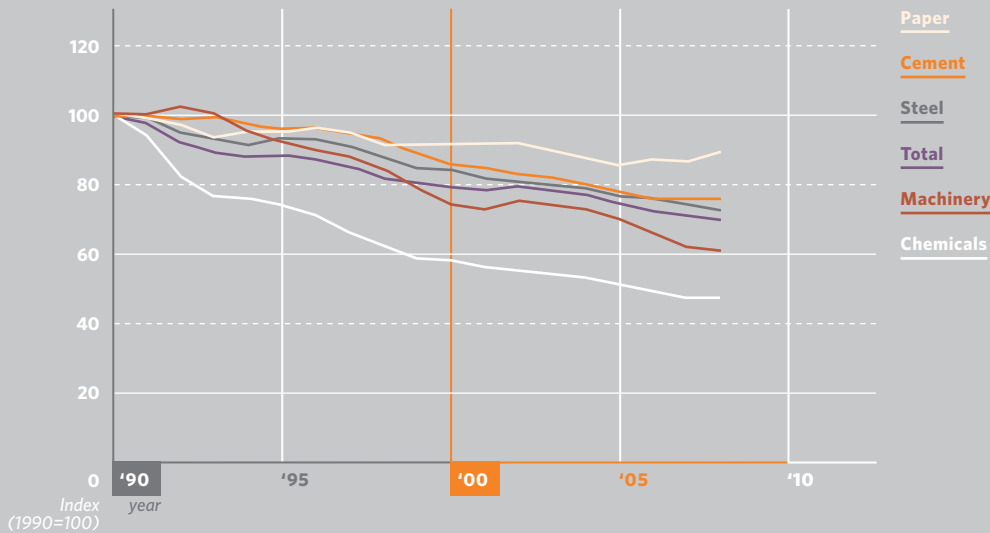
Despite increasing output in the industrial sector (right axis), direct emissions fell, while electricity demand rose as the industrial sector shifted fuel consumption towards a less carbon-intensive fuel mix.

EMISSIONS DRIVERS

ENERGY EFFICIENCY INDEX (ODEX) IN INDUSTRY IN EU27 (1990-2008)

KEY

NOTES



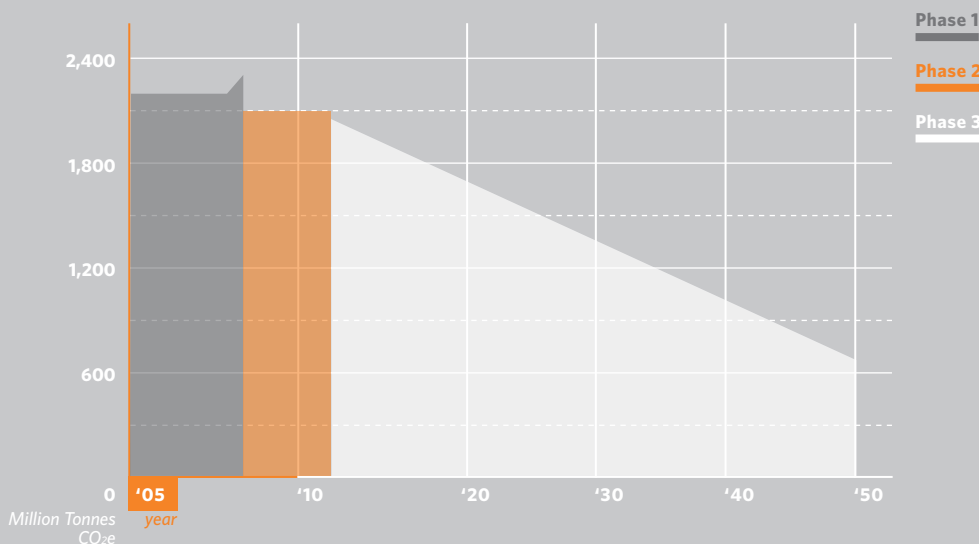
Industrial energy efficiency improved across the board since 1990 (on left). There were no structural changes in industry that affected emissions intensity (chart above).

POLICY

EMISSIONS CAPS UNDER THE EU ETS (2005-2050)

KEY

NOTES



The EU ETS is the world's first significant carbon market, and has been operating since 2005. Roughly 45% of the EU's emissions—including industrial sectors—are covered by the market. In addition, the EU has targeted specific technologies through voluntary agreements and minimum energy performance standards (not shown).



1990-2000

Climate change took a prominent place on the EU political agenda in the 1990s. EU industry saw improved energy efficiency as energy-intensive plants in Eastern Europe closed and the EU passed regulation to limit CO₂ and other pollutants from industrial facilities.

POLICY

Regulation of pollution from industrial facilities increased and instituted

- Large Combustion Plant Directive (88/609/EEC) limits on CO₂, NO_x, and SO_x from large combustion plants
- 1996 Integrated Pollution Prevention and Control (IPPC) Directive (96/61/EC) instituted a comprehensive permitting regime for industrial facilities to cover all types of pollution

UNDERLYING CHANGES

Change in the make-up of European industry in early 1990s:

- Industry saw energy efficiency improvements and a shift to less energy-intensive activities
- Closure of energy-intensive industries in Eastern Europe (EEA 2011)
- Significant growth in gross value added (GVA) of services and products

Low gas prices drove fuel switch from coal to gas in the industry sector (EEA 2011)

2000-2010

Regulatory action on CO₂ and other pollutants from the 1990s was in full swing and further refined while Europe's evolving Emissions Trading System (ETS) commenced mid-decade. Both contended with the economic downturn later in the decade.

Energy Taxation Directive (2003/96/EC) set minimum tax rates for energy products to incentivize energy efficiency

- Member States varied in energy tax rate levels implemented under Directive

Emissions Trading System (ETS) commenced in 2005 (2003/87/EC, amended 2009/29/EC), covering a wide-range of industrial sectors

- First Phase (2005-2007)
 - Allowance prices crashed in 2006 due to oversupply as allowances were non-transferable to Second Phase
- Second Phase (2008-2012)
 - Allowance prices fell and remained low as a response to economic recession driven fall in emissions
 - Norway, Iceland, and Liechtenstein joined the ETS

Regulation of pollution from industrial facilities continued under the Large Combustion Plant Directive (updated by 2001/80/EC) and the IPPC (updated by 2008/1/EC)

Rising share of biomass in industrial power generation

Increased reliance by the manufacturing sector on generation from public electricity power plants (EEA 2011)

Growth of GVA slowed during the decade, particularly from 2003 to 2007

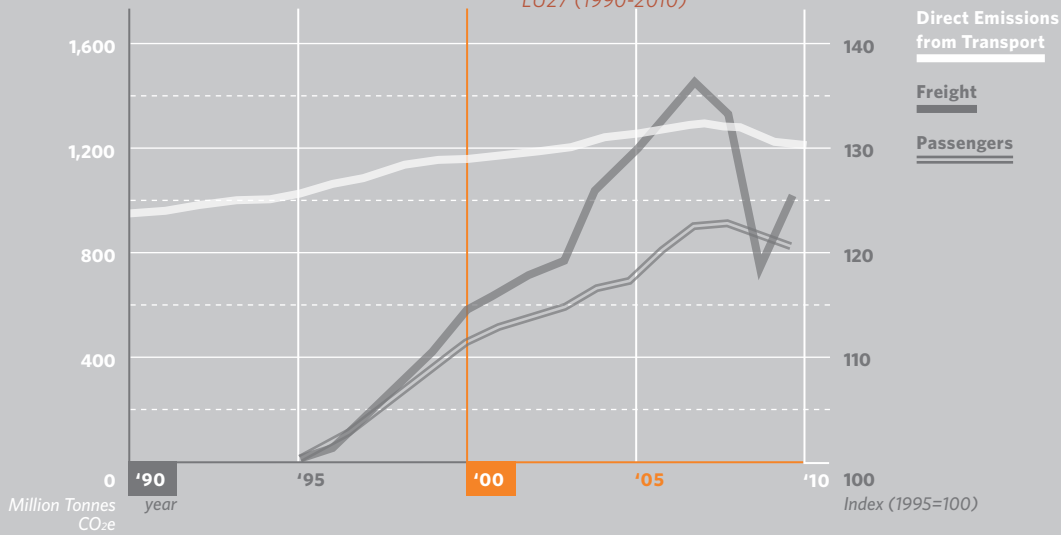
Efficiency continued to improve (EEA 2011)

EMISSIONS & OUTPUT

PASSENGER MILES AND FREIGHT TRANSPORT INDEX (1995-2010) / TRANSPORTATION-RELATED EMISSIONS—EU27 (1990-2010)

KEY

NOTES



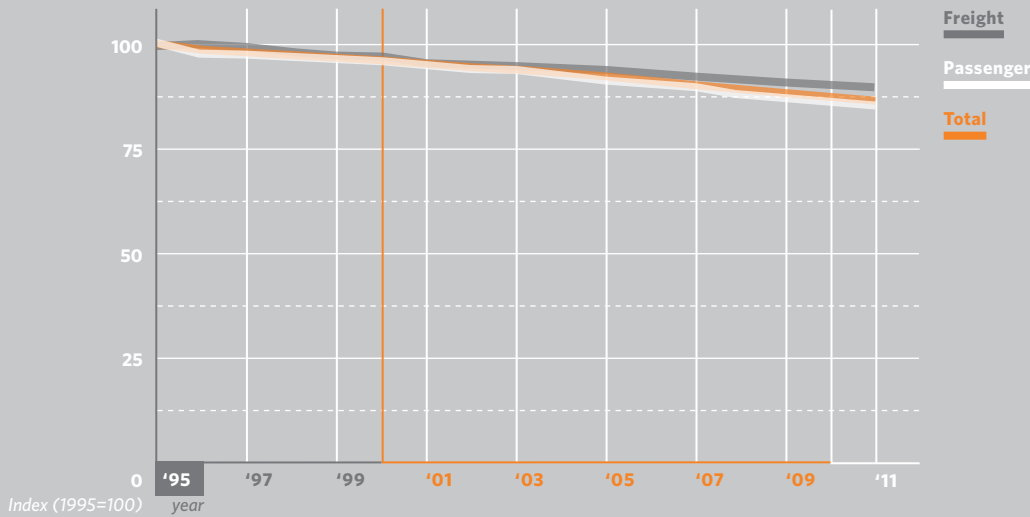
Passenger miles and freight transport rose rapidly before declining as a result of the recession (right axis). Emissions grew slowly but steadily until they peaked in the mid-2000s (left axis).

EMISSIONS DRIVERS

EMISSIONS INTENSITY INDICES—EU27 + NORWAY, SWITZERLAND, AND TURKEY (1995-2011)

KEY

NOTES



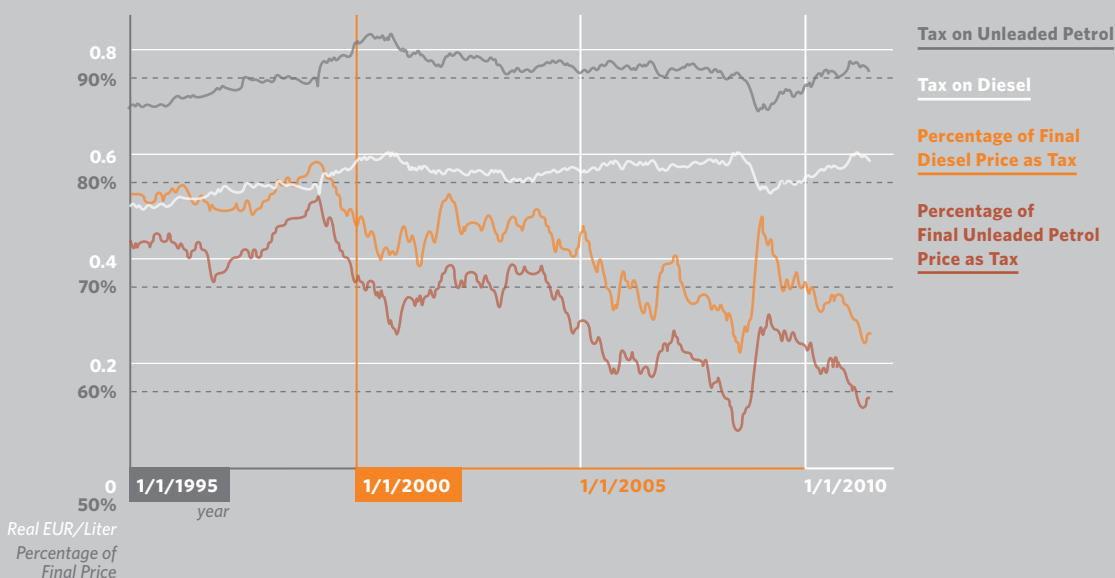
Emissions intensity declined steadily. Passenger transport efficiency improved more than freight transport efficiency. However, within road transport, freight improved three times as much as passenger travel (18% versus 6%) between 1995 and 2010 (not shown).

POLICY

EU15 FUEL TAXES IN EUR/LITER AND AS PERCENT OF TOTAL FUEL PRICE (1995-2012)

KEY

NOTES



Starting from a comparatively high point, real fuel taxes were almost flat since the mid-1990s (white scale on left axis) and steadily declined as a proportion of the final fuel price (grey scale on left axis). Rising oil prices rather than government intervention therefore were the main increase to price signals for more efficient road transport.



1990-2000

High fuel taxes, particularly on petrol, maintained pressure to improve fuel efficiency throughout the 1990s, and began a trend towards increasing the use of diesel in passenger cars. Overall transport demand grew and greenhouse gas emissions from the sector increased over the 1990s. The 1990s laid policy groundwork for lowering vehicle greenhouse gas emissions rates in the next decade.

POLICY

1995 EU strategy to reduce passenger vehicle CO₂ emissions established 3-pillared approach: voluntary commitments, improved consumer information, and fiscal measures (EC 2007)

- EC signed commitments in 1995 with major automobile manufacturer associations to target 140 gCO₂ per km for new vehicle fleets by 2009 (ICCT 2013)

High tax premiums on fuel across EU Member States

- Fuel taxes remained flat after the mid-1990s
- Diesel taxes were lower than petrol taxes

UNDERLYING CHANGES

High fuel prices

Shift towards diesel passenger vehicles from petrol vehicles

Increase in demand across all modes of freight and passenger transport from 1995 onward (EEA 2013a, 2013b)

- Passenger air transport demand rose by 46%
- High-speed rail passenger kilometers traveled steadily grew across decade (EC 2010)
- Freight road, rail, and maritime transport all rose by over 10%

Modal share of freight and passenger transport

- Shares of freight transport modes remained stable
- 4% modal shift from passenger road to passenger air transport

Increased fuel efficiency across passenger (1%) and freight ground (6%) transport (EEA 2011)

Increased private vehicle ownership (EEA 2011)

2000-2010

Transport demand and vehicle efficiency continued to grow across the decade; including a significant shift to diesel in passenger cars. In the late 2000s, all forms of transport, and particularly air travel, fell with the high oil prices and the economic crisis of the late 2000s. The EU mandated increasing biofuel use for transport.

Notable increase in mandatory measures to reduce on-road emissions

- States commenced labeling fuel efficiency and CO₂ emissions on new passenger vehicles (1999/94/EC)

Mandated that biofuels make up 2.5% and 5.75% of transport fuel use by 2005 and 2010, respectively (2003/30/EC)

Minimum taxation levels of energy products and electricity in EU (2003/96/EC)

Railway reform (2001/14/EC, 2004/49/EC and amendments) to improve infrastructure efficiency, but measures were not fully implemented by States

Marco Polo Programme provided financial assistance to shift 12 billion tonne-km of freight off roads to improve freight efficiency. (Regulation (EC) No 1382/2003)

Amended Fuel Quality Directive set greenhouse gas standards for road transport energy for next decade (Directive 2009/30/EC)

Increased oil prices

Continued growth in passenger and transport demand. High speed rail particularly grew

Diesel passenger vehicle share surpassed petrol vehicle share

Modal share of freight and passenger transport

- Shares of freight transport modes remained stable
- Continued decrease in passenger road modal share and increased passenger air transport share
- High-speed rail passenger kilometers continued marked growth across decade (EC 2010)

With economic downturn, air passenger travel stagnated in 2008, fell in 2009, and rebounded in 2010 (Eurostat 2012)

Continued increase in private vehicle ownership (EEA 2011)

Infrastructure investment dominated by road transport while investment share in rail, maritime, and inland waterway infrastructure fell from 2000-2006 (Eurostat 2009)

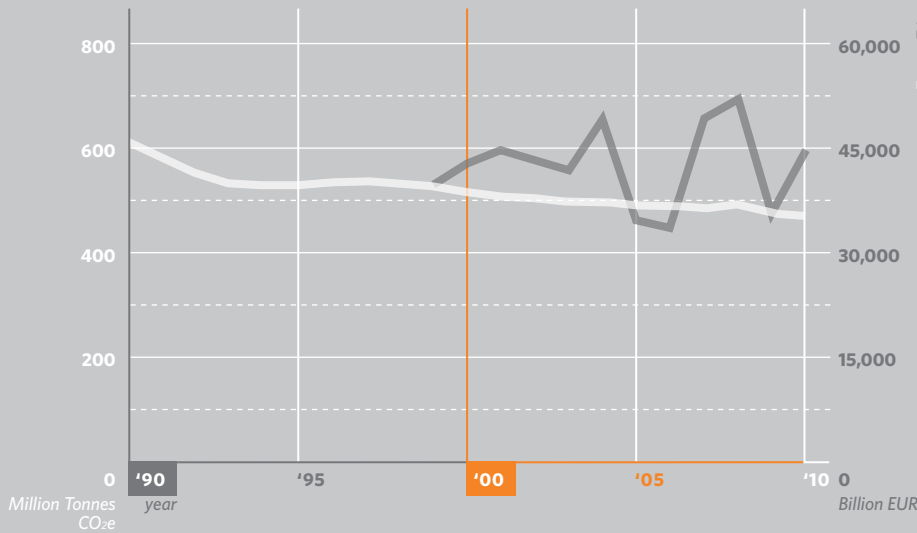
Increased fuel efficiency across passenger (6%) and freight ground (12%) transport (EEA 2011)

EMISSIONS & OUTPUT

AGRICULTURAL EMISSIONS IN THE EU27 (1990-2010)

KEY

NOTES



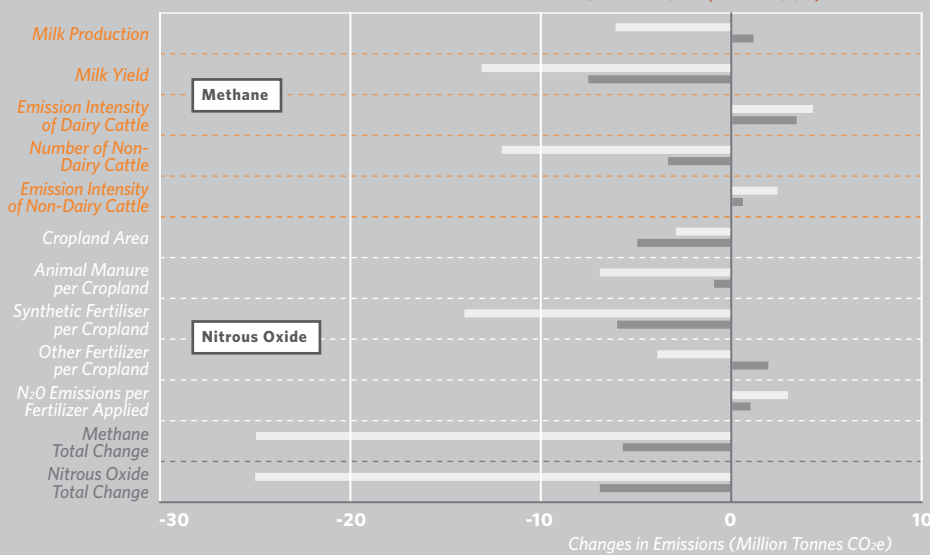
Emissions have declined since 1990, despite a slight increase in agricultural production.

EMISSIONS DRIVERS

CONTRIBUTION OF AGRICULTURAL EMISSIONS DRIVERS TO CHANGES IN AGRICULTURAL GREENHOUSE GAS EMISSIONS IN EU27 (1990-2008)

KEY

NOTES



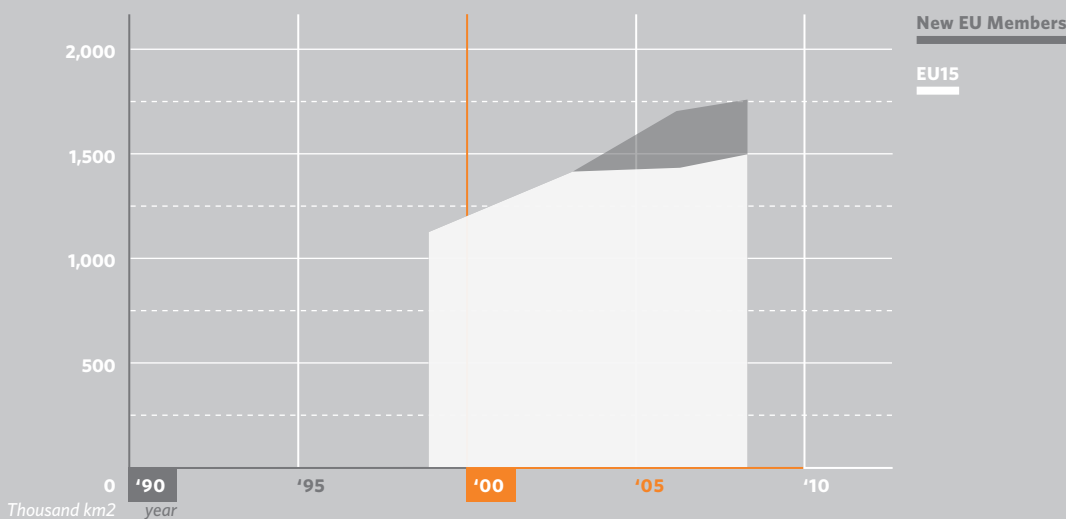
Methane emissions (in orange) from livestock declined as the number of cattle decreased. Nitrous oxide emissions (in white) fell, due to decreases in both cropland area and fertilizer intensity.

POLICY

LAND DESIGNATED AS A NITRATE VULNERABLE ZONE IN THE EU (1999-2008)

KEY

NOTES



Most agricultural policy in Europe was developed for reasons beyond climate protection. Nevertheless, these policies had a very real impact on greenhouse gas emissions. For example, the Nitrates Directive encouraged decreasing levels of nitrate fertilizer application, thus reducing NO_x emissions.



1990–2000

Major agricultural policy reforms cut commodity price supports and required agricultural land set-asides in the 1990s. Agricultural output suffered in Eastern Europe as the region transitioned to the EU. Cropland area and cattle numbers declined steadily over the decade while fertilizer rates dropped and then increased again.

POLICY

1992 Common Agricultural Policy reforms to reduce commodity prices (EEC 1992)

- Shifted emphasis from commodity price support (cut support for cereal by 35% and beef by 15%) to direct support to farmers based on farm production (EC 2012)
- Targeted production capacity reduction
 - Compulsory but compensated set-aside of 15% arable land
 - Environmental and afforestation measures

Designated Nitrate Vulnerable Zones

- Required compulsory programs to limit fertilizer application in Nitrate Vulnerable Zones and establish voluntary good farming practices
- Comprehensive implementation by some Member States

Milk Quota extended through 1990s: a levy was due on excess dairy produce

UNDERLYING CHANGES

Total EU cropland slightly decreased, number of farms decreased, and average farm size increased (EEA 2011, EEC 2011)

Synthetic fertilizer application rate decreased in early 1990s followed by an increase in the late 1990s (EEA 2011)

Significant fall in Eastern European agricultural output (IAMO 2007)

Steady decline in number of cattle (particularly dairy) as dairy productivity showed sustained strong increases

2000–2010

Europe continued agricultural reforms throughout the decade, further cutting price supports, fully decoupling farm support from production, and making support contingent on compliance with environmental requirements. Biofuels were required to be incorporated into the fuel supply. Cropland, cattle numbers, and fertilizer rates all decreased.

Multiple rounds of Common Agricultural Policy reform

- 2000 (EC 1999)
 - Further move to direct support, phasing in price support cuts (cereals by 15%, beef by 20%)
 - Introduced agri-environmental payments
 - Compulsory arable land set-aside revised to 10% (2000-2006)
- 2003 (EC 2003)
 - Single Payment Scheme (SPS): direct income support to farms decoupled from production
 - Cross Compliance: SPS payment contingent on compliance with environmental and animal welfare requirements
 - No significant decrease in pasture land
- 2008 "Health Check" (EC 2008)
 - Further price support decreases
 - Arable land compulsory set-aside repealed

Increasing biofuels policy over decade

- Mandated that biofuels make up 2.5% and 5.75% of transportation fuel use by 2005 and 2010, respectively (2003/30/EC)
- Updated biofuels mandates to require greenhouse gas emissions reductions from biofuels in next decade (2009/28/EC, 2009/30/EC)

Milk Quota extended through 2000—program to end in 2015

2007-2008 global food price crisis—world food prices for several major commodities rose by over 100% from 2006-2008

High oil prices and increased fertilizer costs

Decreasing fertilizer application rates across decade (EEA 2011)

Agricultural output of Eastern European countries recovered at varying levels (IAMO 2007)

Continued steady decline in number of cattle and sustained increases in productivity

THE ROLE OF INVESTORS IN CLIMATE CHANGE POLICY

Often, successful climate policy hinges on attracting investment at reasonable terms; at other times, providing finance may be a specific part of a policy. Similarly, policies designed to require or encourage climate-related activities, including the building of new plants or equipment, can be frustrated by real world financing challenges. With this in mind, CPI dedicates a significant portion of its work to finance, financial institutions, and to understanding what the availability, costs, and risks associated with finance can tell us about policy effectiveness and how public and private interests can be aligned to achieve low-emissions development.

Broadly speaking, finance can come from at least seven very different sources:

1. Households and small enterprises—to meet their own transport, energy, food, or other needs
2. Individual investors—for individuals and small companies to meet their financial goals
3. Institutional investors such as pension funds and insurance companies—to meet future liabilities for pensions, insurance contracts, or others
4. Corporations—as part of their business activities
5. National/subnational governments and national/regional financial institutions—as part of policy activities to manage the national economy
6. Foreign governments and international financial institutions—as part of aid and development activities
7. Banks—in their role as transaction facilitator and market maker as well as for their clients

Each of these investors has very different investment goals, risk tolerances, knowledge levels, and skills. For any given policy, only a subset of these investor classes matters. For example, in utility-scale renewable energy in the U.S., institutions, corporations, banks, and the national and state governments are all important main players, while for rooftop water heating in Tunisia, households and foreign governments combine with national governments and banks. Thus, different policies can attract different investors.

At CPI we assess the needs of different investor groups to understand how they will respond to policy. We evaluate risk-sharing facilities for green investments to identify the role of the public sector in bearing risks private investors are unsuited to take on. We also analyze international climate finance flows and specific investments to provide international financial institutions and governments the knowledge to spend money wisely. Our case studies are selected to understand the roles and objectives of different types of potential investors, and provide lessons on how to align incentives to unlock different sources of capital. We specifically analyze the objectives and constraints facing institutional investors. We also examine the impact of specific policies and financing vehicles on risks and the ability to finance projects and programs, and ultimately, the attractiveness of these investments.

In all, these projects help ensure policies take into account real world investor concerns and that public money is used wisely.



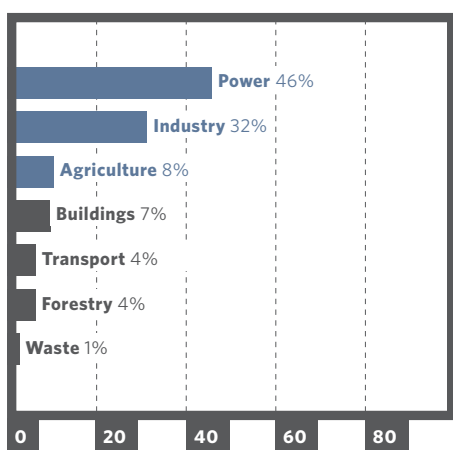
An aerial photograph of a busy street in India, featuring a large crowd of people and vehicles. In the background, a prominent mosque with multiple domes and minarets is visible. The entire scene is overlaid with a decorative white circular frame that has a scalloped, scalloped edge. The word "INDIA" is centered within this frame in a bold, white, sans-serif font.

INDIA



NDIA

BALANCING CLIMATE POLICY AND DEVELOPMENT



Percentage of Greenhouse Gas Mitigation Potential

In many ways, among the regions covered in this review, India has both the most to lose and the least to lose from climate change. Models of greenhouse gas related temperature and climate change forecast a disproportionately large long-term impact on the Indian subcontinent with droughts, floods, and desertification. But with 57% of the Indian population living on less than \$2 a day, present concerns, such as finding tomorrow's meal, take precedence over avoiding floods 30 years hence. Faced with immediate development needs, there is little domestic political pressure in India to curb the country's growing emissions.

Yet in 2012 India was the world's fourth-largest market for new wind power projects, it has ambitious solar energy targets, and it has significant government programs focused on energy efficiency (Global Wind Energy Council 2012). Renewable energy, energy efficiency, and land use policies have been about improving energy security, reducing energy imports, improving the nation's balance of payments, creating new and profitable industries, and providing affordable energy and food to the poor. These are development objectives, and they are not about how much there is to lose or how to protect what India has, but about what there is to gain, and how to grow and keep growing. Thus, even while India pursues renewable energy and energy efficiency, it also pursues the largest build-out of coal-fired power plants, coal mining, and related infrastructure anywhere outside of China.

India's climate policy challenge—and one shared by the other rapidly developing countries in our study—is to ensure that it can realize the full long-term economic benefits of low-carbon development, without sacrificing short-term growth. Further, the challenge is to ensure that institutional and technological development in India, along with technology transfer, foreign aid, and investment from outside India, can continue to reduce the costs and increase the benefits of low-carbon development. India holds great potential for low-cost emissions reductions, and capturing these emissions reductions could be cost-effective both within India and at a global scale.

This is not an easy challenge. India is a complex place, with different cultures, languages, and resources spread across an area the size of Western Europe with the world's largest democracy. The policy challenge is con-

founded by the state of the Indian economy and the immature financial markets in India, by differences between the Indian states, by the democratic imperative to develop policy that is fair to all, while limiting opportunities for corruption. All of these challenges exist in a country that is eager to learn from international experience and technology and eager to accept foreign investment, even as a colonial legacy makes the country wary of undue outside influence.

RISING EMISSIONS FROM GROWING POWER, INDUSTRY, AND AGRICULTURE SECTORS

The key sectors driving emissions in India are power, industry, and agriculture. Both emissions and power generation have increased dramatically, more than doubling in 15 years (see Emissions & Output, page 60). India's economy is very energy intensive, and coal accounts for 42% of consumption (EIA 2011). While the vast majority of the increase in power demand has been met through coal and natural gas generation, recently wind generation has increased significantly (see Emissions Drivers, page 60). And demand for power will continue to increase, as some 40% of Indians, mostly in rural areas, do not have access to electricity.

In the industrial sector, productivity gains have outpaced emissions growth: Since the early 1990s, industrial productivity has tripled, but emissions have gone up only about 60% (see Emissions & Output, page 62). Agricultural emissions have increased, driven mainly by an increase in fertilizer use (see Emissions Drivers, page 64).

MANY CLIMATE POLICIES, SERVING VARIED GOALS

Struggling with short-term development concerns, a budget deficit, a trade deficit, and current account balance woes, India places priority on economic development. In many ways, India has been successful in this struggle, with growth averaging over 7% over the last decade (World Bank Group 2012). Energy security is a paramount concern due to India's reliance on imported energy sources and increasing demand for energy, and interest in renewable energy is driven by the idea that India could substitute a domestic energy

source for imported coal and oil. By relying more on renewable sources, India could channel funds toward domestic capital investment rather than importing fuel.

In this context, most major, national Indian policies related to climate have been developed relatively recently to address energy demand and energy security issues.

In response to major inefficiencies and rising demand, major reform of the electricity sector began in the early 2000s with feed-in tariffs, tax incentives, and especially the Electricity Act of 2003, which sought to update the state electricity boards by increasing private sector participation and to reduce transmission losses. It also empowered state electricity regulators to establish policies and rules for the development of renewable energy.

In 2008, India's National Action Policy on Climate Change set a target of producing 15% of the country's electricity with renewable energy sources by 2020. As of 2012, state renewable energy purchase obligations average a little more than 5% (see Policy, page 60).

In 2010, India launched the Jawaharlal Nehru National Solar Mission, which aims for 4,000-10,000 MW of grid-connected solar PV by 2017 and 20,000 MW by 2022. However, the 2017 and 2020 targets may be difficult to achieve under current policies, programs, and limited financing options. India also aims to install 31 GW of wind power by 2017, up from 16 GW in 2011, but wind faces similarly daunting policy and financing problems.

A desire to improve industrial energy efficiency has spawned another new policy. Launched in 2012, the Perform, Achieve and Trade scheme assigns mandatory energy efficiency targets for 478 energy-intensive enterprises across eight sectors that account for around 80% of India's industrial energy use (British High Commission New Delhi 2012). The initial target is modest: a 4% improvement in energy efficiency over the first three years, the equivalent of saving 6.7 million tonnes of oil. Enterprises that exceed their targets earn credits, which can then be traded with enterprises that fail to reach the target. The idea is that enterprises with lowest cost energy efficiency options will have the incentives to maximize their potential, lowering the

cost of energy efficiency to the industrial sector as a whole. Because the Perform, Achieve and Trade scheme is so new, its potential effect will not be felt for a couple of years.

India is also making a concerted effort to drive innovation, and both technology transfer and domestic innovation will also continue to be part of the Indian climate policy picture.

Meanwhile, government subsidies and loans to agriculture have increased steadily, many of them encouraging increased mechanization and fertilizer use. While mechanization and fertilizer use have increased emissions from the sector (see Emissions Drivers, page 64), India manages to feed a growing population without deforestation thanks to improvements in agricultural productivity; indeed, forested land is slowly increasing. More analysis is needed, but it is unclear whether the increase in agricultural productivity has led to increased emissions when its impact on land-use change is considered.

Ultimately, however, climate policy in India is driven by development goals, not climate change, even though India is one of the top at-risk countries for climate change impact. Indian policymakers believe that fostering renewable energy and energy efficiency will improve India's energy security by lowering its reliance on imported oil and coal, while simultaneously developing a renewable energy industry that could diversify India's economy. So, although agriculture and forestry are important emissions sources in India, there is little policy focus on these sectors.

FACING INDIA'S MANY POLICY CHALLENGES

Low-carbon development in India faces four major challenges. First, the particulars of the Indian economy and financial markets change the way policy will act—and could make low-carbon investment more difficult. Second, major differences between states require that Indian policymakers tailor policies to the state level. Third, there are overarching policy priorities that will guide the design of low-carbon growth policies. These include fundamental principles of fairness, as well as concerns about corruption. Finally, India balances its openness to foreign investment with the desire to avoid excessive foreign influence.

ECONOMIC FUNDAMENTALS

If policies are to succeed, they must get the economics right. In India, the barriers to low-carbon development, and more specifically, renewable energy deployment, have more to do with the fundamental issues in the country's economy than with the specifics of support policies. India's rapid growth and deficits have contributed to high inflation, and with it, high interest rates. High interest rates make infrastructure more expensive and distort the impact of policy. Policy tools that effectively promote renewable energy in other countries are less effective in India, because the high cost of debt restricts the ability of project developers and investors to respond to policy signals (CPI forthcoming).

Renewable energy is more capital-intensive than fossil fueled electricity generation, so it is disproportionately harmed by high interest rates. A joint CPI-Indian Business School analysis found that high interest rates and relatively short-term loans for renewable energy projects in India add 24–32% to the cost of renewable energy in India compared to similar projects in the U.S. and Europe. This high cost of finance trumps other challenges faced by renewable energy in India (CPI 2012d). For example, the high cost of financing solar projects overwhelms India's natural cost advantage due to low-cost labor.

One factor limiting investment in renewable energy—and in energy infrastructure more broadly—is the poor financial condition of many of India's state-owned utilities, the state electricity boards. Most renewable energy developers sign power purchase agreements to sell power to the state electricity boards, making them important parties in the renewable energy market. But many state electricity boards are in poor financial shape; they do not charge enough to cover their costs of operation and are sliding into bankruptcy. As a result, renewable energy developers are unwilling to sign contracts with them.

The state electricity boards' financial woes create inefficiencies for renewable energy policies. For example, although Tamil Nadu has the highest wind energy capacity in India, banks are unwilling to lend to new wind projects in Tamil Nadu due to the poor financial health of its state electricity boards.

DIFFERENCES BETWEEN STATES

To ensure that policies account for regional differences and interests—and more fully represent the needs of India's diverse population—Indians devolve much policy from the national to state level. This means that policy must be designed to reflect differences among Indian states in terms of infrastructure, available resources, business environment, and other factors.

India is rich in renewable energy resources, but this wealth is not spread evenly across states. There are big differences in the extent of existing power infrastructure, such as transmission lines that allow renewable energy projects to connect to the grid. And the business environment—including the ease or difficulty of managing bureaucratic processes, as well as problems with corruption—also differs widely from state to state.

Existing renewable energy investments have been concentrated in a handful of states perceived to have a good business environment for foreign investors, such as Gujarat. Moving forward, India's challenge is to spread that investment more evenly across states, and to get renewable energy investment where the greatest renewable energy resources are.

In 2011, India introduced a national system of tradable Renewable Energy Credits, a market-based policy that was intended to provide a more efficient, equitable way for states to meet renewable energy purchasing targets. Renewable Energy Credits were meant to tie together disparate state programs to allow for trade across states, allowing all states to benefit from the country's renewable energy resources and allowing a flexible path to meet renewable energy targets. However, CPI analysis indicates that participation in the Renewable Energy Credit market is very low, for a few reasons (CPI 2012b). In order for the Renewable Energy Credit market to function, states need to set strong renewable purchase obligations and enforce those obligations, but that hasn't happened yet. Furthermore, the Renewable Energy Credits have one-year pricing, which is too short term to persuade investors to take a risk on long-term capital investment in renewable energy projects.

KEEPING POLICY FAIR AND CLEAN

Issues of equity and governance are foremost concerns for policymakers in the world's largest democracy. There is a strong focus on creating equality of opportunity and fairness across disparate states to improve the lives of India's vast number of people living in poverty. This means that low-carbon development must include energy access for the 40% of Indians who lack electricity.

India's population thus requires a mix of policies targeting both large and small actors. While large-scale investment in renewable energy and other infrastructure can meet some of India's growing energy demand, there is a large percentage of the population that will not be reached through large actors such as utilities. Meeting their needs requires low-carbon development on a household scale, including measures such as off-grid electricity generation and clean-burning cookstoves.

Additionally, Indians' deep cynicism about government corruption and ineffectiveness drives their desire to use market-based mechanisms to solve policy problems. Based on the country's past struggles with corruption, many fear that giving administrative control to government agencies will only result in crony capitalism, with money filling the pockets of those with connections to the administrators.

This fear of instilling too much power in the bureaucracy influences the range of available policy options. For example, the role of development banks has been severely constricted by rules that were intended to improve India's finances in general. As a result, India's development banks are not able to offer concessional loans for renewable energy projects.

FOREIGN INVESTMENT AND PRESSURES

India is eager to attract foreign aid and investment but, given its colonial history, is wary of allowing too much foreign influence. It seeks to strike a balance, creating attractive opportunities for foreigners to invest while protecting its population from being exploited.

India's experience with the Dabhol power plant more than a decade ago looms large for both Indian policymakers and foreign investors. During the early 1990s, the Maharashtra

“CLIMATE POLICY IN INDIA IS DRIVEN BY DEVELOPMENT GOALS, NOT CLIMATE CHANGE, EVEN THOUGH INDIA IS ONE OF THE TOP AT-RISK COUNTRIES FOR CLIMATE CHANGE IMPACT.”

State Electricity Board signed a long-term power purchase agreement with the Enron Corporation to buy power from a gas-fired power plant Enron was constructing. Once the plant began operating, the electricity prices charged to the SEB were so high that it decided to stop purchasing power, terminating its agreement with Enron rather than absorbing the high costs or passing them on to consumers. Enron shut down the plant in 2001, claiming over \$1 billion in losses. This experience has left foreign investors wary of investing in India and has left Indian policymakers wary about being exploited by foreign companies.

In order to support its domestic industry, India has instituted local content requirements for some solar PV projects, angering foreign solar manufacturers. India wants to create new businesses and is wary of low-cost imports undermining domestic industry, which would exacerbate the balance-of-payments problems that renewable energy is meant to alleviate. But there is also a domestic cost to the local content requirements—particularly if the Indian businesses forced to buy local content end up paying more than they would otherwise.

The connection between foreign aid and India’s focus on development, however, holds potential for energy and climate policy gains. Much of the enormous amount of foreign aid poured into India annually is related to development. To the extent that energy is a very important component of development in India, it can be a very important part of combating climate change. For example, the Indian government’s decision to allow direct investment from abroad has brought in significant capital to improve industrial operations with better technology.

LOOKING FORWARD

India does not yet have a clear path to a low-carbon economy, but there are many opportunities for climate-friendly policies and programs. In the future, India must develop a clearer vision to evolve low-carbon development over the next 40 to 50 years. India could look to Brazil—another region with a high growth rate, development needs, and population pressures—for further policy ideas.

MEETING GROWING DEMAND

The overarching policy challenge for India is to continue to meet its population’s growing demands for energy and food in a sustainable way. Rapid economic development will continue to be the top priority for India’s policymakers. Along with development comes the need for more energy, and for improvements in agricultural productivity. India’s task is to achieve rapid growth that is also low-carbon—reducing its dependence on foreign energy sources and investing in domestic infrastructure.

LOOKING FOR LESSONS IN THE RIGHT PLACES

At times, India has adopted climate policies from developed countries that have not worked well in the Indian context. The effectiveness of many Western policies depends on having robust capital markets and readily available debt, with low transaction costs. These are not necessarily present in India.

India is experimenting with many policy and technology options; with both, the challenge is to identify what will work in India. ■

Rather than look to Europe or the U.S. for policy inspiration, India may need to look to other growing economies that face similar financial and policy constraints. In particular, Brazil has successfully used its development bank to drive renewable energy investment by providing low-cost loans; India could learn from this model. The challenge for India is to learn from successful policy experience elsewhere while ensuring that its policies are adapted to fit its own economic and policy

FITTING ADAPTATION INTO CLIMATE POLICY

Mitigating the causes of anthropogenic climate change, and helping humans and the world adapt to the effects of climate change as they occur, are the two important thrusts of climate change policy. In this review, and in most of CPI's work so far, we focus on the first of these challenges. We focus on mitigation because in some ways it is the more immediate challenge. The more, and the earlier, we can mitigate the causes of climate change, the less we will be required to adapt.

On the other hand, much adaptation policy and investment is already underway as we build infrastructure to protect against storms and floods or as we adapt to changing patterns of rainfall, droughts, and heat waves. Yet from a climate policy perspective, the key is that these challenges are wrapped up in the broader tasks of planning and policy in infrastructure, agriculture, water, health, and other areas. In fact, humanity has been adapting to different climates for thousands of years, so the challenges of building and paying for the related infrastructure, while immense, are not necessarily new.

The one area where climate change adaption may stand out from traditional infrastructure development is the scale of the challenge and the fact that it may be happening everywhere around the world, simultaneously. Thus, the key differences are likely to be the scale of funding required and directing funds to all the corners of the world. In our climate finance work, we pay attention to the separate paths of climate adaptation funding and the implications for overall policy. However, even here, we note that adaptation funding is a component of, and therefore difficult to separate out from, funding for general infrastructure, population expansion, commerce, health, or development.

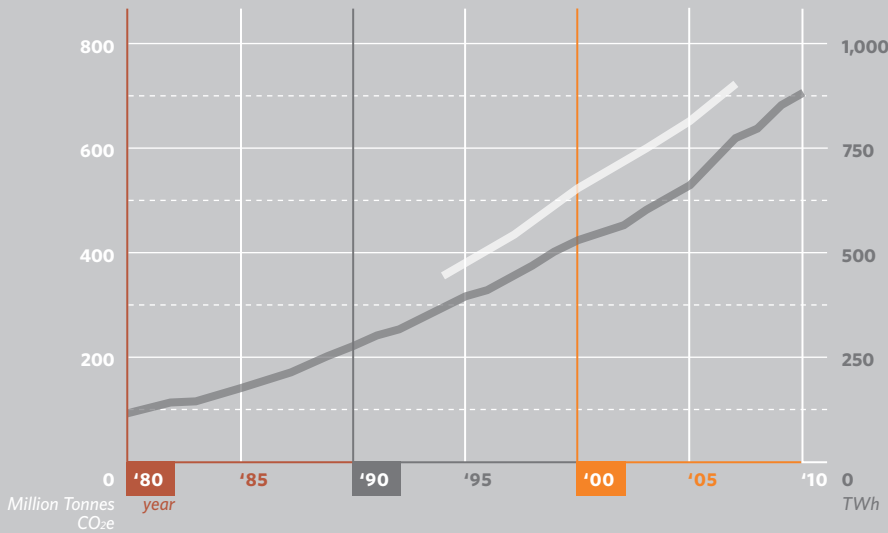
Finally there may be many cases in which the same policies and actions will concurrently reduce emissions (mitigation) and reduce vulnerabilities (adaptation). This is particularly true of policies that improve efficiency and increase productivity in sectors which natural resources are intensive inputs. For example, a well-structured shift into high productivity agriculture can simultaneously reduce deforestation, decrease the intensity of water use per food calorie yield, and improve cropping flexibility in the face of declining and more volatile patterns of rainfall.

EMISSIONS & OUTPUT

GREENHOUSE GAS EMISSIONS AND GENERATION (1980-2010)

KEY

NOTES



Emissions
Generation

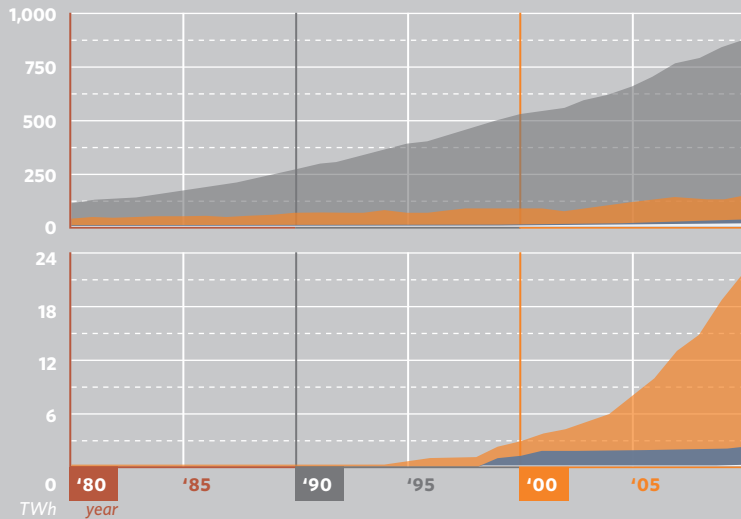
Emissions (in white on left axis) largely tracked the growth in electricity generation (gray on right hand scale).

EMISSIONS DRIVERS

FUEL SOURCES FOR POWER GENERATION (1981-2010) / LOW CARBON FUEL SOURCES (1992-2010)

KEY

NOTES



TOP
Conventional Thermal
Hydro
Nuclear
Non-Hydro Renewables

BOTTOM
Wind
Biomass and Waste
Solar and Other Renewables

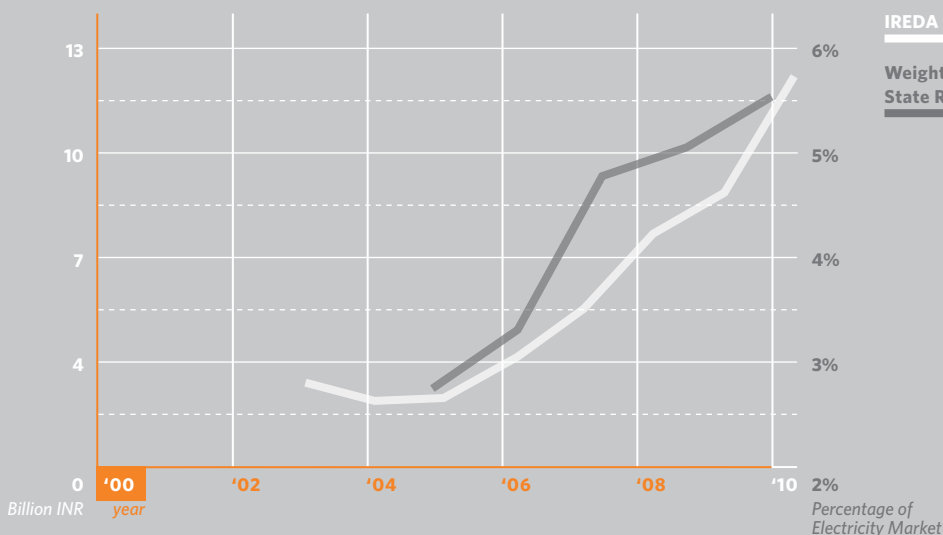
Most new generation came from conventional sources (particularly coal) (top chart), although the past decade saw exponential growth in renewable energy generation (bottom chart).

POLICY

IREDA LOAN DISTRIBUTIONS (2003-2011) / WEIGHTED AVERAGE OF STATE RENEWABLE TARGETS (2005-2010)

KEY

NOTES



IREDA Loan Distributions
Weighted Average Of State Renewable Targets

Renewable energy growth was supported by increased loan distributions by the central government, including the Indian Renewable Energy Development Agency (IREDA) (in white on left axis). Meanwhile, the central government required that each state set renewable purchase obligations that require renewable energy in the mix of electricity generation in each state. The average of these targets reached 5.5% by 2010 (right axis).



1980–1990

Prior to 1990, fundamental level policies aimed to improve the functioning of the electricity sector. However, high state control continued.

POLICY

Indian Electricity Act, 1910

- Established rules on supply and use of electricity
- Established rights and obligations of licensees

Electricity Supply Act, 1948

- Uniform national power policy for rationalization of production and supply of electricity
- National grid infrastructure envisioned
- Established State Electricity Boards

1990–2000

Government policy focused on improvement in governance and regulation of the electricity sector. Policies also aimed to increase captive power generation.

The Electricity Regulatory Commissions Act established Central Electricity Regulatory Commission and State Electricity Commissions, 1998

- Commissions determined tariffs for generation and transmission
- Aimed to improve State Electricity Board health
- Central Electricity Regulatory Commission was responsible for regulation of inter-state sale of power

Accelerated depreciation benefits for renewable energy and for energy efficiency was introduced

2000–2010

The 2000s marked the beginning of major reforms in the electricity sector due to inefficiencies in existing systems and rising demand.

Energy Conservation Act of 2001 mandated a number of energy efficiency provisions for certain energy-intensive industries (including the power industry)

The Electricity Act of 2003 transformed the electricity sector

- Increased private sector participation in generation by allowing independent power producers and captive generation
- Promoted competition among generating companies by allowing open access in transmission
- Reduced transmission and distribution losses
- Yearly revision of end-user tariffs linked to power purchase prices and inflation indices

Feed-in tariffs and premiums for renewable energy introduced, 2000

Various tax incentives for power sector projects introduced (Government Notification No. 21/2002)

Generation Based Incentive (GBI), 2008–2009

Gujarat solar power policy, 2009

- Only state solar power policy with fixed feed-in tariff
- Did not use reverse bidding process for tariff determination

Clean Development Mechanism project approvals in India commenced in 2005

Jawaharlal Nehru National Solar Mission (JNNSM) policy framework introduced in 2010 to achieve 20GW solar power installed capacity by 2022

UNDERLYING CHANGES

Government of India established PowerGrid Corporation in 1989 to build a national power grid (based on recommendations from Rajadhyaksha Committee report on power sector reforms)

Population increased by almost 25% by end of decade (IMF 2011)

GDP grew nearly 94% (from USD 150.86 billion in 1980 to USD 292.92 billion in 1990) (World Bank 2012)

By the 1990s, the majority of states had State Electricity Regulatory Commissions to oversee tariff revisions

Wind energy took off, attracting substantial equity investments

Population grew from 843.25 million in 1990 to 1,024.25 million by 2000—approximately 20% increase (IMF2011)

Primary energy consumption increased by 64% over the decade (BP 2012)

Private sector participation in power generation projects increased

Solar power industry started witnessing growth at end of decade

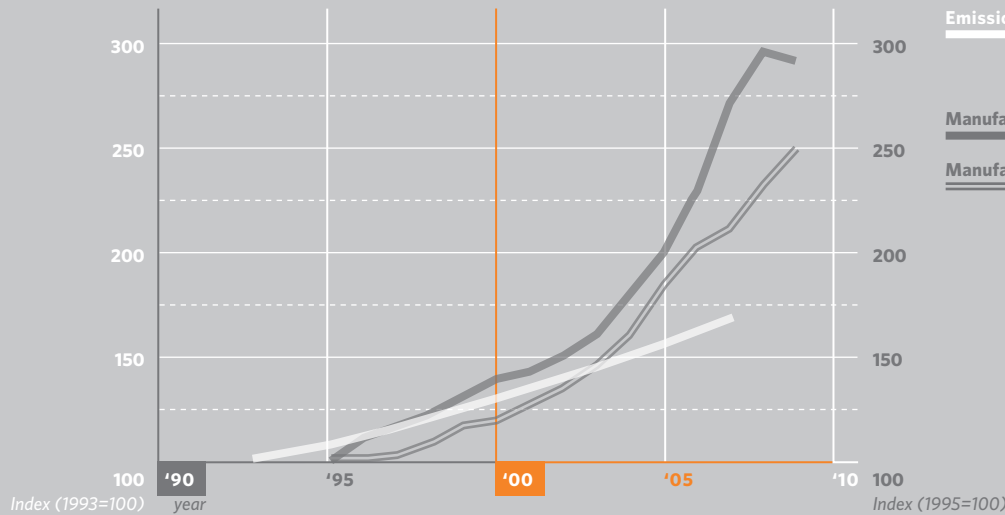
Primary energy consumption increased by 76% over the decade (BP 2012)

EMISSIONS & OUTPUT

GREENHOUSE GAS EMISSIONS AND PRODUCTION (1993-2007)

KEY

NOTES



Emissions Index

Manufacturing Production

Manufacturing Value Add

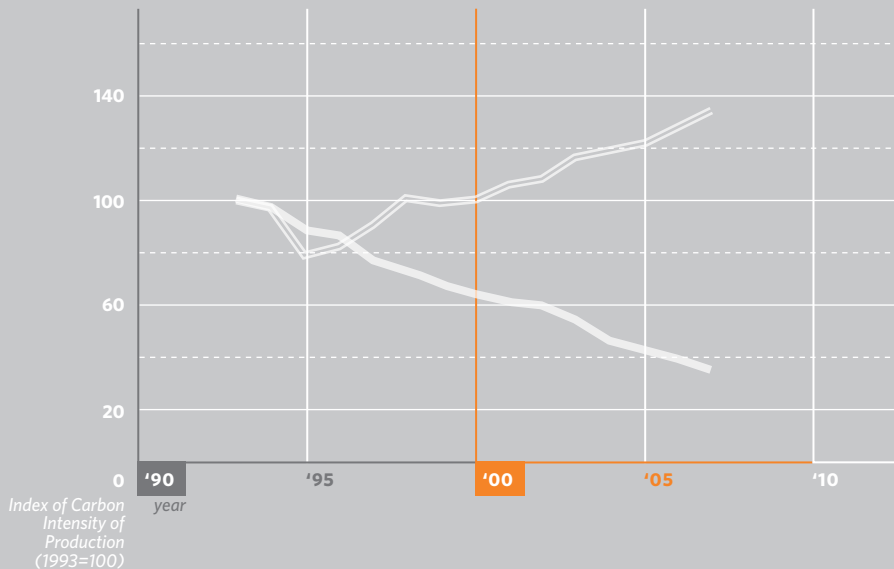
Manufacturing output nearly tripled in India since 1995 (left axis). Emissions also rose, but not as rapidly (right axis).

EMISSIONS DRIVERS

SECTORAL INTENSITY CHANGES (1993-2007)

KEY

NOTES



Iron and Steel

Chemical

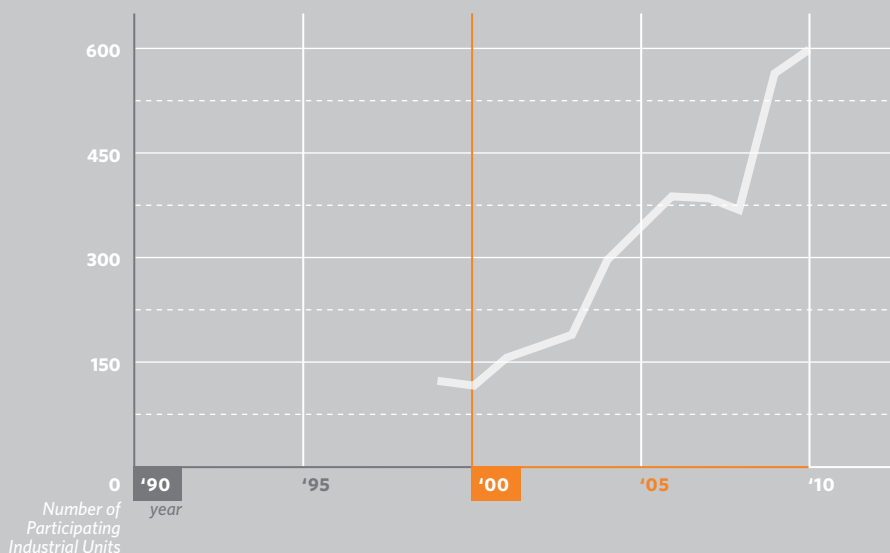
Indian industry largely improved in efficiency, although performance at a sectoral level was mixed. The steel industry emissions intensity increased due to an increase in primary steel production versus scrap.

POLICY

NATIONAL ENERGY CONSERVATION AWARD SCHEME (1999-2010)

KEY

NOTES



Participation in Award Scheme

Indian policy towards industrial energy efficiency effectively began in the 2000s, which saw the creation of a number of programs targeting high-visibility energy efficiency programs, the largest of which, the National Conservation Award Scheme, has seen increasing participation over the last decade.



1980-1990

Policies prior to 1990 focused on improving the functioning of public sector undertakings and (in general) aimed to improve technology and productivity.

POLICY

Policy prior to 1980 aimed to facilitate establishment of basic industries and building core infrastructure

Industrial Policy of 1980 aimed to promote domestic competition, technological advancement, and modernization of industries

- Measures also taken to improve efficiency of public sector undertakings

The Seventh Plan (1985-1990) focused on technical and talent improvement measures to improve productivity, quality, and reduce cost of production

- Public sector was freed from a number of regulatory constraints and was given greater autonomy

Air Act of 1981 established Central and State Pollution Control Boards for data collection and enforcement (Greenstone 2011)

Environment Protection Act, 1986

- Centralized environmental control
- Gave Ministry of Environment and Forests power to close firms violating pollution regulations (Reich 1992)

UNDERLYING CHANGES

Industries advanced technologically and increased scale of operations (e.g., automotive, cement, cotton spinning, food processing, and yarn industries)

Development of lesser developed areas commenced under Growth Centre Scheme (1988), driving building of critical infrastructure

Bhopal Disaster of 1984 prompted new attention to environmental protection (Greenstone 2011)

GDP grew nearly 94% (from USD 150.86 billion in 1980 to USD 292.92 billion in 1990) (World Bank 2012)

1990-2000

India took on major industrial reforms in 1991 as the country faced an unprecedented balance of payments crisis.

New Industrial Policy, 1991

- Removed licensing requirements for the majority of industries, with only 15 industries requiring compulsory licensing post-April 1993
- Foreign investment permitted up to 51% in high priority sectors (e.g., software, electrical equipment, hotel and tourism)
- Reduced number of industries exclusively reserved for public sector from 17 to 8 sectors

Foreign Direct Investment (FDI) increased from INR 10.9 billion in 1992 to INR 107.3 billion by 2000 (Ministry of Commerce & Industry 2013)

GDP increased by 54% from USD 292.92 billion in 1990 to 450.48 billion in 2000 (World Bank 2012)

Consumption of finished steel increased from 14.84 million tonnes in 1991-92 to 27.65 million tonnes by 2000-01 (Ministry of Steel 2012)

2000-2010

The Indian economy continued to liberalize as benefits of the 1991 reforms started accruing.

Continued economic liberalization

- By start of next decade, only six industries required licensing
- Only three industries reserved for the state sector as of 2012
- Various policy measures increased private participation in key infrastructure sectors (e.g., telecommunication, roads, ports) (Jadhav 2005)
 - 100% foreign equity participation permitted in construction and maintenance of roads and bridges
- FDI limits raised to 74% for private banking and 100% for oil exploration, petroleum product marketing, petroleum product pipelines, natural gas and LNG pipelines, and periodic publications in 2004

GDP increased by over 200% over the decade from USD 450.48 billion in 2000 to 1,380.64 billion in 2010 (World Bank 2012)

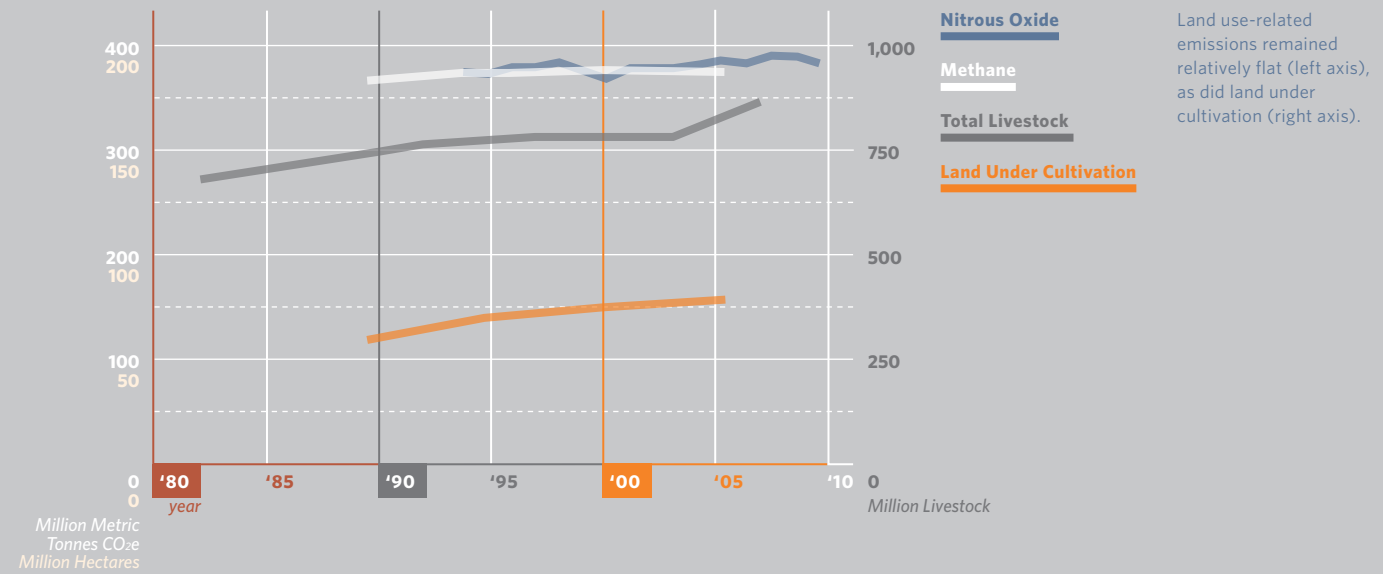
Consumption of finished steel increased from 27.65 million tonnes in 2000-01 to 66.42 million tonnes by 2010-11 (Ministry of Steel 2012)

EMISSIONS & OUTPUT

EMISSIONS AND LAND USE (1989-2008)

KEY

NOTES

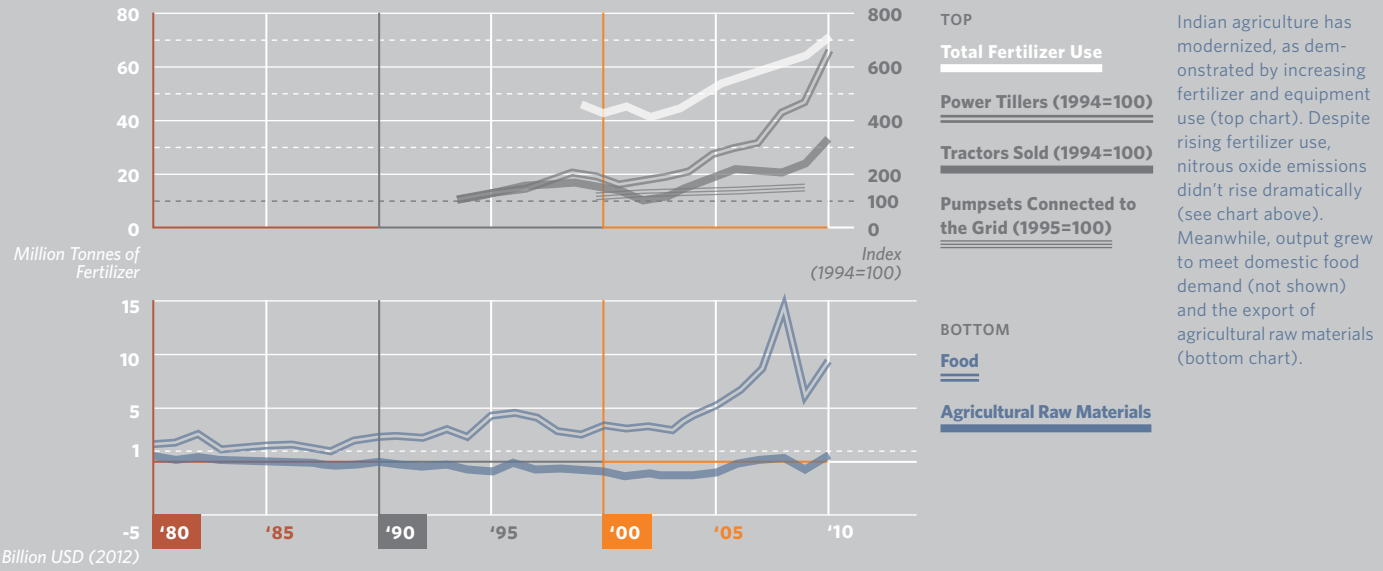


EMISSIONS DRIVERS

MECHANIZATION INDICES (1994-2010) / AGRICULTURAL NET EXPORTS (1980-2010)

KEY

NOTES

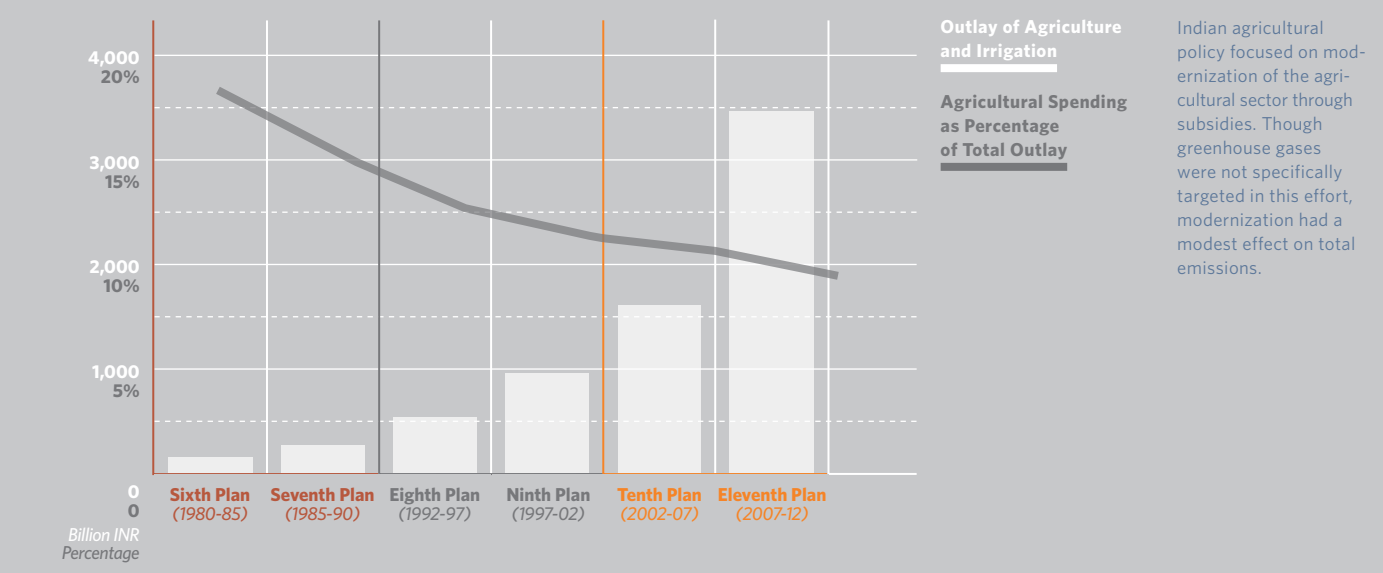


POLICY

CENTRAL GOVERNMENT SUBSIDIES TO AGRICULTURE (1980-2012)

KEY

NOTES





1980-1990

The Government of India's agricultural policy between independence (1947) and 1990 was largely focused on improving the domestic production of food grains by expanding irrigation and extending incentives such as input and output price regulations.

POLICY

Minimum Support Price for wheat introduced in 1966-67

- Protected farmers from commodity price fluctuations

Quantitative restrictions on import of agricultural commodities, specifically on pulses and edible oils, were removed during the 1980s

1990-2000

After 1990, the focus of government policy moved toward increasing the efficiency of the agricultural sector by improving the supply chain infrastructure.

Uruguay Round Agreement on Agriculture entered into force in 1995

- Quantitative import restrictions lifted in accelerated fashion for most agricultural commodities (1997-2001)
- Removed most quantitative controls on agricultural exports during the late 1990s
 - Export ban remained available for essential commodities as needed to stabilize domestic market

2000-2010

Policy shifted toward sustainable development of agriculture by attracting private investment due to rising subsidy expenditure.

The National Policy on Agriculture of 2000

- Aimed at agricultural sector annual growth rate of over 4%
- Emphasized technologically, environmentally, and economically sustainable growth
- Targeted efficient resource use and conservation of soil, water, and bio-diversity

Policy incentives to improve sector (USDA/ERS 2012)

- Restrictions on private movement and storage of farm commodities relaxed over decade
- Taxes on processing of agricultural products reduced and simplified

Policy incentives to promote exports (USDA/ERS 2012)

- Restrictions on processing firms largely removed
- Import duty reductions on imported inputs to products for export
- Government support for domestic marketing and transport extended
- State marketing laws relaxed to increase private participation

By 2008, import tariffs reduced for many major commodities to decrease inflationary pressure on domestic market

Export ban on non-basmati rice in 2008 in response to global rice price crisis

27 commodities covered under the Minimum Support Price program as of 2012

UNDERLYING CHANGES

Population increased by almost 25% by the end of decade (IMF 2011)

Marked agricultural growth largely due to adoption of high-yield seeds and fertilizers throughout the 1980s (Singh 2010)

Substantial growth and investment in rural infrastructure (Singh 2010)

Increasing population

Growth agricultural output fell from 4.8% in early 1990s to 2.5% in mid-1990s (Ministry of Agriculture 2012)

Mechanization of agriculture increased over decade (Ministry of Agriculture 2013)

2007-2008 global food price crisis

Growth agricultural output fell to 2.45% by early 2000s and started to recover after 2005 (Ministry of Agriculture 2012)

Increased mechanization of agriculture (Ministry of Agriculture 2013)

Population increased from 1,024.25 million in 2000 to 1,190.52 million by 2010 (IMF 2011)

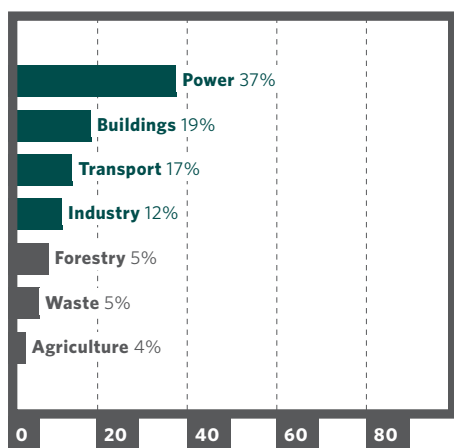


U S A



U S A

MAKING PROGRESS DESPITE POLICY GRIDLOCK



Percentage of Greenhouse Gas Mitigation Potential

Over the last seven years, energy-related CO₂ emissions have fallen by 13% in the United States (Rhodium Group 2013). Yet, at the national level, the U.S. is mired in political infighting while comprehensive climate policy is nowhere in sight. The apparent contradiction should give us all food for thought. Are there lessons to be learned for global negotiations about how progress can be made even without an agreement? How important can policy be, if a seemingly policy-scarce environment can nevertheless reduce emissions?

The answer is that there are surely lessons to be learned—not because there hasn't been policy, but rather because there has been so much policy, spread unevenly across states, sectors, and levels of government. And importantly, we can't judge the success or failure of U.S. policy without considering other key drivers such as resource endowment, economic conditions, and technological progress.

The United States is the world's largest economy and is rich in natural resources—both renewable (solar and wind) and nonrenewable (coal, oil, and natural gas). Historically, the U.S. has been a leader in environmental and climate policy; it took the lead in implementing clean air and water measures in the 1960s and 1970s, and later in controlling sulfur dioxide and CFCs.

But U.S. political will has waned during the last 20 years, as environmental and clean energy concerns have become increasingly partisan. After decades of population growth and a massive construction boom, the United States is now suffering from the lingering effects of the financial crisis, and budgetary concerns are a priority at all levels of government. While economic stimulus efforts provided historic levels of support for renewable energy and energy efficiency deployment, continuation of these policies faces stiff political opposition. At the same time, a boom in shale gas has transformed the U.S. energy landscape. The sudden abundance of cheap natural gas seems to be driving short-term emissions reductions in the electric power sector, but the broader emissions implications, particularly over the long-term, are less clear.

While we don't know the relative importance of the economy, shale gas, and policy in driving the recent emissions reductions, there are three broad lessons to draw from the U.S. experience. First, even amid political gridlock and serious institutional constraints, policies at the federal, state, and even local levels can make progress on emissions reductions. Second, policies are more effective when they work with economic forces; economics can drive policy effectiveness. Third, many uncoordinated policies can work together without a unified national climate policy framework, albeit less efficiently, and sometimes provide beneficial experimentation to identify the best policy options. The challenge going forward will be to weave together the existing collection of policies into a national framework that reaches the necessary levels of ambition.

FEDERAL POLICY: USING INCENTIVES, REGULATION, PERSUASION, AND INNOVATION TO INCH FORWARD THROUGH THE GRIDLOCK

Without strong congressional support for climate action, the U.S. government makes use of other policy levers: incentives, regulatory power, persuasive power, and support for innovation. With these approaches, the U.S. made progress without a nationwide carbon price or cap-and-trade system—though this progress has not been as steady or efficient as it could be.

INCENTIVES

Subsidies for renewable energy and energy efficiency are one of the most significant federal climate policy tools in the U.S.

For example, the U.S. subsidizes renewable energy development and deployment through the Production Tax Credit (PTC), first implemented in 1992 and primarily supporting wind power, and the Investment Tax Credit (ITC), which was created in 2005 and primarily supports solar power. The PTC and ITC have retained political support through a coalition of policymakers concerned with climate action and those who represent areas rich in renewable resources.

These incentives have been instrumental in driving renewable energy deployment. The U.S. has doubled its electricity generation

from renewable sources (excluding hydropower) in the past four years alone (EIA 2013a). This period also saw the development of significant domestic wind manufacturing capacity, with the domestic content of wind manufacturing growing from 35% in 2006 to 67% at the end of 2011 (DOE 2011a). These incentives have worked to harness economic forces by supporting early-stage deployment that helps drive down technology costs and make renewable sources more cost-competitive.

State action has complemented these incentives, creating demand for renewable energy by setting renewable portfolio standards (see below) and often adding their own incentives on top of the federal ones. This kind of interaction between states and the federal government is messy but useful; it has led to experimentation, expanded coverage, and increased ambition.

However, it's also an example of policy that could be more efficient and cost-effective if adjusted. A recent CPI study found that changing the existing wind energy tax incentive to a taxable cash incentive could deliver the same support to wind projects as current policy at half the cost to taxpayers (CPI 2012g). Moreover, the tax credits themselves have not been consistently available, as political support has fluctuated. Periodic uncertainty about whether the program will be extended or end leads to inefficient deployment efforts, as developers worry about investing in a long-term project only to have policy support disappear.

REGULATION

Without the prospect of congressional action on climate, the federal government is putting an old regulatory tool to new use to reduce greenhouse gas emissions. The command and control architecture of the Clean Air Act has driven dramatic improvements in national air quality since the 1970s. Throughout the decades, the U.S. has found flexibilities in the Clean Air Act's command and control approach to incorporate market-based mechanisms when possible.

Recently, the U.S. has turned back to the Clean Air Act to set the nation's first greenhouse gas emissions standards for the transportation

sector (see Policy, page 78). Since 2010, new greenhouse gas emissions vehicle standards and updated fuel economy standards have not only initiated a fuel efficiency catch-up to cut passenger vehicle emissions in half by 2025, but have also introduced the country's first greenhouse gas and fuel economy standards for heavy-duty trucks (EPA 2012a, 2012b). The new standards include within-sector banking and trading systems—an example of how action compelled by a regulatory mandate can still leverage market forces to improve cost-effectiveness. The standards raise the average fleet-wide fuel efficiency of new cars and light trucks to 54.5 miles per gallon by model year 2025 and reduce the lifetime CO₂ emissions of new heavy-duty vehicles by 270 million metric tonnes (model years 2014-2018).

In the near future, the federal government will also regulate new power plants and large industrial facilities. Standards will likely extend to cover existing facilities in the coming years.

There are costs, however, to relying on regulatory standards as a primary policy tool. The Clean Air Act is implemented through the states, not directly by the federal government. This means that a coordinated, nationwide market mechanism like a cap-and-trade system is extremely unlikely to emerge under the Clean Air Act; the federal government will set guidelines, but implementation strategies will likely differ from state to state. Under this approach, the U.S. will lose some of the potential benefits of nationwide climate action, including the ability to use inter-state trading to capture low-cost emissions reductions wherever they are available. In addition, the command-and-control structure of the Clean Air Act may be limited in its ability to approach climate mitigation efficiently. Long considered overly technology-specific, Clean Air Act regulations often make it difficult for today's regulators to harness technology-neutral solutions that are more flexible and cost-effective.

The federal government's authority to set greenhouse gas limits remains politically controversial, and there will likely be continued legislative and legal challenges to any further regulatory efforts on climate.

THE ROLE OF POLITICAL WILL

PERSUASION

The federal government has limited jurisdiction on many aspects of climate and energy regulation. But where it lacks the power to mandate, the federal government often plays an important role through convening relevant actors, sharing knowledge, and promoting policy to state and local governments.

For example, there is no federal authority to require adoption of building energy codes, a policy tool that can be effective in improving efficiency, according to a recent CPI report; this is a state and local decision (CPI 2011a). However, the federal Department of Energy promotes model codes to the states and demonstrates their benefits. During the recent economic downturn, the Department of Energy also tied states' receipt of stimulus funding for energy efficiency to adoption of model codes and improved code compliance measures, providing further encouragement to the states. Codes across the nation have become slowly but steadily more stringent. (see Policy, page 76)

INNOVATION

Many of the most important energy innovations over the last 50 years—from the first silicon photovoltaic cells and lithium batteries to horizontal drilling technologies and hydraulic fracturing (“fracking”)—originated in the U.S. The U.S. government uses tax credits, grants, loans, and other policies to drive innovation and create new technologies. Research and development has long been a part of the U.S. energy policy portfolio through the U.S.'s national laboratories, direct funding for researchers, and a tax credit for research and experimentation.

Energy innovation in both the public and private sector surged in the late 1970s and early 1980s, after the oil crisis, but then stagnated. The tide turned again in the mid-2000s, when venture capital began flowing to clean energy technology and federal policy shifted to support more energy innovation.

The Recovery Act of 2009 provided \$400 million to launch the Advanced Research

Nicholas Stern, author of the 2006 UK government report on the Economics of Climate Change recently said that political will, good policies, and innovative approaches will be critical to the issue of global warming. As this review highlights, political will—which we define as the exercise of political authority to achieve desired outcomes—varies widely between countries and within them. Yet, even in regions where political will may run a little short, many climate related policies are being enacted and implemented.

The key is that, to some extent, attractive policy options can be a substitute for political will. In the case of climate change mitigation, the amount of political will required depends on the difference in costs between policy choices that mitigate climate change and choices that do not. When good policies and innovation reduce the difference in costs to the point where the low carbon alternative is less expensive than the higher carbon alternative, the role of political will may be reduced to balancing the tradeoffs between winners and losers in the transition to the lower carbon alternative.

Through our research, we are working to reduce that difference in costs—providing good evidence and supporting improvements in policy effectiveness that reduce the cost of mitigation and help unlock low-cost mitigation opportunities.

CPI's work helps reduce the political challenge of climate mitigation in two ways. First, we provide analysis and evidence on the effectiveness of existing climate policies. If policymakers understand the impacts, benefits, and costs of existing policies, it will be less politically risky for them to expand and strengthen the policies that have been shown to work.

Second, CPI works with policymakers to support development and implementation of more cost effective policies. Lower-cost policies require less political will to enact. And if smart policy decisions can drive down the cost of mitigation, then taking the further steps necessary to avoid climate change will require less political will in the future.

Projects Agency—Energy (ARPA-E), a new agency focused on supporting the development of potential breakthrough technologies. It also provided billions in grants and loans to support the manufacture and deployment of advanced clean energy technologies such as thin film solar, carbon capture and sequestration, concentrated solar power, biofuels, and electric vehicles.

While it is far too early to judge the success of most of these forward-looking investments, a few prominent failures have led to significant political scrutiny of these efforts. In the end, innovation is a risky business, with failures destined to accompany successes as innovators experiment to find what works. The goal of innovation policy is to make sure that successes do come, and that the benefits from the successes outweigh the costs of the failures; to identify who should be incentivized to take these risks and how; and to understand how best to spread the positive innovations once they have been made. Over time, an assessment of the effectiveness of these investments, and an understanding of what factors led to a failure or a success, could help improve clean energy innovation policy in the U.S. and abroad.

STATE POLICIES: A FEW LEADERS, SOME CONSENSUS

In U.S. climate policy, the states are living up to their label as “laboratories of democracy,” experimenting with a range of climate and energy policies not mandated or coordinated by the federal government. A few states and regions stand out as leaders, implementing broad emissions caps and carbon trading, and some clean energy policies are gaining broad support across states.

STATE LEADERS EXPERIMENTING WITH CARBON PRICING

For decades, California has been the U.S. laboratory for progressive fuel and energy standards. In particular, California’s vehicle fuel economy standards have driven federal policy; the state also often leads on energy efficiency standards for appliances and equipment. California is now taking comprehensive climate action with a cap-and-trade system and other complementary policies, including an ambitious renewable portfolio standard.

“INTERACTION BETWEEN STATES AND THE FEDERAL GOVERNMENT IS MESSY BUT USEFUL!”

California’s first auction of emissions permits took place in November 2012; as implementation moves forward, other states and the federal government will be watching closely.

In 2008, a coalition of states in the Northeast U.S. implemented a smaller-scale emissions trading system, the Regional Greenhouse Gas Initiative, to limit emissions from power plants. Although carbon prices have been low, auction revenue raised \$900 million for clean energy and energy efficiency (Analysis Group 2011), and the cap has been tightened going forward.

CONSENSUS SUPPORT FOR RENEWABLES AND EFFICIENCY

While some states lead the way, a majority of states have implemented some energy efficiency and renewable energy policies. Some 30 states have instituted mandatory renewable portfolio standards, which require utilities to generate a portion of their power from clean sources, and seven more have instituted voluntary renewable portfolio targets.

Virtually all states have some form of energy efficiency demand-side management programs. These comprise a wide range of efficiency programs including consumer rebates for efficient appliances, concessional financing for home retrofits, upstream incentives for manufacturers of efficient products, and industrial retrofits. These programs are often operated by electric and gas utilities under the direction of utility regulators, working within the structure of the U.S. electric power system. This structure reflects a preference for policy that interfaces with large actors rather than small ones; policymakers give direction to the utilities, and the utilities take on the responsibility of designing programs to reach their customers. Demand-side management efforts have been found to be cost-effective as a whole, although differences in

measurement practices make it difficult to identify the best-performing individual programs (Arimura 2012; CPI 2012a, 2012i).

The states, and in some cases local governments, have also taken the lead on policies that promote innovative financing of energy efficiency and renewable energy. These include mechanisms that link energy efficiency loans to customers’ utility or property tax bill and that permit leasing of solar photovoltaic systems to consumers.

SHALE GAS: POLICY AND ECONOMICS WORKING TOGETHER

The huge growth in natural gas from unconventional sources in the past few years is a powerful example of the interaction between economics and policy. The shale gas boom has come about due to policy and economic forces working together; a collection of policies (including innovation support and exemption from some environmental regulations) has helped make gas exploration and extraction economical (Breakthrough Institute 2012). The gas boom seems to be a powerful force driving short-term emissions reductions in the U.S. electric power sector. But is this truly a climate success story? Should other countries follow the U.S.’s lead in pursuing shale gas? The full picture is unclear.

In the electricity sector, there is a clear climate and air quality benefit if natural gas can displace coal or other high greenhouse gas emitting fuels. But questions remain about the full climate impact of shale gas. Fugitive emissions from gas extraction are poorly understood and could make a big difference in the true climate effects of natural gas; there is no scientific agreement yet on this point.

Moreover, if natural gas is not displacing coal but is instead displacing low-carbon sources of power, it is clearly a worse alternative

from a climate perspective. In addition, the short-term benefit of gas could become a barrier to future emissions reductions. Cheap natural gas makes it harder for renewable energy sources to compete, reducing deployment, and potentially slowing their path to cost-competitiveness. And although natural gas has been proposed as a “bridge” fuel to lower-carbon energy sources, building out natural gas infrastructure now could make it more difficult to transition away from gas in the future.

Despite these questions, the shale gas boom demonstrates that rapid, large-scale change in the U.S. energy system is possible if the economics are right. And this change didn’t happen with economics alone; policy has set the ground rules and made it possible for economic forces to transform markets. The energy market transformation is already happening. The U.S. needs a strong policy framework to make sure that this transformation ultimately creates the emissions reductions needed.

THE WAY FORWARD

National climate policy seems to be on the horizon, although its shape is not yet clear. Some members of Congress continue to support a comprehensive option such as an economy-wide cap-and-trade system or carbon tax. These comprehensive policies could lead to more cost-effective approaches to reducing emissions. A nationwide approach would allow the U.S. to capture the most cost-effective emissions reductions wherever they are available, enabling greater climate gains at lower cost. A nationwide, market-based mechanism would encourage renewable energy investment in the areas richest in renewable resources, provide an economy-wide incentive for energy efficiency, and incentivize greater investment in low-carbon technologies with the promise of a nationwide market. A nationwide clean energy standard, which would limit emissions from the power sector, has also been proposed.

Alternatively, without further legislative action, the Clean Air Act provides a regulatory framework for limiting greenhouse gas emissions nationwide, with the federal government setting guidelines for state implementation. If regulation is the approach, the challenge for

both federal and state governments will be to harness efficient and effective state programs to meet federal standards. The Clean Air Act provides for some flexibility in implementation, so state implementation of greenhouse gas limits would not necessarily look like traditional command-and-control regulation. For example, the United States already uses an emissions trading system to limit sulfur dioxide emissions under the Clean Air Act, and states may be able to use similar state- or regional-level mechanisms to limit greenhouse gas emissions.

Regardless of what form future climate policy takes, many of the key challenges remain the same.

THE COORDINATION CHALLENGE

The U.S. is rich in renewable energy resources, but these resources are not spread evenly across states. This diversity is one reason a national climate policy framework is needed, to allow the entire country to benefit from those resources. But this diversity has also made it politically difficult to develop that framework, since regional interests are so different.

More specifically, increasing the penetration of renewables will require changes to the way electricity markets in the U.S. are formed and regulated, as well as continued support for technology development and deployment. Efficient electricity policies require joining together the nation’s fragmented electricity transmission network, so that renewable energy resources can be tapped to serve the areas with greatest demand.

Along with an evolving transmission grid, the electricity supply industry structure may evolve, hopefully toward lower-cost and more effective clean energy provision. Policy may gradually alter the structure of utilities and clean energy companies—possibly encouraging more and stronger national companies, or creating smaller, nimbler, more entrepreneurial clean energy developers and clean energy investment funds, or both. At the same time, policy could shift the investment proposition behind clean energy, changing the risk-reward proposition to attract different types of investors, such as pension funds and insurance companies, at potentially lower financing

costs. The states and the federal government will need to work together to ensure that these changes empower and encourage cleaner and more cost-effective energy production.

WEAVING TOGETHER STATE POLICIES

The federal-state relationship, including a strong role for the states, is a fundamental characteristic of public policy in the United States. In any future climate policy framework, there will continue to be a mix of federal and state policies. Additionally, states can, and do, pave the way for future federal action. But relying on state action will only take us so far—the states with the greatest appetite for climate action are not necessarily those with the largest or most cost-effective mitigation opportunities. The challenge going forward will be to weave together the U.S. patchwork of state policies and capture mitigation opportunities that are not reached by existing state action. Building a national climate policy regime will require identifying state policies that can be replicated, scaled up, and/or joined together.

With such a variety of policies already in existence at the state level, it’s important that policymakers can get a good picture of how well current policies are performing. Like many countries, the U.S. struggles to track its climate policy portfolio consistently (CPI 2012c, 2012h). This is a particular challenge with state policies; states all have their own methods of tracking policy impacts, but in order to see how the pieces fit together, federal policymakers need a more complete, consistent picture.

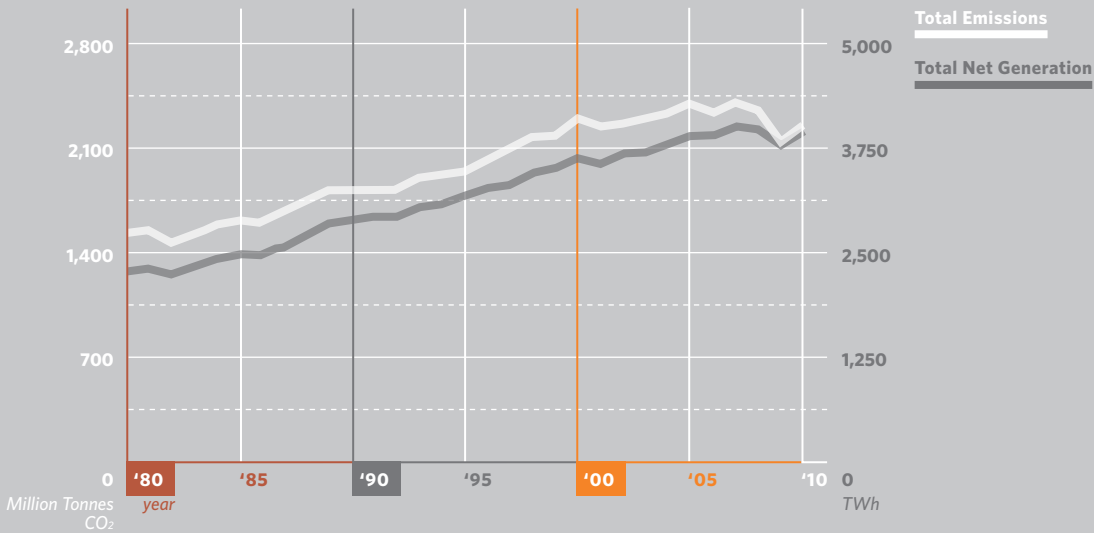
Perhaps, as the world struggles to form its own global agreement, it can look to the U.S. as a model for how things can get done even without an overriding, coordinating policy framework. Lack of U.S. legislative action on climate—while a continuing challenge—does not mean that the U.S. is not doing anything. The U.S. must strive to learn from its own varied experience with emissions-reducing policies, as well as those of other countries, as it builds toward a more coherent, effective climate policy regime—both upward from the state and local levels, and downward from the federal level. ■

EMISSIONS & OUTPUT

EMISSIONS AND GENERATION (1980-2010)

KEY

NOTES



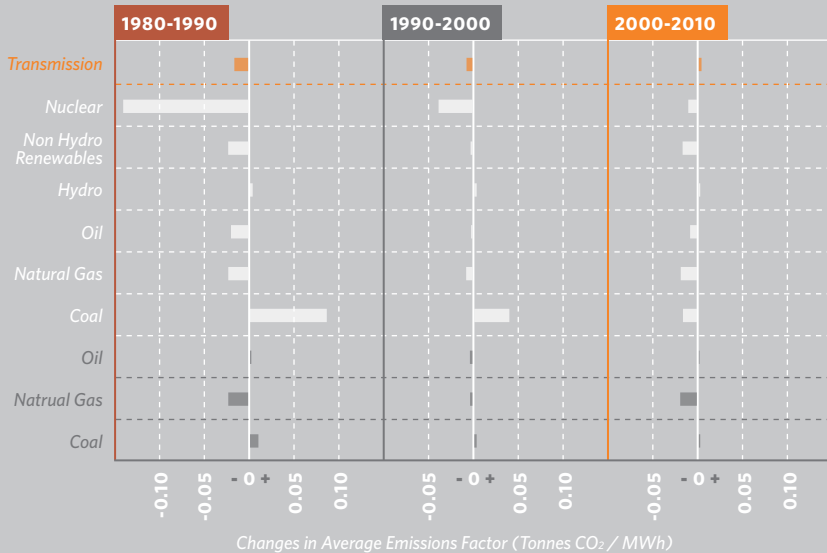
There was steady emissions and generation growth through the mid-2000s. Until recently, emissions grew in tandem with increasing electricity demand.

EMISSIONS DRIVERS

POWER SECTOR VARIABLES AND IMPACT ON AVERAGE EMISSIONS FACTOR (1980-2010)

KEY

NOTES



Transmission
Generation output
Power Plant Efficiency

The expansion and increased availability of nuclear in the 1980s and 1990s offset growing emissions from coal as both were used to meet increasing demand. In the 2000s, most factors were aligned to improve emissions intensity, including increasing renewable energy output and gas replacing coal.

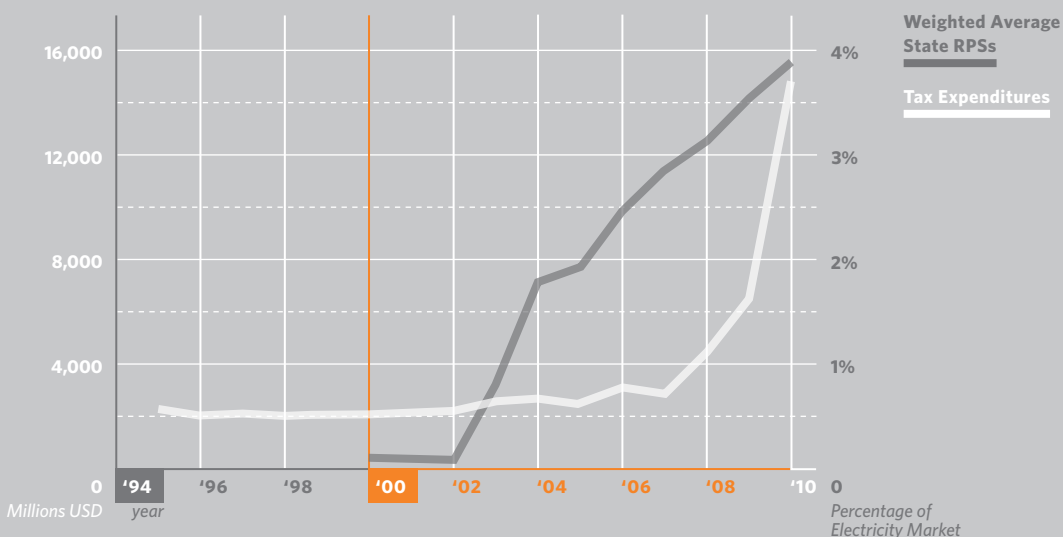
X-AXIS KEY
- Negative
Contributed to decrease in Average Emissions Factor
+ Positive
Contributed to increase in Average Emissions Factor

POLICY

FEDERAL RENEWABLE ENERGY INCENTIVES (1995-2010) / STATE LEVEL RENEWABLE ENERGY PORTFOLIO STANDARDS (2000-2010)

KEY

NOTES



Both state and federal governments created policies to support renewable energy. The two most prominent of these were federal renewable energy tax incentives (in white on left axis), and state-level renewable portfolio standards (in gray on right axis). These policies, and several other factors, are associated with significant increases in U.S. renewable energy capacity.



1980-1990

Power industry deregulation led to independent power producers and the beginning of natural gas generation. The nuclear buildout of prior decades ended, but nuclear generation increased significantly due to increased availability.

1990-2000

The government implemented federal tax incentives for renewable energy. The fuel mix composition changed with increasing nuclear availability and improvements in natural gas generation.

2000-2010

The 2000s marked the beginning of state involvement in renewable energy policy with renewable portfolio standards and a rise in federal tax expenditures towards renewable energy. The global market for renewable energy components led to cost reductions, while new technology and higher gas prices unlocked new natural gas reserves.

POLICY

Natural Gas Policy Act (1978)

- Deregulation of natural gas supplies
- Continued deregulation of oil and natural gas throughout the decade

PURPA (1978)

- Creation of independent power producers
- Ability to sell at avoided cost for qualifying facilities

Modified Accelerated Cost Recovery System (MACRS) adopted under Tax Reform Act, 1986

Clean Air Act Amendments of 1977 established New Source Review (NSR) preconstruction permitting program

Power sector deregulation throughout decade

Clean Air Act Amendments, 1990

- Acid Rain Program
 - Established cap and trade system to limit SO_x emissions from coal-fired EGUs.
- Limited NO_x emissions from EGUs

Energy Policy Act 1992

- Wholesale transmission access guidelines
- Production tax credit for renewable energy

State renewable portfolio standards implemented, increasing goals over decade

Federal tax expenditures grew throughout decade

- Residential Renewable Energy Tax Credit, 2005
- Investment Tax Credit, 2005
- MACRS + 50% Bonus Depreciation, 2008

Energy Independence and Security Act, 2007

- Required states to consider integrated resource planning and rate modifications to promote energy efficiency

Failure to identify long-term nuclear storage site

UNDERLYING CHANGES

Restrictions on gas for power generation changed

End of nuclear build out, but increased nuclear utilization

High oil prices, and the beginning of the phase out of oil-fired generation

Increased nuclear availability

Emergence of Combined Cycle Gas Turbine (CCGT) plants

Coal-powered plants greater than 40 years old proved still competitive (Joskow 2001)

Stable energy prices

Reduction in levelized costs of renewables (particularly wind and solar)

Unconventional gas emerged and very cheap natural gas

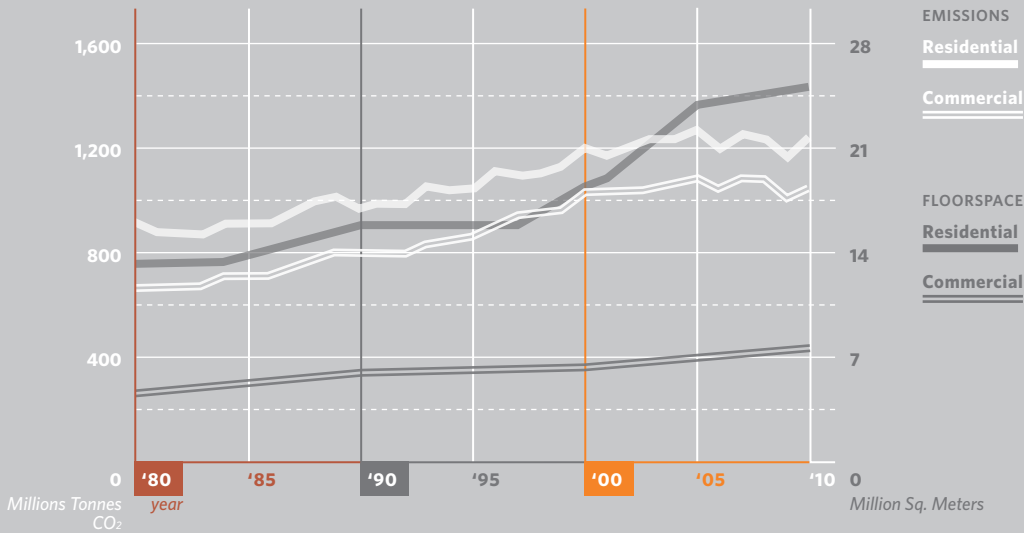
High oil prices

EMISSIONS & OUTPUT

TOTAL RESIDENTIAL AND COMMERCIAL FLOORSPACE / BUILDING SECTOR EMISSIONS (1980-2010)

KEY

NOTES



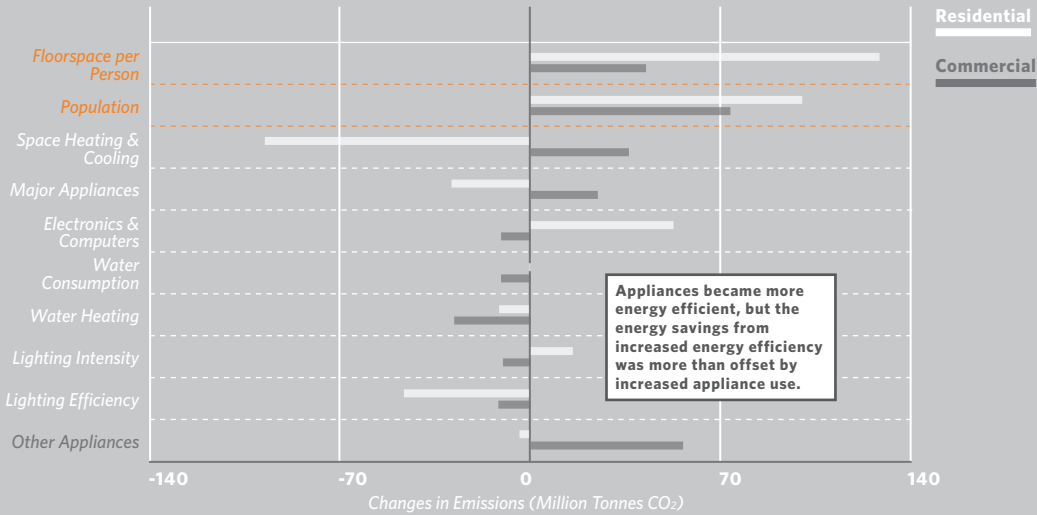
Total building stock, as reflected by total floor space statistics (in gray on the right axis), grew steadily, while the increase in residential floor space between 1995 and 2005 was particularly noteworthy. Emissions grew more slowly (in white on left axis), but steadily, until 2005, when emissions peaked and slowly declined.

EMISSIONS DRIVERS

CONTRIBUTION OF KEY DRIVERS TO INCREASE OR DECREASE OF ANNUAL BUILDINGS EMISSIONS (2000-2010)

KEY

NOTES



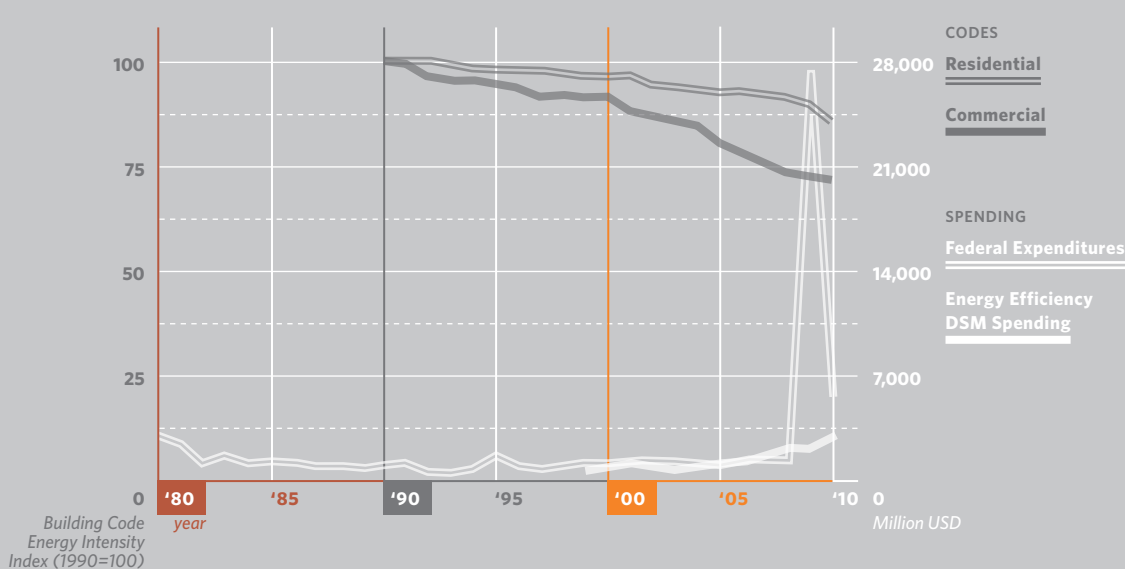
Growth in population and floor space per person were the largest drivers of buildings emissions (in orange). In the late 2000's, energy efficiency gains, particularly in residential heating and cooling (in white) caught up with slowing floor space growth (see emissions chart above).

POLICY

BUILDING ENERGY EFFICIENCY SPENDING BY GOVERNMENT (1980-2010) / BUILDING CODE INDEX (1990-2010)

KEY

NOTES



Building codes tightened steadily (in gray on left axis)—particularly for commercial buildings where the federal government played a larger role. At the same time, efficiency spending by federal and local governments increased over the last decade, with a spike due to the 2009 stimulus.



1980-1990

The first building and appliance standards appeared before the decade began; heterogeneous state standards led to federal appliance standards. Utilities began energy efficiency programs.

1990-2000

The 1990s saw wider and more stringent building code adoption due to federal requirements and assistance. Federal appliance standards and voluntary programs increased in scope. A residential construction boom began in the latter half of the decade.

2000-2010

The federal government increased spending on building energy efficiency. A “green premium” was associated with energy-efficient commercial building construction and retrofits.

POLICY

Emergence of building codes

- First ASHRAE standard, 1975
- Scattered code adoption by states

Demand-side management emerged

First appliance labeling and standards

- National Energy Conservation and Policy Act of 1978 authorized Department of Energy to set energy efficiency standards for 13 appliances
- Appliance Labeling Rule of 1980 mandated “EnergyGuide” labeling of appliances
- National Appliance Energy Conservation Act adopted uniform minimum efficiency standards for many household appliances, 1987
 - Industry-driven in face of variety of state standards (Geller 2006, EERE 2012)

Tax Reform Act of 1986 increased deduction for mortgage interest payments

Montreal Protocol to phase out halocarbons entered into force in 1989

First close federal involvement in state code creation with assistance in creating ASHRAE 1989 (PNNL 1994)

Energy Policy Act, 1992

- Required states to adopt commercial building codes
- Required the Department of Energy to offer states technical and financial assistance in code creation and adoption
- Expanded Department of Energy’s authority over labeling and energy efficiency standards in appliances

Energy Star voluntary energy efficiency labeling program initiated, 1992

Power sector restructuring led to demand-side management cutbacks (ACEEE 2006) (RFF 2004)

Market transformation programs initiated (RFF 2004)

Energy Star program expanded to cover wider range of appliances

Financial incentives

- Tax incentives for domestic and commercial building energy efficiency (Energy Policy Act 2005)
- State Energy Efficient Appliance Rebate Program
- American Recovery and Reinvestment Act, 2009
 - Energy Efficiency and Conservation Block Grants
 - Funds for states to decouple utility rates and to improve building codes

Energy Efficiency Resource Standards (EERS)

- First was Texas in 1999
- By 2011, 24 states (including California, Texas, and New York) have EERSs (ACEEE 2011)

UNDERLYING CHANGES

Suburbanization trend that began mid-century continued

Residential construction boom commenced in mid-1990s

Suburbanization continued and home size increased

IT build-out and increased use of electronics and appliances across commercial and residential buildings (EERE 2008)

Increased appliance “plug load” (DOE 2011)

- Rise in residential air conditioning continued (68% - 77% of all households) (DOE 2011)
- Space heating shares between gas and electric constant

“Green Premium” in energy efficient office space drove “green” commercial occupancy and leasing rates above average commercial rates (Miller 2008)

Residential construction boom until 2007 housing bubble collapse

Crime fell in urban areas, associated with accelerating residential construction in urban areas (EPA 2009)

Fuel shifted in space heating (DOE 2011b)

- Residential buildings shifted increasingly to electric space heating (from approximately 29% to 35% of households)
- Decline in natural gas for residential space heating (from approximately 55% to 50% of households)

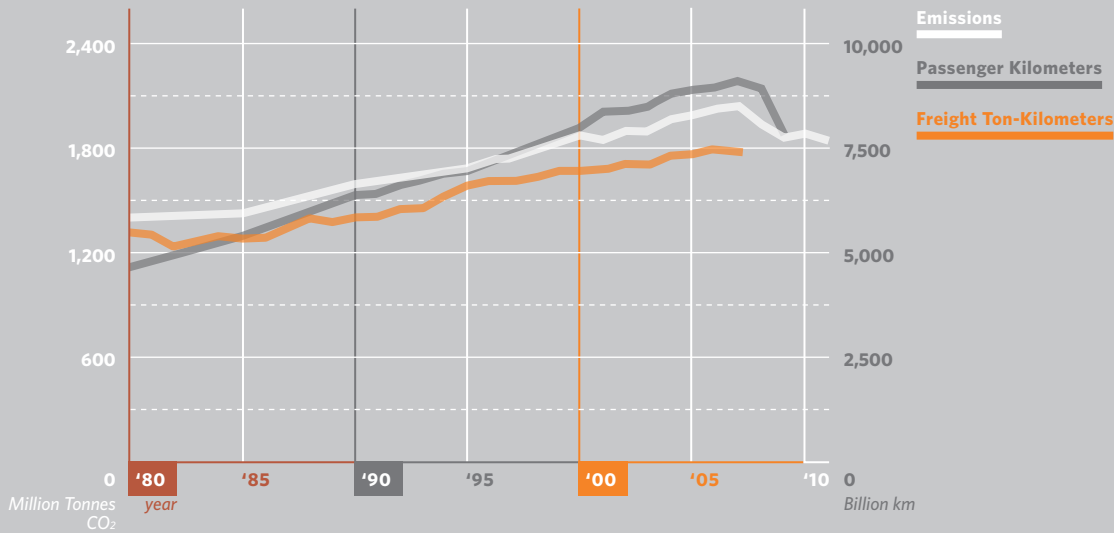
Continued IT build-out and household appliance growth across commercial and residential buildings (EERE 2008)

EMISSIONS & OUTPUT

EMISSIONS AND TRANSPORT ACTIVITY (1980-2011)

KEY

NOTES



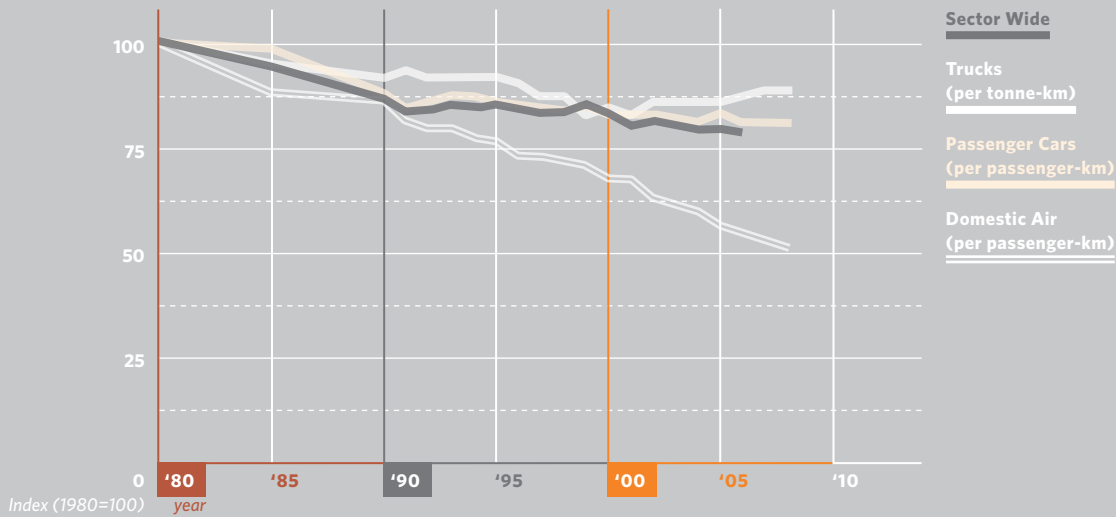
Both passenger and freight travel increased since 1980, though passenger travel grew more rapidly than freight (right axis). Both modes of travel were sensitive to economic conditions, and activity dropped significantly during the recession (left axis).

EMISSIONS DRIVERS

EMISSIONS INTENSITY (1980-2008)

KEY

NOTES



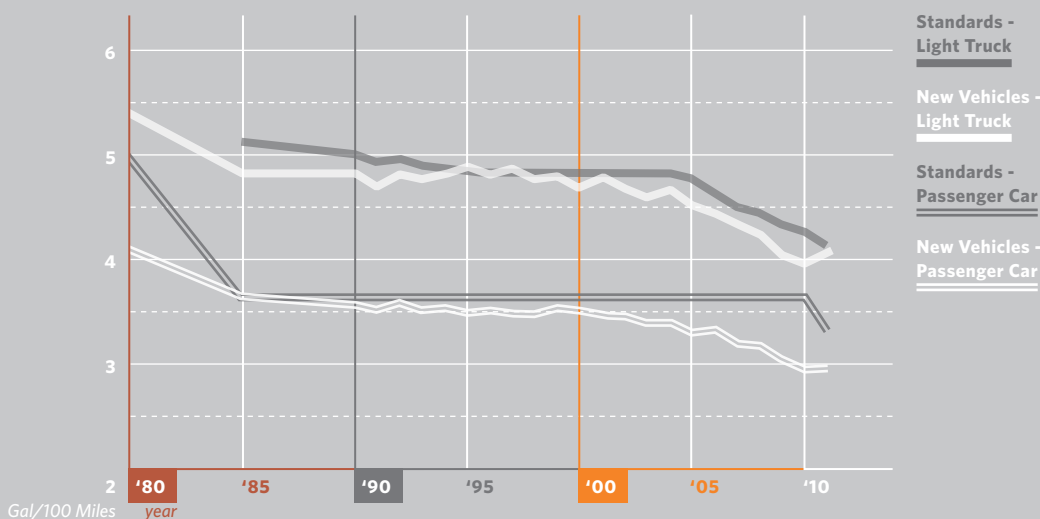
Large gains in vehicle engine and transmission efficiency did not result in significant fuel efficiency gains, as cars became heavier. Fuller flights, more efficient planes, and improved routing improved aviation efficiency. There was little shifting between transport modes (not shown).

POLICY

CORPORATE AVERAGE FUEL ECONOMY STANDARDS (1980-2011)

KEY

NOTES



Fuel efficiency standards, after tightening rapidly after their inception, remained largely unchanged for over two decades. Starting in 2005, standards for larger passenger vehicles became more demanding. Very recently, standards for smaller passenger cars were revisited.



1980-1990

Deregulation and energy efficiency were the major policy themes for the 1980s as the air and rail industries underwent significant overhauls and passenger vehicle fleet efficiency standards increased significantly in the first half of the decade.

1990-2000

The 1990s saw stable energy prices and an associated drop in attention towards increasing overall energy efficiency. Consumption behavior shifted towards larger, amenity-rich vehicles.

2000-2010

Both the automobile market and policymakers shifted focus towards lighter, more efficient vehicles and alternative fuels. The financial crisis and automobile industry bailout late in the decade reshaped the policy landscape in favor of more stringent regulation.

POLICY

Corporate Average Fuel Economy Standards (CAFE) improved automobile efficiency

- Energy Policy and Conservation Act of 1975 required 27.5 mpg by 1985
- EPA began labeling fuel efficiency

Surface Transport Assistance Act, 1982 goal to complete Interstate Highway System by 1991

Raised federal gas tax from 4 to 9 cents per gallon—first increase since 1959—to fund completion of Interstate Highway System by 1991 (CRS 2006)

Surface Transport and Uniform Relocation Assistance Act, 1987

- Allowed states to raise speed limits to 65 on rural interstate highways

Railroad and Airline deregulation

- Railroad Deregulation and Regulatory Reform Act, 1976
- Staggers Act, 1980
- Airline Deregulation Act, 1978

No change to CAFE standards

Gas taxes raised from 9 to 18 cents from 1990 to 1993, the last time federal gas taxes increased significantly

Energy Policy Act, 1992

- Federal fleet purchasing required to build alternative-fuel vehicle fleet

Clean Air Act Amendments, 1990

- Increased stringency of heavy and light duty pollution standards

Communications, Navigation, and Surveillance / Air Traffic Management (CNS/ATM), 1997, aimed to reduce airplane idling and travel time

Continued tightening pollution standard for heavy and light duty vehicles

High Occupancy Vehicle lane exemptions for low-emissions or hybrid vehicles, 2005

Energy Policy Act, 2005

- Tax incentives created for alternative fuel and advance technology vehicles
- Renewable Fuel Standard (RFS) established to mandate biofuel volumes in national fuel supply

Energy Independence and Security Act, 2007

- Advanced Technology Vehicles Manufacturing Loan Program
- Increased RFS volumes and set greenhouse gas requirements for qualifying fuels

SmartWay voluntary program established to facilitate fuel efficiency and reduced costs for freight, 2004

UNDERLYING CHANGES

Oil shocks

Increasing fuel economy (approximately 20%) across ground transport

- Efficiency gains limited to first half of the decade (Joskow 2001)

Rapid changes to light duty fleet mix

- Light truck share increased from 16% to 30%
- Car share decreased from 83% to 70% (ORNL 2012)

Deteriorating fuel economy in passenger vehicles (EIA 2005)

- Engine and transmission efficiency gains were offset by horsepower, size, and weight increases
- Continued changes to light duty fleet mix
 - Light truck share rose to 40%
 - Car share decreased to 60% (ORNL 2012)

Fleet mix changes slowed (ORNL 2012)

Increased use of hybrid and other alternative-fuel vehicles

Return to high oil prices

2008-2009 recession reduced travel and freight movement (ORNL 2012, FHA 2012)

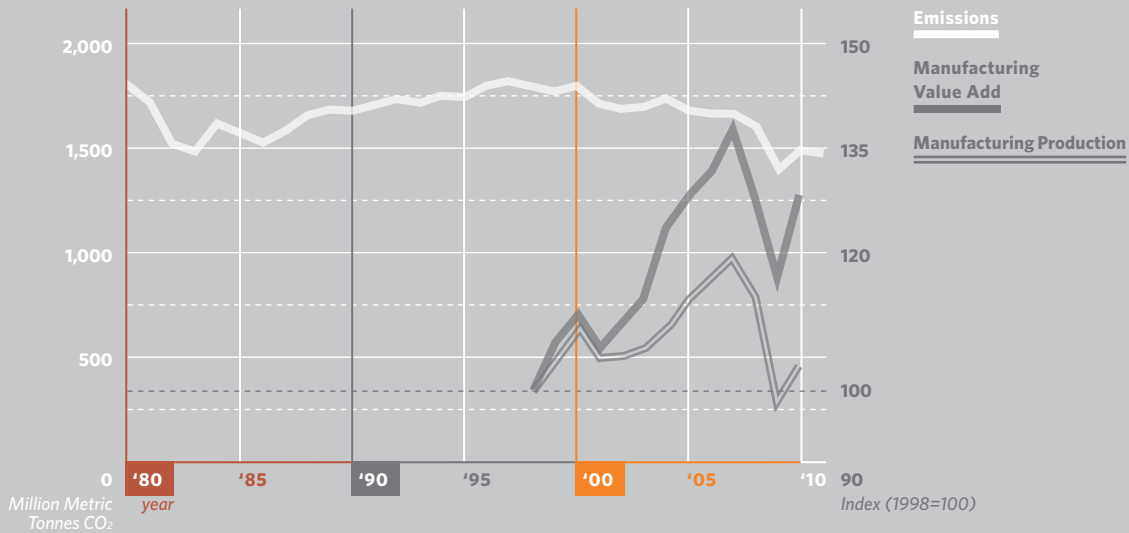
Domestic commercial aircraft improved in operational efficiency and fuel efficiency; passenger demand grew (CRS 2010)

EMISSIONS & OUTPUT

INDUSTRY EMISSIONS (1980-2010)

KEY

NOTES



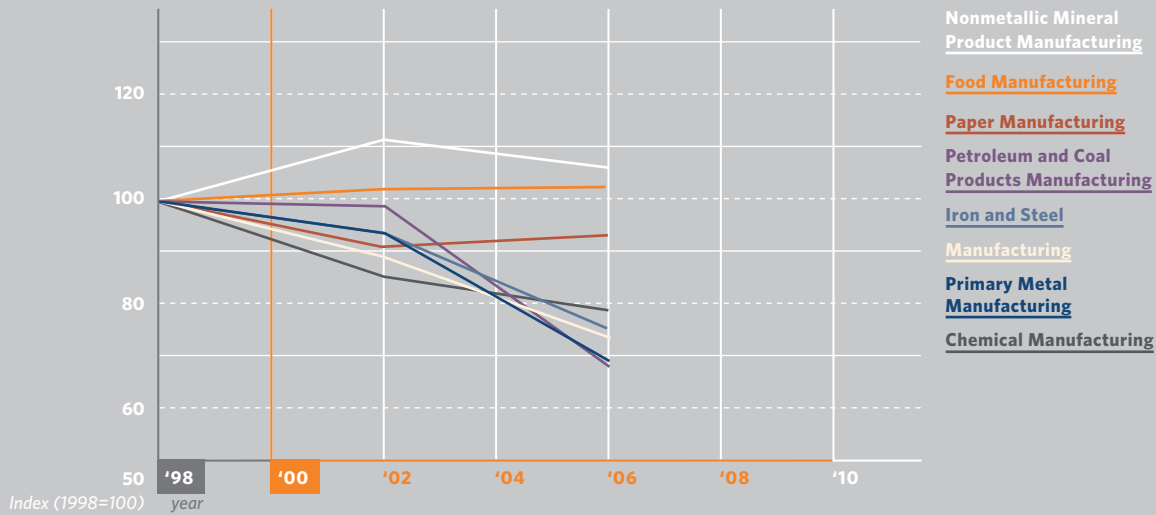
Industrial emissions declined even before the recession as industrial production rose.

EMISSIONS DRIVERS

ENERGY INTENSITY BY SECTOR (1998-2006)

KEY

NOTES



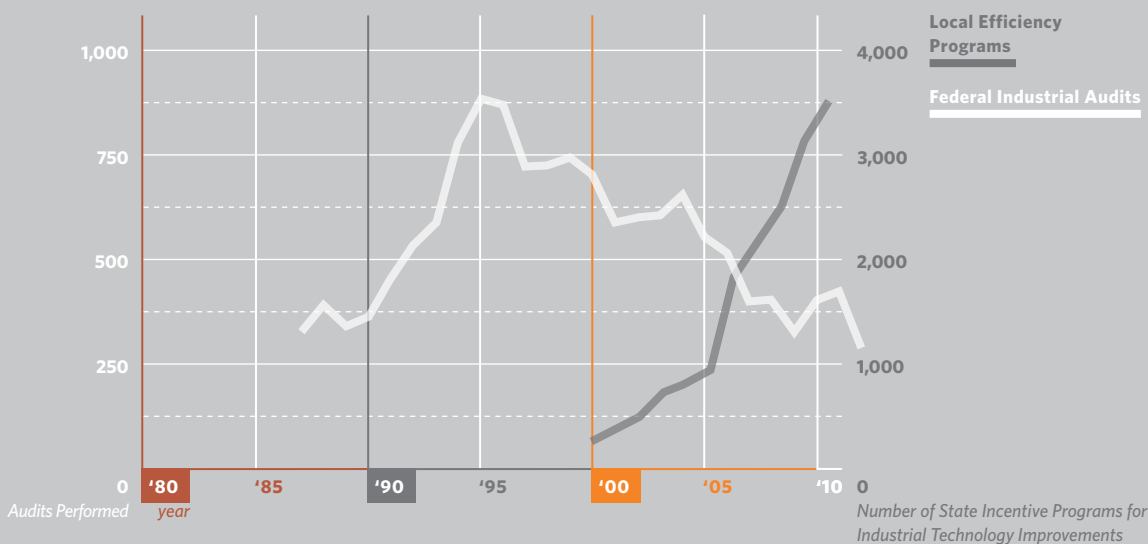
As manufacturing grew (see chart above), industrial sectors generally improved their energy intensity (on left), but in some cases performance declined. Structural changes to U.S. industry led to lower emissions intensity (see chart above).

POLICY

NUMBER OF STATE INCENTIVE PROGRAMS FOR INDUSTRIAL TECHNOLOGY IMPROVEMENT (1987-2011) / FEDERAL INDUSTRIAL AUDITS (1992-2011)

KEY

NOTES



There was little cohesive industrial policy. Participation in the federal industrial assessment program declined (left axis), while state level programs grew (right axis).



1980-1990

Utilities began exploring integrated resource planning in a time of high energy prices and fixed retail prices. The 1980s also marked the beginning of federal involvement in knowledge-transfer to industry.

1990-2000

The continued deregulation of the power sector spurred a reduction in funding towards demand-side management programs. There was increased attention on appliance standards with the Energy Policy Act.

2000-2010

States began implementing energy efficiency resource standards and utilizing public benefit charges to fund energy efficiency programs, which saw a funding resurgence throughout the decade.

POLICY

Industrial Assessment Centers (IAC) Program, 1976

- Environmental, energy, and productivity audits of facilities by trained engineers

Integrated Resource Planning (IRP) by public utilities responding to high energy prices and fixed retail prices

Demand-side management (DSM) programs began

- Explored by utilities in response to high energy prices and stranded nuclear costs

Policy shifted to partnership programs between EPA, DOE, and industry

- Energy Star voluntary energy efficiency labeling program began, 1992
- Increased use of IAC audits

Deregulation of utilities after 1994 led to a decrease in demand-side management spending (RFF 2004), (ACEEE 2006)

Utility market transformation programs initiated in mid-1990s (RFF 2004), (ACEEE 2006)

Energy Policy Act of 1992 required states to consider DSM programs

States began enacting Energy Efficiency Resource Standards (EERS)

- First is Texas in 1999
- By 2011, 24 states (including California, Texas, and New York) had EERSs (ACEEE 2011)

Energy Policy Act, 2005

- Provided loan guarantees for new energy efficient technologies

Use of Public Benefit Funds for energy efficiency, renewable energy, and research and development increased (RFF 2004)

- Rise in demand-side management spending in 2000s

UNDERLYING CHANGES

Rising imports of finished goods (FRBNY 1991)

Falling relative share of manufacturing (Sachs et al. 1994)

Rise in manufacturing productivity

Shift from integrated mills to minimills in steel sector

Industrial sectors declined in GDP contribution, but increased gross value-add

1995-2000 saw increases in durable-goods manufacturing, driven in part by IT equipment (BEA 2004)

Elimination of trade restrictions

- End of trade restrictions protecting U.S. steel industry in 1992 (CRS 2003)

Declining use of basic oxygen furnaces (BOF); increasing use of electric arc furnaces (EAF) (CRS 2003)

Rise in steel industry bankruptcies due to rising energy prices, financial crises, and legacy costs (RFF 2004)

Return to high energy prices

Unconventional gas emerged and domestic exploration rose

Recession 2008-2009



ECONOMIC SECTORS



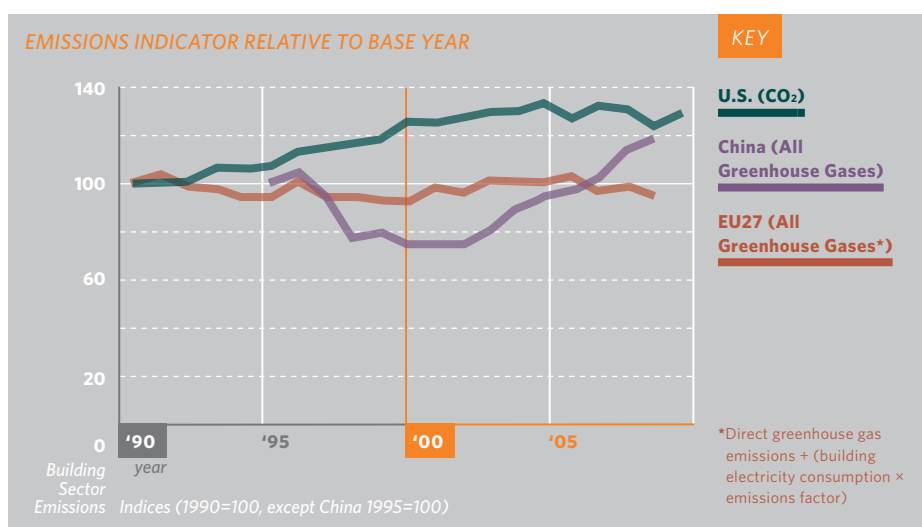
BUILDINGS

CHINA, EU, U.S.

A long history of policy intervention yielded energy efficiency gains, but faced offsetting factors

Energy efficiency in buildings has been the target of policy since at least the 1970s. Common policy tools include building codes and appliance standards, utility-based energy efficiency programs, incentives, and information campaigns. Policy activity accelerated in the 1990s in Europe and after 2000 in the U.S. It became a target more recently for Chinese policy makers. Unfortunately, despite substantial

efficiency improvements in heating, cooling, and lighting, growth in building floor space and the increasing range, penetration, and use of appliances and electronics have more than offset efficiency gains in China and have just about balanced efficiency gains in Europe. In the U.S., efficiency gains have only recently caught up with slowing floor space growth.



CHINA

Significant policy action, particularly in improving the efficiency of district heating, decreasing the use of coal for household heating, and instituting better building codes was overshadowed by growth in floor space and residences connecting to the grid and using more appliances

Chinese policy addressed building use, but except for the district heating program, most of China's signature energy efficiency programs were directed towards industry

U.S.

Emissions grew as new construction and IT boomed and added to energy demand

Policy activity started early, but emissions continued to grow until energy efficiency policy increased and new sources of demand slowed after 2000

Policy activity was mostly at state level, using utilities as facilitators

Commercial sector was particularly quick to adopt more efficient technologies

EU

Policy activity began early

Carbon efficiency benefited from fuel switching and improved building envelopes (insulation, etc)

As a result, emissions plateaued in the early 1990s

Household sector efficiency improved particularly rapidly, but overall consumption was impacted by growth in floor space and demand from new appliances

POLICY

Building energy codes

- Active development of performance standards for new buildings began in the 1970s-1980s in each region; many codes grew considerably more stringent in recent years, but enforcement was a challenge

Appliances and equipment: standards and labeling

- Appliance standards and labeling began in the 1970s in the U.S and Europe and in China in the 1990s; more recently, standards were harmonized across Europe
- Policy across regions grew to cover more and more devices (e.g., consumer electronics)

Incentives for purchase of efficient devices and for retrofits of existing building envelopes; some delivered by government, some through energy utilities

UNDERLYING CHANGES

Increasing proportion of energy use by appliances and equipment in all countries, making electricity more important relative to heating fuels

Market transformation of appliances

- Significantly more efficient appliances available in all regions
- Offset by rising electronics use; electronics only beginning to be addressed by standards and incentives

Urbanization / Suburbanization

- U.S.: massive suburban residential build out in early-mid 2000s
- China: significant rural-to-urban migration and rising incomes greatly increased energy demand

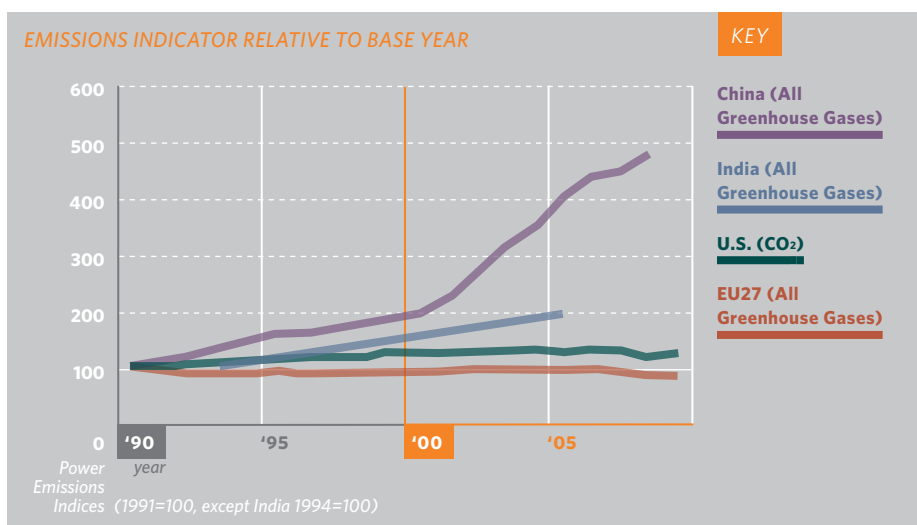
POWER

CHINA, EU, INDIA, U.S.

Fast growth in power demand and the use of indigenous coal supplies drove emissions growth

Rapid growth in electricity demand mirrored rapid economic growth in China and India. In both countries, the most readily available source of indigenous fuel was coal. China was better at exploiting its coal resources, while India had to rely on imports. Slower demand growth

and a gradual move away from coal to nuclear, gas, and renewable sources kept EU and U.S. emissions from growing and led to recent declines. In all four countries, despite the strong growth in renewable energy, the impact on carbon intensity was only beginning to be felt.



INDIA

Indian electricity demand did not grow quite as fast as China's, but was also fueled mainly by coal, both domestic and imported

Renewable sources were just beginning to have an impact

CHINA

Despite concerted efforts to diversify Chinese power generation, unprecedented growth in electricity generation was fueled mainly by coal, which remained China's cheapest and most abundant fuel

The efficiency of China's power plants improved rapidly and significant renewable and nuclear generation was built, which kept Chinese emissions from rising even faster

U.S.

Increased nuclear output more than offset increased generation from coal to keep emissions from rising rapidly in the 80s and 90s. More recently, falling gas prices and the threat of tightening regulation on coal plants led to a switch from coal to gas. Falling demand due to the recession played a part in the recent fall in emissions, as did the growth in renewable energy

EU

Policies like the EU Emissions Trading System and the Large Combustion Plant Directive altered the economics of coal fired generation, but unlike the U.S., gas prices remained high, limiting switching

The increase in nuclear output was a significant driver over the last decades, and more recently, the growth in renewable energy began to have a significant impact, as did the decline in demand due to the financial crisis

POLICY

Renewable energy policy grew strongly at both the national level and state or provincial level

- U.S. and India—both combined distribution of incentives at national level with statewide targets
- Europe—EU-wide targets set in 2000 and 2010; incentives provided at national level and through ETS
- China employed mix of feed-in tariffs, targets, and incentives to transmission providers

Additional policies altered the economics and attractiveness of coal in the U.S. and Europe, including the Large Combustion Plant Directive (aimed at reducing local pollutants in Europe) and the use of Clean Air Act authority in the U.S.

UNDERLYING CHANGES

Power industries in the U.S. and Europe underwent significant restructuring over the last 30 years in an attempt to make the underlying economics of electricity more transparent; competitive dynamics now dominate capacity build and plant dispatch

Rapid industrialization and economic growth, which was highly correlated to increased electricity demand, drove unprecedented new generation capacity build

In all markets, volatile energy prices created uncertainty and changed the relative economics of coal versus gas and other generation forms

The Fukushima disaster in Japan led to a backlash against nuclear

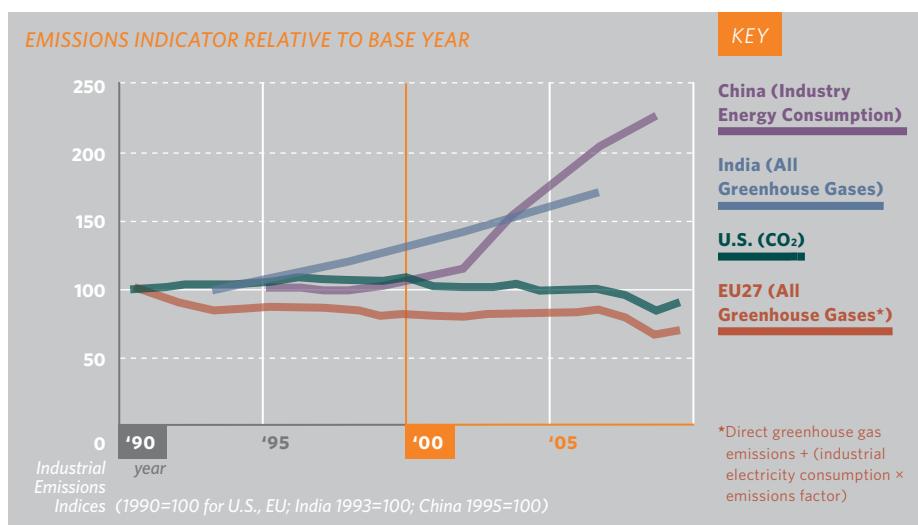
INDUSTRY

CHINA, EU, INDIA, U.S.

Growth and differences between industries created a varying landscape

Industrial sector greenhouse gas policy is difficult to generalize about because the carbon efficiency opportunities vary so much between different sectors like steel, manufacturing, or food processing. Only three carbon saving technologies cut across most industrial sectors: combined heat and power, high efficiency motors, and to a lesser extent efficient lighting. Economic forces play a stronger role in industry than in buildings. Many policies, such as the EU Emissions Trading System, sought to provide incentives to improve efficiency by changing the economics. The scale and concentration of energy savings opportunities in fewer, larger consumers enabled more targeted

policies, such as those employed in China that included energy audits, mandated equipment closure and upgrade, and finance. Emissions fell in the more developed countries, as policies, rising energy prices, and pressure to maintain economic competitiveness combined with the gradual decline and movement offshore of more carbon intensive industries. In the developing world, meanwhile, rapid growth and industrialization overwhelmed the significant improvement in energy efficiency that was possible due to the lower starting efficiency of industries there.



INDIA

Large differences between sectors and energy efficiency policy just developing

National energy efficiency policy is set to accelerate with the Perform, Achieve, Trade system—an energy efficiency certificate scheme

Energy intensity fell in some, but not all sectors, as new facilities geared up for industrial growth in India

CHINA

Concerted policy effort targeted a reshaping of the industrial energy consumption landscape and initial emphasis on the largest industries

Decline in carbon intensity, but from a very carbon intensive starting point

The sheer growth of industrial production overwhelmed efficiency improvements

U.S.

No coherent national industrial carbon policy, but energy efficiency policy at the state level, market forces including rising energy prices, and outsourcing of some industrial production to other countries facilitated decline in emissions

EU

The EU Emissions Trading System combined with rising fuel prices, outsourcing of production, and a number of member country level programs to improve efficiency

Other Europe-wide programs, such as a Combined Heat and Power Directive and the Large Combustion Plant Directive targeted certain sectors within industry

POLICY

Focus on Local Air Pollutants

- In the 1990s, measures in the EU (Large Combustion Plant Directive) and U.S. (1992 Clean Air Act)
- India: funding for State Pollution Control Boards a primary policy tool

Capital investment and industrial sector growth prioritized in developing countries

- China: efficiency 10th FYP emphasized capital investment over energy
- India: opening up to foreign investors

EU Emissions Trading System

Utility based energy efficiency programs in the U.S.

UNDERLYING CHANGES

Only two technologies were large and pervasive across industries: high efficiency motors and combined heat and power, other changes were relatively industry specific

In general, economic shifts had a very large impact including:

- Volatility of energy prices in the 1980s and 2000s; and the low prices through the 1990s
- U.S. and EU: long-term shift away from heavy industry to sophisticated manufacturing
- Growth in industry and infrastructure build out in India and China

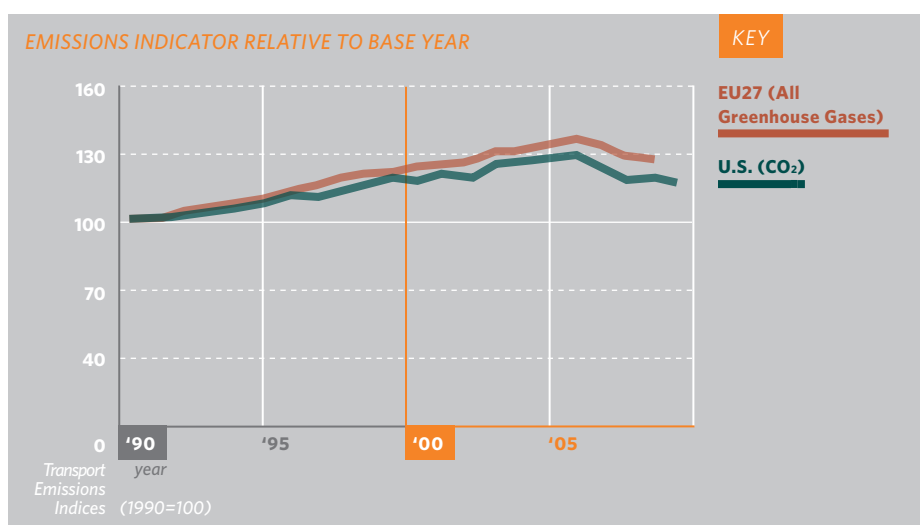
TRANSPORT

EU, U.S.

The economy hid underlying policy differences

Transport offers large immediate and long-term opportunities to reduce greenhouse gas emissions in Europe and the U.S. The pattern for transport-related growth in greenhouse gas emissions in the two regions was remarkably similar—a sustained rise with increasing passenger and freight traffic and strong growth in air travel only partially

offset by gradual efficiency improvements. Emissions peaked in 2007 in both economies before high fuel prices and then recession curbed and reversed emissions growth. This general pattern overshadowed the European automobile fleet's more fuel efficient starting point, thanks in part to significantly higher fuel taxes in Europe than in the U.S.



EU

High taxes on petrol and diesel fuel were in place before 1990, leading to a relatively smaller and more efficient vehicle fleet

Taxes, on average, peaked around the turn of the century. Fuel price movements had greater relative impact on total prices as pre-tax fuel costs rose

The EU generally taxed petrol more than diesel, overcoming the usual cost advantage of petrol and encouraging a switch to diesel for passenger vehicles

U.S.

Fuel taxes and fleet efficiency standards did not change after the early 1990s

Meanwhile, significant improvements in transmission and engine efficiency were offset by increasing weight across passenger vehicles classes and increasing SUV share of the passenger fleet

With lower taxes and lower mileage vehicles, rising fuel prices had a larger relative impact on the economics of transport in the U.S. than in Europe

POLICY

Fuel Taxes

- EU: Higher taxes on gasoline than diesel, encouraging diesel vehicles
- U.S.: After a fourfold increase in fuel taxes between 1980 and 1993 (yet still lower than EU levels), fuel taxes did not change significantly after the early 1990s

Fuel Economy Performance Standards

- EU: Voluntary agreements with manufacturers began in 1995. EU set greenhouse gas standards for passenger vehicles in 2009
- U.S.: Long history of fuel economy standards started in 1978. The standard remained flat throughout 1990s and 2000s. New greenhouse gas standards and improved fuel economy standards for heavy and light-duty were set in 2010 and 2011

UNDERLYING CHANGES

Very little shift in passenger or freight mode shares

Similar gains in modal efficiency across both regions

Aviation

- Improved aviation efficiency through improved operations and better technology
- Large increase in air travel demand

Economic

- Low fuel prices in the 1990s, followed by high prices and a commodity boom in the 2000s

Fleet Shifts

- EU: Shift in fleet from gasoline to diesel in the 1990s
- U.S.: Shift towards heavier, feature-rich vehicles in the 1990s and early 2000s, offsetting gains in engine and transmission efficiency

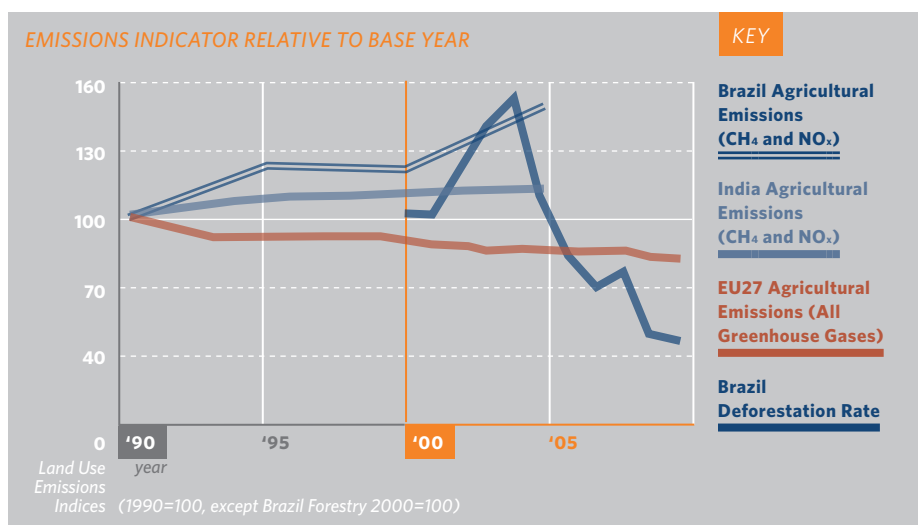
LAND USE

BRAZIL, EU, INDIA

Policy drove modern agricultural practices and emissions declines

Continual modernization of agricultural practices in India, Europe, and southern Brazil enabled increased productivity without marked increases in cultivated land. In fact, cultivated land area remained flat or decreased in some cases. Greenhouse gas emissions from agricultural land use followed suit. In India, mechanization-focused policies and increased fertilizer intensity contributed to this pattern, whereas Europe moved beyond increased fertilization and instead improved agricultural practices that lowered fertilizer application. On the

other hand, for India and Brazil, exports might have driven increased cropland expansion or agricultural intensification, while northern Brazil maintained more traditional agricultural practices, expanding cultivated land area to keep up with demand. Brazilian deforestation rates spiked in the early 2000s along with emissions from Brazilian agriculture; however, aggressive Brazilian policies helped drive down deforestation rates in the late 2000s.



BRAZIL

DEFORESTATION

Significant ramp-up in Brazilian land use policy in the mid-2000s and lower agricultural commodity prices led to a dramatic decline in deforestation rates

Large-scale deforestation was all but eliminated by the end of the decade; small-scale deforestation persisted

AGRICULTURE

Brazil increased planned rural credit under subsidized rates in the 2000s, conditioning credit on compliance with environmental requirements

Approximately half of government support for Brazilian agriculture was in the form of fixed capital formation credit in the late 1990s and 2000s. The other half was more traditional subsidization tied to production quantities

EU

Europe's Common Agricultural Policy reforms in the early 1990s aimed to reduce cultivated land area. The reforms in the 1990s and 2000s shifted subsidies from a price support structure towards direct farm support. Environmental compliance increased in importance in awarding government support in the 2000s

INDIA

India had lifted most agricultural commodity export bans and accelerated removal of import restrictions by the late 1990s. Over the 2000s, agricultural policy emphasized mechanization and efficient resource use and conservation in agricultural practices

POLICY

Central Government Support:

- Subsidies from central government to increase production intensity in India
- Subsidies to EU producers decoupled from production quantities
- Brazilian subsidization tied to production quantities and in the form of fixed capital formation credit
- Increasing emphasis on environmental compliance for government support in Brazil and EU

UNDERLYING CHANGES

Market Dynamics

- Rising value in gross exports in each region
- Trade agreements in the 1990s
- High food, fertilizer prices in the 2000s

Food Security

- India prohibited export of most grades of rice in response to the 2008 food price crisis

Mechanization

- EU and Brazil already saturated, India made concerted efforts to increase technology use



A landscape photograph featuring a range of mountains in the background and a dense forest in the foreground. The entire scene is bathed in a warm, golden-orange light, suggesting a sunrise or sunset. The word "INNOVATION" is centered in the middle of the image in a white, bold, sans-serif font.

I N N O V A T I O N

LOOKING FOR BREAKTHROUGHS TO MEET THE CLIMATE CHALLENGE

Imagine that all the barriers to low-carbon activities are removed. Suddenly consumers invest in energy efficiency, industrial processes are streamlined, more waste is recycled, and greenhouse gases are saved. Next, financial incentives encourage the building of on-shore wind turbines, more carbon efficient land management and the replacement of coal-fired generation with nuclear or hydro and more greenhouse gases are saved. And yet with all of these savings, we still fall short of our targets for greenhouse gas reductions. What next?

Alternatively, imagine that a new, almost limitless source of zero carbon, low-cost electricity generation is perfected, transport and much of industry is electrified, and greenhouse gas emissions fall precipitously. In this case, perhaps, financial incentives for carbon mitigation might not need to be so high and the economic impact of climate change mitigation might shrink.

The two scenarios show the allure of innovation in the world of climate change policy. The need for more, as yet undefined, and sometimes seemingly impossible, greenhouse gas savings on one hand; and on the other hand, the distant promise of a breakthrough that suddenly makes the whole problem that much easier to solve. Yet unlike the greenhouse gas savings associated with barriers and incentives, what actually happens to achieve the innovation related savings remains somewhat of a mystery.

So far in our reviews of sectors and regional policies, we have focused mainly on policies affecting barriers to the adoption of existing lower carbon alternatives and incentives for mature or maturing technologies. We note how these policies have begun to accelerate over the last ten years, and are having a real impact, but we also note that even multiplying the impact of these policies many times over could leave us far short of our climate change goals.

Realizing this, many countries place considerable weight on the need for innovation to address climate change and so dedicate significant policy and resources toward moving forward innovation. However, unlike policies for barriers and incentives, the impact of in-

novation policy on climate change has the potential to spread far beyond the policymaking country, as lower costs and new technologies spread around the world. Thus, we believe it is appropriate to look at climate change-related innovation policy on a global basis.

In some ways, we have a good starting point to work from. The world has vast experience with technological innovation. Recent developments in communications, medicine, and other fields of science spring to mind immediately. Experience from other areas can provide us with some very important lessons about how innovation can be driven by markets or policy, or how innovation can spring from the fruits of scientific discovery and

research and development (R&D). However, there are key differences for innovation when it comes to climate change policy.

First, for climate change, innovation policy may service a global goal as well as national goals like economic growth. Second, rather than focusing on new technologies purely to foster growth, climate change innovation may focus on achieving climate protection goals with a minimum negative impact on economic growth. Third, and most importantly, the climate protection goal includes time pressure: It gets more difficult the longer we wait. Thus, uniquely, climate change-related innovation places a premium on timing. We cannot afford to wait and see which innova-

tion leads to some new economic benefit; we need to innovate to head off climate change, and we need to innovate fast.

World experience tells us that innovation takes many forms, and so does innovation policy. Technologies at different stages of innovation raise different policy issues and require different policy approaches. Successful innovation support must, first, employ the right tools for each of the various stages and the distinct issues they pose; and, second, distribute resources and interventions to the stages where they are most beneficial.

TABLE 1: STAGES OF INNOVATION AND ASSOCIATED POLICY ISSUES

	Basic Research & Development	Applied Research & Development	Demonstration	Commercialization	Deployment/Market Accumulation	Diffusion
DESCRIPTION	“Blue skies” scientific research, often with broad application (or with no particular application in mind)	More engineering oriented; attempts to join the findings of basic research with technological possibilities	Prototypes are created, tested, and brought to scale to demonstrate their feasibility to potential users and investors	New or existing firms deploy multiple units for the first time and major market players get involved	Technology is rolled out in significant numbers, generally with continuing regulatory support to compete with mature technologies	Technology becomes competitive and established on a large scale, and targeted policy support is withdrawn from technologies
SAMPLE TECHNOLOGIES	Materials science Plasma physics	Nuclear fusion Advanced batteries	Carbon capture and storage Tidal power Cellulosic biofuels	Offshore wind Concentrated solar power	Onshore wind Solar photovoltaics Conventional biofuels	Compact fluorescent lights
POLICY ISSUES	High uncertainty about outcomes or benefits creates risk, so innovation needs to create a portfolio of options Long time frame until commercial payback		Portfolio and investment horizon still a concern, but now ownership of intellectual property and commercial and environmental risks take a greater role	Harnessing market forces to bring costs down Incentivizing cost differential vs. conventional alternatives, and adjusting incentives as market develops Encouraging economies of scale Balancing property rights necessary to appropriate benefits of innovation with role of beneficial competition to deploy technology	Phasing out financial support while maintaining market momentum Encouraging continuing innovation and cost reduction	
PUBLIC VERSUS PRIVATE RESPONSE	Longer paybacks require patient capital to recover benefits Funding likely to be based less on long-term commercial incentive, but can be based on longer-term social benefit Long time frames and distance from market generally provide weak incentives for the private market, leaving more to the public sector			Payback periods begin to shorten and commercial incentives can strengthen private response Early stages may depend on longer-term strategies that require confidence in public support or the eventual size of the market opportunity Later stages may develop their own momentum, but public support can still be needed to reduce risks or improve economics		
POLICY EFFECTIVENESS QUESTIONS	Technology selection and maintaining portfolio Increasing and measuring the effectiveness of the research portfolio		Maximizing learning for technology development and providing confidence for next stages Cost effectiveness	How well policy promotes deployment to accelerate learning and cost reduction Relative effectiveness of broad market pull policy (e.g., renewable portfolio standards) vs. targeted policy (e.g., on specific value chain segments or streamlining processes) Promoting local learning (to appropriate benefits) and global learning (to drive worldwide deployment and cost reduction)		

THE STAGES OF INNOVATION—AND THEIR DISTINCT POLICY CHALLENGES

In the classic model of technology innovation, innovative activity begins with basic research, which is then further developed, applied to specific uses, demonstrated as effective, and ultimately commercialized and diffused to the marketplace. The relative roles of the public and private sector change as technologies move through the stages of innovation, and the form of policy changes as well.

Table 1 defines the stages of innovation and the policy issues that arise at each stage.

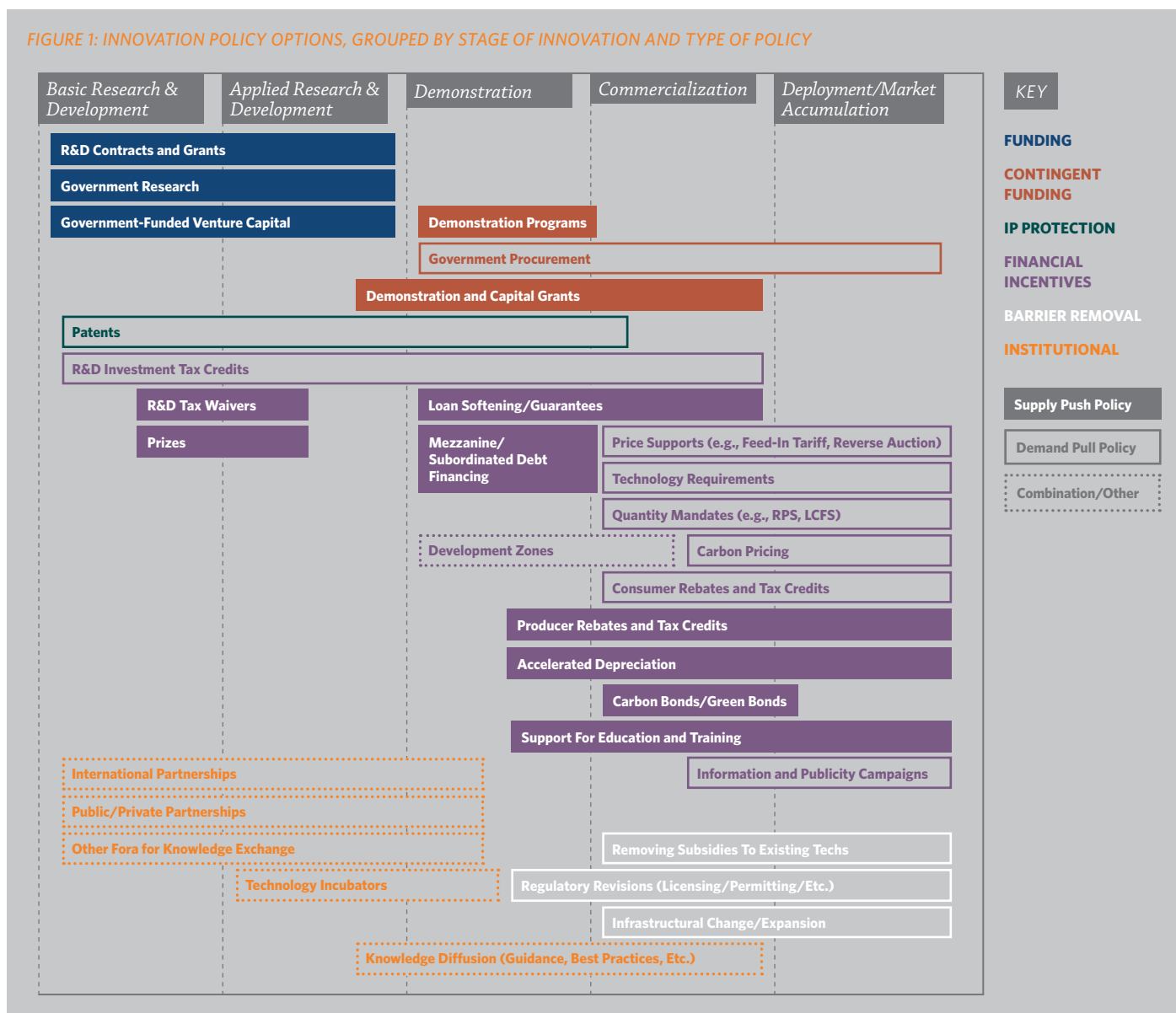
Of course, the stages of innovation are not so neatly divided in practice—they interact with each other, and technologies can span multiple stages. (Kline 1986) Technologies in later stages are often informed by continuing R&D, particularly if existing processes prove to be insufficient. Moreover, technologies that begin life in different sectors can also benefit each other. For example, solar PV has greatly benefited from spillover R&D developments in silicon technology undertaken for the semiconductor industry.

Figure 1 presents a partial list of innovation policy options that are relevant to climate change and groups them by type of policy, as well as by the stage of innovation. A key

distinction between innovation policies is whether a policy works by providing support to a technology to “push” its prospects forward, by stimulating consumer demand to “pull” the technology into the market, or by doing both. Figure 1 distinguishes between these types of policy.

All of the regions in our study have implemented policies targeting innovation, both independently and as part of international efforts. We briefly discuss some of their experiences to illustrate the variety of innovation policy challenges and solutions.

FIGURE 1: INNOVATION POLICY OPTIONS, GROUPED BY STAGE OF INNOVATION AND TYPE OF POLICY



BASIC AND APPLIED R&D

Basic R&D and applied R&D are the earliest stages of innovation. At these stages, common policy tools include direct funding for research, broad incentives for research activities, and institutional arrangements that aim to solve coordination problems, either across governments or between government and the private sector. However, applying these tools with the scale and urgency necessary to have an impact on climate change has been a significant challenge.

One prominent example of this issue is the global research effort on nuclear fusion. The promise of fusion is alluring—nearly unlimited energy with virtually no fuel constraints and no high-level radioactive waste. However, in practice, the scale of investment needed for progress in fusion and the uncertainty of its payoff have made it politically unviable at the national level.

To address these issues, an international effort, known as ITER, launched to build a machine capable of exploring the science of controlled fusion at the needed scale. However, since its inception in 1985, ITER has faced a host of difficulties and delays, wavering funding commitments, evolving technical and scientific requirements, and, consequently, ever-escalating costs. The attachment of the project to a single energy technology concept (tokamak magnetic fusion) may have increased its political and international coordination challenges. But to address the climate challenge in the limited time we have, we may need to employ big basic science globally as part of the solution; we need to figure out how to coordinate policy support to get it done, and done well.

At the applied R&D stage, policy solutions often involve offering intellectual property protection to the innovators. This raises some tough questions given the time frame of the climate challenge. Assigning monopoly rights for a particular technology gives an incentive for private actors to innovate. But it also means the rest of the world must pay—or wait—to benefit from the technology.

Given the time pressure, monopoly rights and the medium-term economic inefficiencies they present—including, possibly,

slower adoption rates—may not be the most effective way of incentivizing innovation. But government-directed R&D, the most obvious alternative, can sometimes suffer from lack of commercial focus or even a lack of incentive to commercialize a good technology.

To create a more dynamic incentive for innovation through government R&D, the U.S. 1980 Bayh-Dole Act gave patent rights to inventions arising out of government-sponsored R&D in order to increase the likelihood and speed of commercializing technologies. The results have been a qualified success, with many observers citing increases in patents, licensing, and commercialization of technologies related to government R&D—for instance, since 1980, “8,778 new firms have been established to develop and market academic R&D.” (Schaat 2012) However, some observers question whether the increased activity was due to the Act itself, or to underlying trends in research and technology development that were already independently underway.

Where applied research questions are smaller in scale and more narrowly defined, offering a prize may be an attractive alternative to intellectual property protection that can overcome the collective action problem. For example, in 2007, the United States established the Bright Tomorrow Lighting Prize, or “L Prize,” for manufacturing an ultra-efficient replacement for common light bulbs. One \$10 million prize was awarded in 2011 for an ultra-efficient replacement for household 60-watt incandescent bulbs, and this technology is now commercially available. However, prizes may work better for some innovative activities than for others: pursuit of prizes is an uncertain endeavor, as innovators must face the possibility that they will fail to win and not receive the prize as a return on the capital they spend.

DEMONSTRATION

The middle stages of technology development are known as the “valley of death,” where nascent technologies seek to prove their commercial viability as public funding tends to wane. As projects move to the demonstration stage, they often begin to attract venture capital funding, easing the burden on public funding. But many technologies fail

to make this transition. For some technologies, amassing sufficient support to scale up can be a serious challenge. Global efforts on carbon capture and storage technology have met this problem: there have been many attempts to demonstrate the viability of carbon capture and storage, but available funds have been spread too thinly over too many projects. Demonstration projects have progressed slowly and proven very expensive, and in recent years, several planned large-scale projects have been scaled back. (Global CCS Institute 2012) The challenges of carbon capture and storage illustrate the need for policy coordination, to ensure that the allocation of funding across multiple projects and technologies still allows large-scale individual projects to move forward.

COMMERCIALIZATION, DEPLOYMENT, DIFFUSION

As innovative technologies move into the marketplace, they increasingly generate profits for their producers. The timeframe for realizing gains from innovation is shorter, and technology risk is lower. The private sector can play a larger role at these later stages, with policy serving to support continued innovation as technologies mature. At these stages, policy support generally takes the form of market pull measures: Policy tools aim to expand the market for the new technology, with the hope that costs will fall as it gains market penetration.

The expansion of the solar PV industry and the phenomenal decline in solar PV system costs reflects a complex interaction of national policies and market forces to foster potentially game-changing innovation. Arguably, learning by doing—the experience gained from cumulative global experience in manufacturing and design—has been a major contributor to declining costs. From this perspective, multiple national solar PV deployment policies, and the German feed-in tariff in particular, have contributed to fostering cost-reducing innovation by greatly expanding the market for solar panels. Chinese manufacturing support policy has also helped grow the industry on the supply side, while competition among manufacturers has driven down costs.

The solar PV experience shows that a combination of policies can work effectively to drive

down technology costs. But it also points to questions of how policy effort is spread across countries. When one of the most important inputs to reducing technology costs is global cumulative experience, how do countries share the costs of gaining that experience?

As technologies mature, they may also require innovation beyond the technology itself, including novel financing and policy approaches. In solar PV, innovation and learning have also been needed to drive down costs associated with project development and finance, permitting, construction, connection to the grid, and maintenance. As the costs of solar cells fall, these other costs constitute a greater proportion of total system costs, and differences between countries and regions have become more important. Here, local policies can play an important role—for instance, in streamlining permitting. This experience points to the importance of looking across the entire value chain to address enabling processes and institutions, and creating a package of policies that work together.

BALANCING POLICY SUPPORT ACROSS INNOVATION STAGES

In practice, technologies often span many stages of innovation at once, creating the challenge of finding the right balance of policy supports across multiple stages. As the first technologies progress towards demonstration and commercialization, next-generation improvements often offer additional potential.

The first generation of biofuel technologies—biodiesel from soy and ethanol from corn kernels and sugar crops—are now commercially viable, but have limited climate benefits or scope for further scaling. Advanced biofuel technologies may have much greater promise. The EU and the U.S. have unleashed a full suite of policies to bring advanced generation biofuels to commercialization. Technology push programs in both regions include grant programs for R&D and demonstration, as well as loan guarantee programs. Both regions have also established demand pull policies, such as mandating biofuel use in transport fuels and offering biofuels-related tax incentives.

Yet, commercially viable cellulosic and drop-in biofuels have failed to live up to policy time-

tables, raising questions about policy coordination. How are innovation-targeted policies best coordinated to achieve timely deployment of a needed technology? Are the delays due to problems with the policy mechanisms themselves, or institutional issues, such as consistency in priorities across programs?

THE BIG POLICY QUESTIONS: MAKING INNOVATION POLICIES MORE EFFECTIVE, AND GETTING THE MIX RIGHT

There is broad consensus that in order to solve the climate challenge in the limited time we have, a massive R&D effort is needed, spanning both public- and private-sector actors around the globe. Numerous observers have concluded that current worldwide R&D expenditures in clean energy are far from adequate—one-tenth to one-half of what is needed to avert dangerous climate impacts. (Nemet and Kammen 2007)

Meeting this challenge motivates two overarching policy questions. First, how can we make policies at each stage of innovation most effective—and quickly? Second, how should government allocate support among the different stages of innovation?

The successes and failures of past innovation policy efforts are surely useful in answering these questions. But drawing clear lessons from past experience can be difficult. Innovation is notoriously hard to measure. The object being measured is very abstract: the creation or development of new ideas. Innovation is a high-risk, high-reward proposition, particularly at early stages. By supporting low-carbon technology possibilities at each stage of innovation, governments are seeking to improve the odds of uncovering a game-changing technology. Even after the fact, it is difficult to determine which policy efforts were successful at doing this, particularly due to long lead times and uncertainty. A successful innovation policy may not produce measurable results for years, and may only produce results in a small fraction of the ventures it impacts. As a result, there is a dearth of empirical evidence on the impact of policy on low-carbon energy technology innovation, and even on innovation in general.

Given the enormous promise of low-carbon innovation, however, these questions are too important to set aside. ■

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