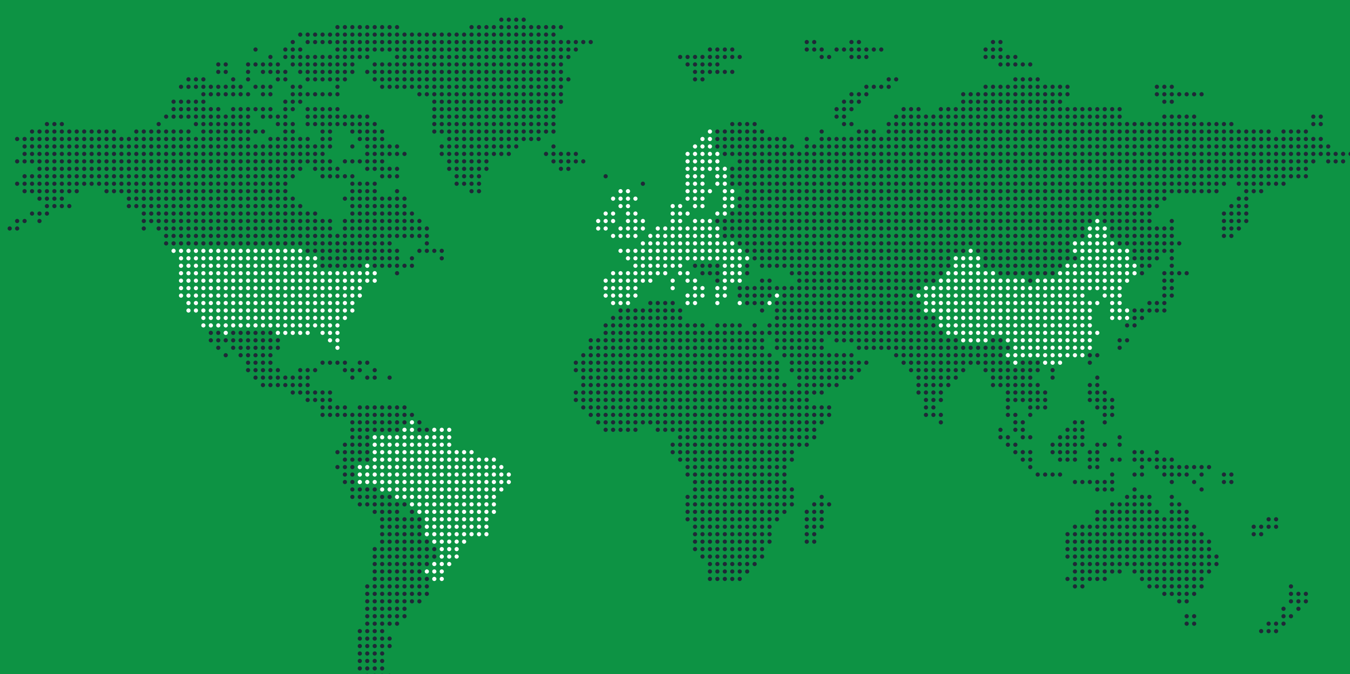
GREEN GROWTH LEADERS

GREEN GROWTH: FROM RELIGION TO REALITY

7 case studies on ambitious strategies to shape green growth



BRIE Berkeley Roundtable on the International Economy

The Pathways Project and CRESTS
Discovering the path to a low-carbon tomorrow

Prepared for Green Growth Leaders by:

Mark Huberty, Huan Gao, and Juliana Mandell, John Zysman, Nina Kelsey, Jakob Riiskjaer Nygård, Jeremy Pilaar, Andrea Seow, Pilar Fox, Alice Madden with Jany Gao, Kate Goldman, Irene Choi, Crystal Chang and Benjamin Allen

INDEX

FROM RELIGION TO REALITY:

Energy systems transformation for sustainable prosperity[1]

John Zysman[2] and Mark Huberty[3]

1 Earlier versions of this paper were prepared for the European Council Informal Competitiveness Discussion – Internal Market during the Belgian Presidency Brussels, September 30, 2010; and Green Korea 2010: Strengthening Global Green Growth Strategy: Policy and Cooperation."September 9, Seoul Korea, sponsored by the National Research Council for Economics, Humanities, and Social Sciences (NRCS), the Presidential Committee on Green Growth (PCGG) and United Nations Department of Economic and Social Affairs (UNDESA).

2 John Zysman is Professor of Political Science, University of California Berkeley and Co-Director, Berkeley Roundtable on the International Economy.

3 Mark Huberty is a Ph.D. Candidate in Political Science at the University of California Berkeley and Graduate Researcher at the Berkeley Roundtable on the International Economy. Support for this research came from the United States Environmental Protection Agency STAR Fellowship and the Fulbright-Schuman Fellowship.

1: Green growth: moving the discussion from religion to reality?

There are compelling and varied arguments for moving to low-carbon, high-efficiency energy systems. Reducing emissions to limit or avoid climate change leads the public debate, but reduced dependence on imported energy, avoidance of conflicts over energy resources, and the rising price of fossil fuels also motivate action. Nevertheless, the potential cost and difficulty of making the transition to a new energy system have generated substantial opposition from entrenched economic interests and consumers alike.[4]

In this article we ask whether and how this transformation could become an economic opportunity rather than a costly burden. Could a transformation to a low-carbon energy system induce net economic growth that can ease the transition to a low carbon economy? Or must it only be a pricey impediment whose costs offer support to those who would resist change? We address three aspects of this problem:

1. What are the proper roles for markets, prices, and governments in the move to a new energy system?
2. Which policy interventions can become investments in a productive future, and which are just costs that we must bear to achieve our other policy objectives?
3. Can the shift to low-carbon, high-efficiency energy drive “green growth” and business opportunity?

As we shall argue, answering these questions must begin with the concept of *an energy systems transformation*, which we turn to in the next section.

To date, such discussions of “green growth” have been more religion than reality. For those convinced of the urgency of a low-carbon energy systems transformation, “green growth” holds out the hope that the investment and innovation required for this transformation can become the foundations of a new wave of economic growth. This would cut the Gordian knot of tradeoffs between economic growth and emissions reduction. Doing so, it would solve the political economy problems created by the transition to a low-carbon society, offering a world where a growing green economy rewards the winners of the green energy revolution and compensates to its losers. Given these advantages, it is no surprise that politicians from Brussels to Beijing have embraced the promise of green growth via energy systems transformation.[5]

"The easiest arguments about green growth are not satisfactory"

But the easiest arguments about green growth are not satisfactory. Indeed, both politically and technically, the green growth arguments are fraught with challenges. New “green collar” jobs may not be enough to offset the “brown collar” jobs they replace. Green growth wholly dependent on export of green energy products threatens a new green mercantilism where countries view green growth as a zero-sum game. And while green energy may offer new opportunities to the energy sector, it remains unclear what new prospects an energy system built on “green electrons” offers to the wider economy, which already enjoys abundant, dependable energy from otherwise indistinguishable—but cheaper—“brown electrons.”

Debates over energy policy remain rooted in issues of how much must be paid and by whom, and solutions mired in what appears to be diffuse, hard-to-identify benefits in the face of acute and easily observed costs. Whether right or wrong, those fears limit support for the transformation. Moreover, given the central importance of the energy system to modern industrial society, the effort to change the system will in any case encounter determined interests entrenched in the old order. In this context, it’s no wonder that change has been slow in coming for all but those economies most exposed to unstable energy prices and supplies.

4 Certainly, climate change mitigation will require significant reductions in carbon emissions over the next century. The enormous carbon footprint of fossil fuels suggests that this goal will require the transformation of today’s energy system. Dependence on imported energy poses, for many countries, significant economic and political security risks, quite apart from the impact on their balance of payments. Conflict over energy resources will, very likely, become more intense as the energy requirements of the emerging economies particularly the new titans – China, India and Brazil – expand. Apart from conflicts over access to resources as demand pressures mount fossil fuel prices will rise and often spike. A broadly cast solution will be needed to contain emissions, limit import costs and political vulnerability and help stabilize energy cost. Just adding energy efficient lighting or solar panels to the existing system will not solve any of these problems. The changes required will be significant.

5 For a full review of the debates on green growth and the evidence for the positions in that debate, see: Mark Huberty et al, "*Shaping the Green Growth Economy*: a review of the public debate and prospects for success", prepared for The Mandag Morgen Green Growth Leaders Forum, April 2011. Available at greengrowthleaders.org/wp-content/uploads/2011/04/Shaping-the-Green-Growth-Economy_report.pdf. Last accessed 9 May 2011.

2: "Green growth and the transformation of the energy system: a first step toward reality"

The advocates of "green growth" may be correct. Indeed, we hope they are. But moving green growth from religion to reality will require going beyond jobs or exports to examine how changes in to the energy system can create pervasive economic growth. Earlier systems transformations—the railroads or information technology—drove growth by changing the possibilities for production in the broader economy. The opportunities that emerged from these transformations created powerful interests that sustained them, and generated the profits and employment to continue investment in the new system and absorb the workers displaced from the old. Green growth, if it emerges, must come from this kind of systems transformation.

"Earlier systems transformations—the railroads or information technology—drove growth by changing the possibilities for production in the broader economy."

By *system*, we refer to an array of separate elements complementary to one another and tightly inter-linked. In economic terms the widespread adoption of some technologies requires investment in related, complementary, technologies. Thus, as is now understood, widespread adoption of intermittent renewable energy resources will require complementary changes to modes of energy distribution and patterns of energy use.[6] Those complementarities, in turn, are not merely technological but economic and regulatory as well. Absent adaptation of energy markets and regulatory systems along with the technological changes required for low-carbon energy, the energy system will not maintain its ability to provide reliable, predictable energy to the economy. The resulting difficulties will slow the transition to a low-carbon, high-efficiency economy. It is this complementary series of technological, economic, and regulatory changes that we refer to as *an energy systems transformation*.

The character of these complementary changes implies that policy must target a particular kind of transformation. That transformation must emphasize a shift to a different trajectory of energy development, not merely the improvement of the existing system. More efficient light bulbs, or better gas mileage for vehicles, can improve the efficiency of today's energy system. However, those changes will not fundamentally transform our dependence on carbon energy. Doing so will, instead, require an altogether new systems trajectory, one that promotes complementary innovations leading to a low carbon system that produces, distributes, and uses energy in new ways.

This will require more than just one-off technological breakthroughs. For instance, advances in wind power technology must be matched by developments in the power grid and energy use to accommodate wind power's fundamental intermittency. Likewise, an efficient, reliable electric car will require substantial increases in electricity supply from low-emissions sources, and a new network of refueling stations, even as it promises to radically reduce the role of oil in transportation. These problems demonstrate the importance of energy as a system, and inform against approaching treating the problem as one of isolated solutions.[7]

This article argues that political and economic success at such a green energy-led systems transformation can only come from the possibilities it would create for the broader economy. Facilitating those possibilities confronts policymakers with two problems: first, how to shift the development of the energy system from its present high-emissions, low-efficiency trajectory to a low-emissions, high-efficiency alternative; and second, how to enable the broader economy to discover and express the presently unknown—and unknowable—opportunities that such a new system may create. In the past, most of the value of systems transformations, whether the railways and transport or IT and communications, was created by network users rather than by the networks themselves. Green growth will require the same of this transformation of the systems and networks that power the economy.

This argument poses serious challenges to climate and energy policy. Given the need for coordinated transformation of the energy system's capacity to produce, distribute, and use energy, price alone may be insufficient in spite of prevailing policy wisdom. Moreover, the power of a network transformation may lie less in the particular technological characteristics of the new system than in the design of the markets, access rules, and standards that facilitate its exploitation. Finally, and in contrast to appeals for a one-size-fits-all approach to climate and energy policy, the link between green growth and energy systems transformation will depend critically on national circumstances and require distinct national strategies.

Hence green growth is by no means certain and poses serious challenges to the public and private sector. This article lays out those challenges, and explores how they can be resolved given the logic of the energy system itself. In particular, we emphasize that policymakers should exploit the critical role that the power grid will play in this transformation for strategic leverage over the entire energy system. Conceived correctly, both strategic investment and market reform, in the context of broader interventions including a carbon price, offer the best opportunity to exploit emissions reduction to generate sustained and sustainable economic growth.

3: Why a transformation: decentralization, intermittency, and demand management

Most discussion of renewable energy and emissions reduction emphasizes the sources—wind, solar, nuclear, geothermal and others—that will provide the carbon-less

6 Roger Noll (2011) writes " As a result, many prospective technologies that might contribute to reducing the cost of curtailing GHG emissions are complements of either other potential green technologies or other investments that must be made to accommodate their widespread adoption. " See "Encouraging green energy: a comment", *Energy Policy*, forthcoming.

7 This system transformation will require difficult changes in three distinct domains, 1) Energy efficiency can reduce demand, but those demand reductions make planning harder and diminish the requirements for new capital investments potentially embodying low carbon technology. 2) Renewable electrical energy sources are intermittent, creating new demands for grid management. Biofuels require significant alteration of fuel distribution systems; and 3) Decarbonizing existing fuel sources, as well as introducing renewables, comes at the price of higher energy costs. Those costs must be borne directly by energy users, but the benefits are quite diffuse.

"Viewed as mere source replacement, the green energy revolution would have only a limited impact on the economic activity of an advanced industrial economy"

electrons to power a clean energy economy. Why, then, do we speak of a transformation of the energy system, rather than a program for investment in new energy sources? We would argue that source replacement alone cannot achieve the scale of renewable energy adoption required for serious decarbonization of the energy supply. Moreover, viewed as mere source replacement, the green energy revolution would have only a limited impact on the economic activity of an advanced industrial economy. Technically, large shares of renewable energy pose serious challenges to today's centralized, constant-load, supply-equilibrated energy supply. Economically, mere replacement would have a defined and very limited scope, limiting further the growth prospects for replacement of cheap fossil fuels with expensive renewable energy. Thus any hope of both decarbonizing the energy supply and achieving economic growth via clean energy requires looking at the possibilities of the broader energy system.

Technically, renewable energy poses three challenges to the functioning of modern energy systems. Today's energy systems provide constant energy supplies through centralized distribution systems that treat demand as an exogenous variable. Tomorrow's renewable energy systems must manage both demand and supply to accommodate the variability of renewable energy generated by a wide range of distributed energy systems. These three challenges together imply an energy systems transformation. They also demonstrate the importance of the power grid to this transformation.

Centralization poses the first challenge. Since Nikola Tesla's alternating current system won out over Edison, large, centralized power plants have dominated modern energy systems.[8] Improvements in long-distance transmission now mean that most generation plants are now located far from centers of economic demand. Electricity flows almost exclusively from the plant to the center of demand, via a series of transmission substations.

Renewable energy requires a very different structure for the energy system. Because plants must be located wherever renewable resources may be found, renewable energy frustrates any attempt at centralization. To accommodate distributed generation, a power grid designed around centralized power plants must be reconfigured to handle different inputs, of different scale, from a geographically disperse set of resources. This will require significant new investment in transmission and distribution capacity.[9]

These investments are closely related to the second challenge, intermittency. Fossil fuel sources provides electricity as stable as the supply of fossil fuels to their boilers. This has meant a reliable, stable, dependable energy supply for industrial societies. In contrast renewable energy resources like wind and solar are notoriously intermittent, in ways unrelated to the actual demand for energy.[10] Stabilizing the energy supply from renewable energy sources therefore requires complementary measures of one of two forms. Geographic diversification provides one possibility. Intermittency is very weakly correlated over long distances: wind speed in North Dakota and solar intensity in Arizona don't vary in the same way at the same time. If transmission capacity can tie together sufficiently geographically dispersed markets, then energy supply can be averaged to match energy demand.

Alternatively, a range of new energy storage solutions can be added to the grid in order to stockpile energy generated at times of low demand for use at times of high demand. Again, however, this requires that the power grid have the ability to accommodate a much wider diversity of sources than it does at present, and to manage those sources in real time against the demands of industrial societies. In either case, however, the problem remains the same: moving away from fossil fuel dependence for the power supply will require a set of complementary changes to the electricity grid. Source replacement alone will not suffice to achieve a low-carbon energy systems transformation.

Whether some of these challenges can be made easier by demand management brings us to the third driver of energy systems transformation. Historically, the energy system treated demand as a given and worked to provide sufficiently flexible supply capabilities to satisfy it. But managing demand against supply may offer both price and performance advantages to the energy system. If some forms of energy demand can be adjusted in tandem with variability of renewable energy supplies, it could increase both the efficiency and the stability of the system. Such an approach would be vital to the large-scale incorporation of electric vehicles, which would simultaneously represent an enormous new demand on the system and a huge potential pool of electricity storage.

Thus three challenges—intermittency, distributed generation, and demand management—suggest that only a transformation of the energy system will suffice to decarbonize the energy supply of modern industrial societies. Source replacement alone cannot achieve the level of renewable energy generation required without posing serious challenges to the stability and reliability of the electric grid. Taken together, this implies a threefold transformation for energy production, distribution, and use.

This transformation will require huge investments across the economy. A variety of popular and policy arguments has suggested that these investments represent the next technological transformation of the economy, implying manifold new opportunities for innovation, employment, and economic growth.[11] If true, the economic possibilities they imply could more than offset the costs of investment. The "green growth" that ensued would turn the logic of climate change on its head, suggesting that climate change mitigation could generate real, material benefits in addition to the abstract benefit of averted global climate change. This would fundamentally change the terms of debate. But how should we understand the

8 See Thomas Hughes' excellent treatment of the interaction of technology, social structures, and politics during electrification, in Networks of Power: electrification in Western society, "1880-1930 (Baltimore: The Johns Hopkins University Press, 1983) and "The Electrification of America: the system builders", Technology and Policy 1979, pp124-161.

9 Indeed, European Union Energy Commissioner Günther Oettinger has called for € 1 trillion in new energy infrastructure investment in the European Union over the period 2011-2020, in order to accommodate new renewable energy capacity. See "Energy Infrastructure Priorities for 2020 and beyond – a blueprint for an integrated European energy network" (The European Commission, November 2010).

10 Most studies of the manageability of high-renewable-energy systems suggest 20% as the limit for renewable energy penetration in the current system. See, for instance, "Accommodating High Levels of Variable Generation" (Integration of Variable Generation Task Force, North American Electricity Reliability Corporation, 2009). Denmark already obtains 20% of its electricity from renewable energy, mostly wind. At high-wind periods, the flood of wind energy into the power grid can destabilize the grid and drive electricity prices below zero. As a consequence, the Nordpool energy markets, of which Denmark is a part, have imposed a € 200/MWh tariff on Danish wind farm operators who do not shut down their turbines at periods of high energy demand.

11 See, for instance, "Van Jones, The Green Collar Economy: how one solution can fix our two biggest problems" (San Francisco: HarperOne, 2008); The European Commission, "An Energy Policy for Europe", Communication to the European Parliament and European Council no. SEC(2007) 12, 2007; and United States President Barack Obama, "State of the Union Address", January 27 2011.

possibility of this outcome? For that, we turn to other instances of technological transformation in networked systems, to see where and how they supported sustained economic growth.

4: An earlier transformation: networks and the ICT revolution

Significant infrastructure changes have often prompted broad investment to take advantage of them. Railways in the 19th century radically transformed time and space, drove transport costs to a minimum, and opened up vast new territories, resources, and markets to economic activity. Likewise, the information technology revolution built new business models and products atop radical changes to the structure and function of telecommunications networks. Both transformations provided the foundations for decades of sustained economic growth.

"The network—power grids or rail infrastructure—played the critical role in each transformation"

These earlier transformative epochs provide important lessons for thinking about how and where the transformation of the energy system—itself a network like rail or information technology—could do the same. In each case, two lessons stand out: first, that the network—power grids or rail infrastructure—played the critical role in each transformation; and second, that most of the growth generated by these earlier systems transformations came from the possibilities created for the broader economy, rather than from the investments in the system itself. This mismatch between the social and private benefits should lend caution to those predictions of pure market-based solutions.

We begin with the ICT revolution. In 1991, the United States National Science Foundation opened its internal, distributed information network that it had inherited from the Department of Defense to commercial activity. The Internet, as it came to be known, was born. By 2000, internet-related commerce accounted for at least $100 billion in annual turnover and 2.5 million jobs in the United States alone[12], acounted for several firms in the Fortune 500, and laid the foundations for a second round of innovations in social media, communications, and logistics management that continue to this day[13]. Thus, within twenty years of commercialization, the internet had radically transformed both communications and the broader economy, and generated significant economic growth and productivity improvements.[14]

Why did the digital revolution happen so quickly, and so smoothly? We argue that the economic transformation wrought by the Internet and ICT came in two phases. Both phases merged private-sector investment and innovation with public-sector market formation and rulemaking. While neither phase proceeded via some grand design, both shared critical features: support for basic research and development as well as early deployment, market rules that favored openness and access and checked monopoly and tremendous private sector investments in experimentation both within and on top of the evolving network. That experimentation established a symbiosis in which rapid innovation in new ICT products created ever-new possibilities for incorporation of digital technology in production processes and products. Those new possibilities, in turn, drove new demand that funded subsequent waves of ICT innovation. This symbiosis, founded on the possibilities ICT created for the economy at large, made the revolution self-sustaining.

The first phase of the ICT revolution, lasting from the invention of the transistor in 1947 to the introduction of the personal computer in the 1980s, coupled private sector innovation to public-sector restriction on the ability of dominant market players to restrict the diffusion of those innovations. Many of the innovations critical to the ICT revolution came out of industrial giants, most notably AT&T and IBM. Left to their own devices, either firm might have used their monopoly positions to generate rents, constrain market competition, and compete on the basis of network access instead of product features. Instead, AT&T found itself the subject of ongoing antitrust scrutiny starting as early as 1947 – well this goes back to MCI and even answering machines. IBM came under scrutiny starting in the late 1960s. That meant that although AT&T's Bell Labs invented the silicon transistor in the 1950s, the technology quickly diffused into the market, rather than remaining trapped inside the AT&T monopoly. An ongoing set of antitrust and network access decisions meant that AT&T could not use its ownership of the communications network to limit access to new competitors exploiting the possibilities in emerging digital technologies.

Likewise, IBM initially thought that their control of the BIOS—the control logic of a personal computer—would allow them to control the PC, while they outsourced the operating system and other components. But IBM could not dominate semiconductor markets without falling afoul of its federal antitrust investigators. As a consequence, the personal computer became an open standards platform. This gave rise to the IBM clone market, massive competition and price pressures, and increasingly inexpensive computing power. Thus private innovations—the semiconductor, the transistor, and the personal computer—were coupled to public initiative to ensure that new technologies were not constrained by the market power of dominant players.

Finally, especially in the 1950s and 1960s, but less so thereafter, a number of the initial products of private sector firms were predominately purchased by governments with bottomless pockets and a perceived need for maximal performance—chiefly the United States Department of Defense and the space program—whose purchases at very high prices with enormous margins underwrote the early experimentation in the industry.

In the second phase of the ICT revolution, beginning

12 See the summary of Measuring the Internet Economy in John Leatherman, "Internet-based Commerce: Implications for Rural Communities" Review of Economic Development Literature and Practice 2000:5. The United States Census Bureau puts the total value of e-Commerce related shipments in 2004 at $996 billion. See "E-stats", 27 May 2005, at http://www.census.gov/econ/estats/2005/2005reportfinal.pdf. Last accessed 9 May 2011.

13 Tyler Cowen would argue that this last series of innovations marks the erosion of the long tail of investments made in the 1960s and beyond. Whether this holds true or not remains to be seen; though Kondradieff-wave style arguments would suggest this to be true. See "The Great Stagnation: How America ate all the low-hanging fruit of modern history, got sick, and will (eventually) get better" (New York: Dutton, 2011).

14 Those productivity improvements have been famously hard to track. For attempts at quantification, see Bart Van Ark, Robert Inklaar, and Robert McGuckin (2002) ""Changing Gear: Productivity, ICT, and Services: Europe and the United States" Research Memorandum GD-60, University of Grönigen Growth and Development Center; and Sinan Aral, Erik Brynjolfsson, and Marshall Van Alstyne "Information, Technology and Information Worker Productivity: Task Level Evidence". Econometricians have been skeptical of these claims. For an earlier attempt at establishing ICT-based improvements to productivity, see Alan Krueger (1993) "How Computers Have Changed the Wage Structure: Evidence from the microdata, 1984-1989" The Quarterly Journal of Economics 108(1) February 1993, pp33-60. John DiNardo and Jorn-Steffen Pischke (1996) responded to this attempt by using the same methodology to show similar productivity gains from pencils, suggesting that the identification strategy contained severe flaws. See "The Returns to Computer Use Revisited: Have Pencils Changed the Wage Structure Too?" NBER Working Papers Series no. 5606. National Bureau for Economic Research.

in the mid-1980s, private innovation was again facilitated by public action, this time in the realm of standards-setting. Rapid growth in ICT depended on the interoperability of a range of devices. Absent standards, the large positive network externalities of the internet might not have materialized. Indeed, a network model along the lines of first-generation firms like AOL or Compuserve might have led to competition over network access rather than product features. Instead, the early emphasis of DARPA and the NSF on an open, redundant, standards-based network and, in particular, TCP-IP led to what became the Internet. Coupled to antitrust restrictions on control of telecommunications networks, those standards enabled a range of new competitors—from Cisco Systems to Microsoft to Google—to enter markets controlled by AT&T and IBM, disrupt them, and generate transformative innovation.

Those innovations, in turn, drove a series of investment booms in the 1980s, 1990s, and 2000s. In most cases, the investment in ICT technologies themselves were only a part of the overall investment in the new possibilities for business activity they created. The transformation of supply chains, for instance, merged the information monitoring capacity of ICT with fundamental transformations in the production processes and management structures of major firms. Those changes would not have been possible without ICT, but were nevertheless innovations in and of themselves.[15] As noted above, this symbiosis between ICT-sector innovation and innovation in the broader economy drove a virtuous cycle of innovation, demand, and investment that sustained repeated and rapid waves of ICT-driven economic growth.

We can distill this history to five important points:

1. The ICT revolution built new industries, and later transformed older ones
2. The early construction of that industry was heavily underwritten—both financially and structurally—by the public sector, chiefly the United States Defense Department and the National Science Foundation
3. Regulatory intervention ensured that legacy market players could not use dominant market positions to limit competition through control of either technological standards or network access
4. The economic value of the ICT transformation came from both the networks themselves, the products they enabled, and the processes that they transformed
5. And the ICT revolution sustained itself because digital technologies meant that existing tasks could be done more cheaply and more effectively, and new value-added tasks could be envisioned

We would emphasize the point that, for the most part, the ICT revolution created entirely new industries. Most of the infrastructure that the revolution required had no real predecessor: the capabilities of the PC so overwhelmed those of the typewriter or adding machine that they are almost not comparable. As such, the industry faced few legacy barriers to entry. That lack of barriers created the latitude for experimentation, permitting the structure of the network to evolve free of constraints from legacy systems requirements. As we shall see, this condition, so important to the progress of the ICT revolution, is not reproduced for energy systems.

Thus the ICT revolution was predominately a systems transformation, in two senses. First, it marked a transformation of markets in order to support the development and diffusion of information and network technologies. Second, it generated massive spillover benefits by transforming the possibilities for economic activity in the broader economy. The economic growth generated by the ICT revolution was at the very least equally distributed between the ICT sector and the broader economy. Achieving this kind of transformative growth required both the private investments in new technologies and business models, and public support for open, competitive, standards-based markets in which those investments could thrive.

5: Challenges to green growth: employment, mercantilism, and the limits to systems transformation

The core of the green growth argument suggests that the energy systems transformation described in section 3 can drive the same kind of economic transformation that ICT wrought.[16] To date, however, neither policymakers nor policy analysts have paid attention to whether the conditions that made ICT into a revolutionary technology are also present in the transformation to a low-carbon energy system. Instead, most of the emphasis has concentrated on near-term benefits from jobs or capture of export markets for so-called "green" goods.

This lack of scrutiny poses serious problems not least because of the differences between ICT and energy that become apparent upon even cursory examination of these two systems transformations:

1. Unlike ICT, the energy system in the advanced countries is fully built-out, and new capacity will only be added slowly. Consequently, new approaches to energy must be implemented by retrofitting the existing system.
2. That retrofit must occur while preserving an uninterrupted supply of energy to the economy.
3. Both the public and private sector have limited resources relative to the scale of investment required compared with the initial era of semiconductor and ICT innovation
4. In many countries, certainly the US, the networks belong to a diverse set of owners operating in many different regulatory jurisdictions, frustrating attempts to enforce interoperability for new grid capabilities and open access for new technologies and market players.
5. The investment horizons don't support rapid adoption or iterated innovation. Investments in ICT depreciated over months or years, creating consistent demand

15 For a complete discussion of the process of the revolution and its implications for firm strategies, see John Zysman and Abe Newman, eds "How Revolutionary was the Digital Revolution" (Stanford: Stanford University Press, 2006).

16 In some cases, advocates make this analogy quite explicitly. See, for instance, the internet-energy analogy made by Randy Katz and co-authors in Katz, et al (2011) "An Information-Centric Energy Infrastructure: the Berkeley View" Journal of Sustainable Computing 1(1) 1-17.

for new innovation and investment. Investments in energy infrastructure depreciate over decades.[17]

6. Renewable energy does not, for the most part, offer immediate competitive advantage to early adopters the way ICT investments did.

Given these differences, the short-term focus on jobs is particularly damaging to the long-term prospects for green growth. Absent a renewed focus on how the investments in green energy might translate into broader opportunities for the economy, the contribution of green investment to growth—whether jobs, employment, or productivity—will necessarily remain limited. In this context, the real green growth challenge lies in how best to structure and support markets for green investment and innovation that can discover and express new opportunities created by low-carbon energy for the economy as a whole. Anything less risks an energy policy that achieves only short-term job gains and may inadvertently provoke a new wave of mercantilism in green products.

5.1 Mistaking jobs for growth: the myth of green jobs and the threat of green mercantilism

In the aftermath of the 2007-2009 financial crisis, the "green jobs" variant of the green growth argument gained currency across the industrial world. United States President Barack Obama, the European Union, and a range of American states and European countries have all sought to tie green energy investment to job creation.[18] As Barbier (2010) notes, this led to a significant quantity of economic stimulus funds directed to energy efficiency, renewable energy, and energy-related research and development. Support for these investments were buttressed by fears that insufficient domestic support for energy investment would lead to permanent disadvantages in a new green technology frontier, particularly vis-à-vis new economic powerhouses like China.[19]

"This emphasis on jobs and export competitiveness should raise immediate concerns"

This emphasis on jobs and export competitiveness should raise immediate concerns on two fronts. First, a focus on job creation in the green energy sector alone cannot form the basis of sustained economic growth in advanced industrial societies. If those jobs result from Keynesian demand stimulus, as in 2007-2009, their viability necessarily fades as the economy returns to full employment. But even if those jobs could stand on their own, they would have limited potential for widespread employment. As already discussed, those societies have fully built-out energy systems and relatively modest growth in energy demand. In this case "green jobs" will necessarily replace "brown jobs" in operation of the energy system; and the new "green jobs" created for the period of system retrofitting will necessarily be short-lived, lasting only as long as the retrofit itself. Finally, those "green" jobs will have limited impact on the overall employment picture, as they emphasize the energy sector alone rather than the economy as a whole.[20] Thus even if the investment in systems retrofits will lead to near-term job creation, the timeframe for those jobs is necessarily limited.

The quality of those jobs is also open to criticism. Some argue that an investment in green electricity generates more jobs per unit installed capacity than an investment in equivalent brown energy capacity.[21] But this implicitly suggests that the green energy industry achieves, at present, lower labor productivity than the fossil-fuel power sector. If the goal is pure Keynesian job creation to employ idle labor, then this justification may make sense. But as a long-term employment strategy, it cannot sustain high wages in advanced industrial economies.[22]

Moreover, the quality of these jobs in high-wage advanced industrial economies requires careful scrutiny. We can think of green jobs as coming in one of two categories: high-productivity producing the components of the energy system; and relatively lower-productivity jobs in the installation and servicing of these components and in other labor intensive domains such as energy efficiency improvements. The former, largely high productivity manufacturing and design jobs, produce largely traded goods. The latter, essentially construction and installation jobs, produce untraded goods. The advanced countries' stated goal of capturing the high-productivity "green collar" jobs as a path to industrial revitalization has given rise to risks of a new "green mercantilism." Countries now openly express concerns that the failure to create domestic markets in green energy will lead to loss of global competitiveness, particularly to the developing world. On the surface this is an excellent justification for domestic "green" investments. However, it risks improper direct and indirect subsidies at home and a conflict over international access to markets abroad. This view of "green growth" as a zero-sum game portends a counterproductive period of international competition that brings to mind the failures of the mercantile system of the late 19th century or the import substitution period of the mid-20th century.

5.2 Beyond jobs and exports: systems transformation and sustained growth

Short-term emphasis on green jobs or green export competitiveness will not lay the foundations for the "green industrial revolution" predicted by advocates of green growth. But as we have seen, systemic investment in disruptive technological innovation may create new opportunities throughout the economy. Industrial history provides many examples, beyond ICT, of situations where innovations in one sector or technology domain enabled dramatic growth in the rest of the economy. These examples underpin much of our understanding about the connection between disruptive technologies and long-term economic growth. A few examples[23] will suffice:

- Steam power, which dramatically altered the amount of

17 Varun Rai, David Victor, and Mark Thurber make this point for carbon capture and sequestration in particular. The large financial and technological risks that CCS presents, coupled with the huge investment cost and regulatory uncertainty, promise to forestall innovation and investment. See Rai, Victor, and Thurber, "Carbon capture and storage at scale: Lessons from the growth of analogous energy technologies" Energy Policy 38(8), pp 4089-4098.

18 For the European Union, see The European Commission (2007). For the Danish emphasis on job creation from renewable energy, see The Danish Government (2011). For related arguments from prominent figures in the public debate, see Jones (2008) and the European Green Party (2009).

19 Chinese competition in renewable energy industries featured heavily in this debate. In 2010, the United States referred China to the World Trade Organization on the basis of allegations that its subsidies to its domestic wind turbine industry constituted unlawful state aid. China's rapid expansion of capacity in renewable energy also led it to capture 90% of the California solar cell market. For the solar market, see Woody (2010) "China snaps up California Solar Market", The New York Times Green Blog, 14 January, at http://green.blogs.nytimes.com/2010/01/14/china-snaps-up-california-solar-market/#more-38129. For China's rapidly emerging wind industry, and Western responses, see Keith Bradsher (2010), "To conquer wind power, China writes the rules", The New York Times, 15 December 2010, page A1; and Mark Scott (2010), "GE, Vestas fall behind in China's 'Tough' wind market", The New York Times, 14 May.

20 The scale of the energy sector points to the limits of job creation in that sector alone. For instance, Denmark obtains about 10% of its overall exports from its wind energy sector. But that sector employs only 24,000 people, or about 1% of the Danish workforce. In most Western economies, the total value of energy consumption runs about 2-4% of GDP; not insignificant, but also not very large compared with the economy as a whole. As such, betting on massive job creation through renewable energy rings hollow.

21 Daniel M. Kammen and Dietlev Engel (2009) "Green Jobs and the Clean Energy Economy" Thought Leadership Papers Series No. 4, Copenhagen Climate Council. At http://www.copenhagenclimatecouncil.com/dumpfile.php?file=ZmlsZWJveC8xODk=&filename=VExTMDQgX0dyZWVuSm9icy5wZGY=. Last referenced 1 March 2011.

power that could be applied to a given task and created a platform for innovation in economic production and transportation
- Railroad transportation, which significantly lowered the cost of transportation and tied local markets into national economies. Railroads shrank time and space, creating much larger markets for goods that justified wholly new modes of firm organization and capital investment.
- Electrification, which enabled the reorganization of factories, and made possible the introduction of myriads of new devices simply not possible with coal or gas.
- The internal combustion engine, which provided the energy efficiency and intensity necessary for the transportation revolution.
- Semiconductors and information networks, which enabled the information revolution and spawned entirely new forms of value creation based on information as a good. The internet fundamentally changed the ability to aggregate, access, process, and use information.

These innovations made possible products, processes, and ways of doing business that simply were not possible earlier. The network innovations in particular– railroads, the electric grid, the internet – all fundamentally changed the possibilities for the organization of the rest of the economy. The new market possibilities, and not just the networks themselves, generated economic growth.

"Spectacular success in adding renewable energy to the energy system means the energy user will notice no difference between electrons generated by coal and those generated by wind or solar."

There is a real question as to whether "clean energy" generates pervasive opportunity in the same way. Spectacular success in adding renewable energy to the energy system means the energy user will notice no difference between electrons generated by coal and those generated by wind or solar. A watt of electricity is a watt of electricity and joule of power is a joule of power. All the investment in storage, the smart grid, and new energy sources will go towards ensuring that today's patterns of energy use remain viable. It will do little to enable some new generation of energy uses. Even the invention of a whole new class of automobiles still only strives to produce a personal transportation device as good as automobiles available today.

Nevertheless, innovations in energy technology may reduce energy costs or provide value by correcting for negative externalities like pollution-induced health costs or extreme weather events related to climate change. But these benefits are largely about cost savings or avoidance of damage. These technologies do not, as of yet, promise radically different, more productive, more diverse forms of economic value creation.[24] Thus green growth and the energy systems transformation on which it depends remain very different from these earlier epochs of transformative technological change.

These differences make it incumbent on those who advocate for green growth to demonstrate the systems advantages that would lead to repeated innovation in the private sector and that would drive growth through new possibilities for products, production, or productivity.[25]

We would point out that the economic significance of radical systems changes often comes in disguise. The advantages of a new energy system may not be evident immediately. In the 1940s, IBM is reputed to have suggested, famously, that it would only sell a handful of its new mainframe computers.[26] The enormous utility of the mainframe and its successors only became apparent through experimentation in the market. Microprocessors followed a similar pattern. Intel had to invest heavily in explaining to potential customers the possibilities of this new device to a lay audience. Indeed, its marketing manager at the time had a Ph.D. in electrical engineering—a qualification Intel considered necessary for articulating the potential of this new technology for tangible economic benefits to a lay audience.[27] Last but not least, the commercial power of the Internet was hardly obvious at the beginning.

Similarly, the real advantages of "green" tech, and there may well be many, will be discovered in the marketplace. But the very different nature of this transformation, and the very large investments it will require, behooves the participants—private and public sector alike—to proactively identify the economic possibilities that may emerge from green energy. That discussion will prove a necessary precursor to policy that can go beyond merely driving the development and adoption of "green" energy, to enable the broader adaptation in the economy as a whole.

6: The policy challenge: energy systems transformation with an eye to green growth

Thus policymakers face real challenges translating green into growth. The emphasis on green jobs quickly runs into limits from employment and productivity. The attractiveness of export-led growth from green industry risks viewing the green energy systems transformation as a zero-sum game, leading to green mercantilism. Finally, the analogy to earlier transformations in high-technology systems shows how different the transformation to a low-carbon energy system may be. Those differences translate into real challenges in using energy innovation to spur a self-sustaining transformation of the energy system with large spillover benefits for the economy as a whole.

This problem should be addressed in three stages. First, we need to ask what policy must accomplish in order to achieve a successful systems transformation. Second, we need to determine what policy instruments best reflect these goals, and whether the conventional approach to climate policy is consistent with that determination.

22 This argument has re-appeared in the European Green Party's Green New Deal, which explicitly calls for a substitution of productivity for employment in pursuit of energy efficiency improvements and renewable energy installations, among other changes to the economy. While such substitutions may make sense in the guise of lots of labor rendered idle by an employment shock, it doesn't justify high wages characteristic of the living standards present in the advanced industrial economies. See Schepelmann et al. (2009).

23 Carlotta Perez treats these as successive Kondratieff waves. We need not engage in the debate over the relevance of the Kondratieff concept to acknowledge that its core contention—that some technological innovations provide the foundation for a huge spectrum of subsequent growth—holds in each of these cases. See Perez (1985) "Microelectronics, Long Waves, and World Structural Change: New Perspectives for Developing Countries" World Development 13(3), pp 441-463.

24 There may be some exceptions to this. Renewable energy sources such as solar and wind do permit decentralized energy production, reducing energy users' dependence on the grid. Whether this translates into radically new forms of production or the organization of production is as of yet unclear.

25 The problem runs deeper than that. Growth may be the only thing that can sustain the energy systems transformation. No one believes that the policy goals of emissions reduction and energy security will be satisfied in the first generation of new energy technologies. Rather, it will require waves of innovation in energy production, distribution, and use. The scale and diversity of investment in these goals will require can only come from a private sector that sees economic opportunity in ongoing energy innovation.
Politically, commitment to energy systems transformation will only endure if it creates economic opportunities and not merely costs. Public investment must therefore set the foundation that enables this investment, by building a platform for growth along a low-carbon, high-efficiency trajectory. Only green growth along this trajectory can accomplish the energy systems transformation.

26 The source of this story and similar stories is unclear and may be apocryphal. Nevertheless, in the early years few computers were bought or used, and it was by no means obvious that something that would later be called the digital revolution had just begun.

Third, we need to find policies that can be implemented, which is particularly the ease given the resistance to carbon taxes? Finally, if a self-sustaining, growth-inducing energy systems transformation is the ultimate goal, then we should consider how these policy instruments might be best deployed in service of that end.

Addressing the problem of energy systems transformation in light of this approach suggests that today's emphasis on carbon pricing fails to reflect the complexity of energy systems transformation, and may offer little opportunity to put that transformation in service of economic growth. Not only might prices fail to achieve meaningful decarbonization of the energy system, but they offer no sustained support for the complementary changes required to achieve an energy systems transformation of the form described in section 3.

6.1 Goals

Renewable energy-focused policy usually expresses a single goal: to reduce emissions via altering the dependence of industrial economies on fossil fuels. But as we saw in section 3, that goal really requires an energy systems transformation.[28] That transformation, in turn, requires parallel and complementary changes to energy production, distribution, and use in order to adapt to the different technical and economic properties of renewable energy.

The near-term goal for policy in this context is not the completion of the transformation itself. The scale and degree of investment required to do so make such an outcome improbable. Rather, the real goal should be to shift the energy system onto a new and self-sustaining development trajectory. The nature of today's energy system provides large incentives to innovate within its constraints. The scale of the network means that such innovations immediately enjoy large markets and easy compatibility. Note of course that resistance is enormous in larger markets. Often .smaller markets are where new technologies gain a foothold. This of course poses serious problems for any attempt to transition out of the present equilibrium. But it likewise suggests that a self-sustaining process of investment and innovation in favor of a low-carbon energy system is possible, if only we can find the right policy levers to achieve the initial shift in the trajectory of the system as a whole.

Such an achievement may provide the best opportunity for green growth. As with past technological systems transformations, growth via a low-carbon energy systems transformation requires a self-sustaining pattern of innovation and investment in both the energy sector and the broader economy. At present, it remains unclear whether renewable energy can promise this kind of innovation. But it most certainly cannot if it continues to operate under the constraints of an energy system designed predominately around fossil fuels.

6.2 Instruments

Climate change mitigation confronts policymakers with a wide range of choices in service of both "green growth" and a low-carbon energy systems transformation. The most vibrant policy debates today concern the role that four different policy instruments should play:

1. Carbon pricing to incentivize both technological development and low-emissions energy adoption;
2. Technology policy to support research and development;
3. Regulatory policy to change market rules to favor new forms of energy production, distribution, and use[29];
4. Direct state action for public infrastructure investment and industrial policy.

6.2.1 Carbon pricing and its shortcomings

Conventional policy wisdom for carbon emissions mitigation argues in favor of a credible, sustainable, and high carbon price, perhaps supplemented with subsidies to basic research and development for new energy technologies.[30] Such policy, its advocates argue, will allow the economy to discover the most efficient way of reducing emissions. In contrast, other options—such as industrial policy, subsidy of renewable energy sources, or mandates in favor of energy efficiency—are seen as inefficient meddling in the market that will ultimately cost more than a policy reliant on price alone.

This conventional wisdom falls short of the goal of changing the development trajectory of the energy system. Three shortcomings stand out:

1. The self-identified preconditions for a successful carbon pricing policy—a universal, sustainable, high carbon price—appear politically impossible either domestically or internationally
2. It is by no means clear that the efficient carbon price, equal to the marginal cost of emissions, is high enough to overcome the substantial network externalities present in the energy system
3. The carbon price offers little support for the substantial coordination and market reform issues that will play a critical role in the viability of future energy innovations

William Nordhaus' "carbon price fundamentalism" argues that a "universal, sustainable, and high" carbon price is a sufficient condition for the innovation and investment required for a low-carbon energy systems transformation. Realizing those conditions today appears impossible. Moreover, those conditions appear internally contradictory.

"Since any price on carbon is entirely a political construct, the durability of the carbon price depends entirely on the ability of a given political system to sustain it."

Since any price on carbon is entirely a political construct, the durability of the carbon price depends entirely on the ability of a given political system to sustain it. Sustainability will depend entirely on the relative ability of winners and losers created by carbon pricing to either erode or protect the price level. A carbon price will hurt

27 Bill Davidow, recounts this story from his time as head of marketing at Intel. See William Davidow (1986) Marketing High Technology: an insider's view (New York: The Free Press). There are other versions about how the Microprocessor spread. Some contend it spread amongst hobbyists first rather than existing businesses. The two stories are, of course, compatible.

28 Advocates of nuclear energy or carbon sequestration technologies might object that either or both together provide real alternatives to intermittent renewable energy sources, and don't require the kinds of systemic changes we outline. In the case of nuclear energy, this is in fact true. But nuclear energy faces a range of other environmental, economic, and political difficulties that have made it unviable at large scale in most industrial economies. In the case of carbon sequestration, the technology is largely unproven and significantly decreases the delivered power of any power plant (due to the substantial energy required to sequester the carbon in the first place). Thus while either or both technologies may contribute on the margins to energy decarbonization, neither appear politically, economically, or environmentally viable as of this writing.

29 These three elements of the energy system are configured differently in each country by regulation and ownership structure, creating distinct national dynamics of demand and supply. Hence there will not be one universal trajectory to a low carbon future and cannot be a single best regulatory strategy.

concentrated interests like energy firms and large energy consumers (and, to a less concentrated degree, individuals and households). Even if the benefits it generates from emissions reduction entirely offset these costs, they come far in the future, and are broadly distributed across the entire population—and even beyond state borders. This is the classic definition of an externality. Standard political economy arguments from a range of cases show the extraordinary vulnerability of policies that generate acute, concentrated costs for powerful interests while producing weak, diffuse benefits. And those problems worsen with higher, and more punitive carbon prices. Thus "high" undermines "universal" and "sustainable."

This mismatch between political reality and policy theory undermines the edifice of carbon pricing. The absence of a long-term, credible, and increasing carbon price dilutes the incentives for significant investments in innovation and infrastructure. Absent those investments, the changes required to transform the energy system will happen more slowly or not at all.

The demand for complementary changes to achieve an energy systems transformation poses the second obstacle to a price-driven approach. This approach has emerged out of a line of economic argument that treats emissions as a market failure, a negative externality. That approach implies the belief that the market already contains the ability to produce what we need for a low-carbon energy system, but under-produces it because of the mismatch between private and social costs. Under that assumption, correcting this mismatch generates the most efficient incentives for the market to increase its production of the components necessary for a low-emissions energy system.

"Hence we should expect, and accommodate, distinct national solutions to systems transformation"

But the energy systems transformation we've outlined suggests that the present market is locked into a trajectory in which it doesn't produce the elements needed for a low-emissions energy system. A long history of economic research has suggested that technological systems face serious barriers to systemic change because the existence of the system itself provides large incentives not to invest in alternative technologies and business models.[31] In a scenario where we have a reasonably good idea of the broad outlines of what that alternative looks like—a low-emissions energy system capable of supporting the needs of industrial society—these large barriers to entry may impede progress at all but very high prices. Moreover, that price must be high enough such that all three domains of the system—production, distribution, and use—have incentives to generate the complementary changes required of them. Given the size, scale, and complexity of modern energy systems, it's reasonable to argue that these barriers might be very high, such that absent more directed state intervention in the markets, new innovations might not emerge or be adopted at scale.[32]

Appropriate pricing policy, technology strategies, regulatory programs, and infrastructure policies are essential. Each of these policy tools has a role to play. But none constitutes a comprehensive solution on its own. Moreover, we emphasize that national variation in the regulation of the energy sector, the ownership structure of its firms, and the dynamics of finance create opportunities and constraints that will affect each of these three policy tools differently. Hence we should expect, and accommodate, distinct national solutions to systems transformation.

6.2.2 Technology policy to support research and development

Proponents of public support for research and development argue that these policies can achieve the goals that carbon prices cannot. Certainly the need for innovation in renewable energy, energy distribution, and energy efficiency will require significant public investment. How best to make those investments remains the subject of spirited debate.

Traditional technology policy can take at least three forms: 1) intensive support of narrow innovation priorities, as in the Manhattan project, 2) diffuse support of research and development through research institutes and universities, and 3) policies to promote the adoption and diffusion of the new technologies. Manhattan Project-style efforts may be appropriate for capital-intensive, high-risk problems like nuclear fusion or carbon sequestration, but are of little use in delivering diffuse innovations for efficiency across a spectrum of sectors. Diffuse innovation, in contrast, is enormously successful when the standards for interoperability are already settled, and thus coordination among researchers is unimportant. Similarly, policies for adoption and diffusion of technologies, whether through public or private mechanisms, assume reasonably mature technology development. One must emphasize that technology policy does not necessarily constitute "industrial policy" since it need not determine technology choices in the market.

6.2.3 Regulatory intervention

Governments can successfully use regulatory incentives to drive the adoption of new energy technology where, again, the technological targets are well-understood and where the regulators have significant weight in the marketplace. Many countries or U.S. states have already done so, via Renewable Energy Portfolio requirements for power generators, energy efficiency programs for homeowners, and changes to energy tariffs. Regulation can affect the deployment and diffusion of technology, but does not necessarily create the framework for sustained private investment. Without considerable regulatory will the incentives to continue these programs may fade. Unless an energy systems change can be achieved, the impact of these regulations would be limited.

30 See here William Nordhaus (2010), "Designing a Friendly Space for Technological Change to Slow Global Warming", at http://nordhaus.econ.yale.edu/documents/sm_052610.pdf. Referenced 1 March 2011. This is the latest and most comprehensive review of what Nordhaus styles "carbon price fundamentalism."

31 See Michael Katz and Carl Shapiro. "Network externalities, competition, and compatibility". The American Economic Review, pages 424–440, 1985; "Technology adoption in the presence of network externalities". The Journal of Political Economy, 94(4):822, 1986; and " Systems competition and network effects." The Journal of Economic Perspectives, 8(2):93–115, 1994.

32 For a parallel discussion of this problem, see Roger Noll (2011) "Encouraging green energy R&D: a comment" Energy Policy, forthcoming.

6.2.4 Direct state action: infrastructure and industry policy

Government, of course, may act in energy markets directly, as in building out new energy infrastructure or obligating private actors to do so. The question becomes whether energy systems transformation requires directed state action in addition to the less intrusive policies noted above. Importantly, infrastructure policy need not be directed at industrial policy; it need not dictate or support the success of particular firms or of particular technologies. Nevertheless, the classic questions arise of how to best organize state action, whether through administration, public companies or public-private partnerships. There will be a variety of national answers. Similarly, the issue raised throughout this discussion remains: which elements of the energy system, such as the electricity grid, if altered, will induce a significant shift in the energy system?

7: Points of leverage for the green energy systems transformation

Given the complexity of these systems, policymakers face difficult choices about where to apply these policy tools. With limited resources, policymakers should seek points in the energy system where limited interventions can change the trajectory of development, by altering the choices of actors throughout the system. We have noted that the railroad and the telecommunications network played this role in past economic transformations. Do similar levers exist for energy, which if pulled would induce broad private investment to capture the diverse advantages of the new system?

"With limited resources, policymakers should seek points in the energy system where limited interventions can change the trajectory of development,"

Certainly there must be a debate about whether there is such a lever and what it might be. We define a lever to be a change or set of changes to part of the system that, if carried out, will induce or enable complementary changes in the rest of the energy system. For the case of the energy system, the power grid provides an excellent example of such a lever. The grid is central to choices about how to produce, distribute, and use energy; and changes in the grid alter options in all three dimensions of the energy system. Consequently the grid provides significant leverage for policies intent on accomplishing energy systems transformation. Energy policy should use tightly focused technological innovation, coupled to regulatory reform and standards-setting processes, to develop and deploy a power grid capable of handling significant change to technologies for production and use. For example, the introduction of a "smart" grid—the integration of digital intelligence and power transmission—can support not only more efficient transmission, but also more and different forms of renewable energy and improved energy efficiency. Standardization of the networks may also enable the grid to operate as a platform for further private sector innovation. That innovation, in turn, can drive both the technological advances required for the adoption of new energy sources, and the investment and employment required for green growth.

8: Climate policy in comparative perspective: a diversity of responses

We have advocated for a transformation of the debate about "green growth" from a justification for environmental policy into a search for the absolute advantages of a lower-emissions energy system. Doing so would frame the green growth problem in terms similar to earlier eras of transformative economic change. But, like those earlier eras, the initial expense of the transformation and the interests of those who profit from current arrangements have often delayed action. "Green energy" sources are, at least in the short-to-medium term, more expensive than conventional ones. Their "green electrons" have no obvious and automatic advantages over "brown" ones. The higher costs of "green energy" pose a burden for those who use energy, potentially lowering productivity and slowing growth. Unsurprisingly, then, most existing energy suppliers of energy and energy equipment have been as content to continue providing low cost, dependable, reliable fossil-fuel energy as their customers have been to consume it.

Consequently the push for a low carbon energy system has required a policy strategy capable of addressing an array of problems created by today's high-carbon system—many of which have little to do with emissions per se. The structure of the current system implies one set of winners and losers, groups that benefit from the configuration of today's energy system and others that suffer various forms of harm. The transition to a new system will create another, different, set. But there, the losers from the transition to a new system are obvious and powerful, while the winners are often unknown, weak, or both. This bias in favor of inertia lies at the root of prominent examples of inaction. In the American case, America's overwhelming dependence on domestic coal for electricity and significant domestic coal and natural gas deposits have created a foundation for resistance to a de-carbonized energy system. Similarly, in China, the inescapable need for energy to fuel economic expansion and rising living standards—the basis of both political stability and prosperity—has made the government reluctant to part with fossil fuels in any meaningful sense. Indeed, given such a thorny political economy problem, a cynic might ask why we observe any progress at all.

Elsewhere, however, "green growth" strategies are much in evidence. Denmark has committed to a fossil fuel free economy by 2040.[33] The South Korean government has embarked on the development of a broadly

33 This and subsequent country cases are based on Kelsey et al (2011),

34 Ibid.

35 Information based on interviews and correspondence with executives and staff at DONG Energy and Vattenfall, Inc. Denmark, February-April 2011.

36 California's energy efficiency programs are generally credited to have contributed about 25% of the state's reduced energy input to a unit of GDP. The rest of the gains are attributed to other factors including shifts in industry composition and away from heavy manufacturing, mild climate, and other particular demographic statistics. For a more complete analysis of these policies see Sudarshan and Sweeney (2008).

rooted growth strategy intended to reorient the Korean economy around green technology, public transport innovation, and efficiency-improving uses of information and communications technology. Despite the broader American inertia, California and Colorado have both embarked on economic growth strategies that emphasize the link between action on climate change mitigation and new economic opportunities.

This variation in both openness to and action on green growth as an economic strategy cannot be viewed only as an outcome of enthusiasm for environmental protection. Rather, it reflects important differences in national prerogatives for domestic energy systems. In cases where "green growth" has received significant attention, that attention is in every case motivated by significant non-environmental domestic interests—whether economic development, energy security, or competitiveness. Because those interests can provide immediate counterweights to resistance from those who benefit from today's system, they help overcome the policy inertia generated by the pre-existing structure of domestic energy production, distribution, and use.

Two dimensions appear particularly critical in shaping national positions on energy systems transformation. First, a country's choices on energy policy in particular derive from a set of idiosyncratic national goals—whether for energy security and independence, reliability, affordability, emissions reduction, or other goals. Second, those goals are viewed through the lens of a country's domestic resources, natural or otherwise. For example, as Kelsey et al (2011) make clear, the sharp contrast between China and Denmark reflects different priorities.

"**Denmark's** core problems and objectives have to do with: (1) ensuring predictable availability of energy at an acceptable long-term cost, ideally by achieving energy independence; (2) driving economic growth; and (3) lowering emissions. Choosing to make green industry a core of Denmark's economy – and choosing to structure its economy and infrastructure to take full advantage of this industry – creates a unified solution to all of Denmark's problems.

China, by contrast, needs to do the following: (1) achieve massive, near-future increases in energy availability; (2) continue growing economically at a rapid rate; and (3) very much secondarily, deal with a growing particulate emissions problem. Moreover, it is well-endowed with coal, a cheap-but-dirty energy source. Given the current state of technology, these objectives mandate both green technology and brown growth. Denmark's solution would not solve China's problems."[34]

We observe a diverse set of "green growth" strategies, and a variety of instruments employed to accomplish the distinct goals. Amidst the diversity, we propose, that there is a common political foundation. That foundation requires a deal between industry and those who would advocate for significant transformation of the energy system. Sometimes those advocates will be environmental or energy consumer groups, as in California or Colorado. In others, as in the case of Korea, the advocates will include or be led by government strategists concerned with security—either energy security in a narrow sense, or national security more broadly—or with finding the basis of a new trajectory of economic growth. No matter where the initial impetus comes from, however, the energy system transformation cannot be sustained by environmental consciousness alone. Rather, it requires a broader deal that brings economic interests inside the coalition in favor of a low-carbon energy systems transformation.

"We propose, that there is a common political foundation. ...... a deal between industry and those who would advocate for significant transformation of the energy system.

The origins of those deals have, in the past, varied significantly. In some cases, as in Denmark and California, the deals grew from the synthesis of historic concerns about energy security and modern priorities for economic development and environmental protection. For the Danes, the initial problem was one of energy security, when following the oil crisis of the 70s the country's political elite recognized their vulnerability to dependence on imported energy. Policies at that time gave rise to a wind industry that has been a global leader and generates nearly 10% of Danish exports. Those policies also set a framework in which the major energy producers found advantages in moving both to renewable energy sources and more efficient energy generation technologies.[35] In contrast, for California the initial problem was urban smog, particularly in the Los Angeles basin, that contributed to a strong environmental movement in the state. Resistance to nuclear power when Jerry Brown was first governor gave rise to the energy efficiency programs.[36]

In contrast, political realignment enabled change in Colorado and policy realignment underpins South Korean strategies. In Colorado, an initial grass-roots push for clean energy quickly garnered support from major energy companies who stood to benefit from the shift from high-emissions coal electricity generation to lower-emissions gas and a renewable energy-based generation. In Korea, the need to respond to both increased competitive pressure from developing countries and a stagnant global economy promoted a drive toward a broad reorientation of the economy in the direction of "green" goods. That reorientation was secured by positioning policy measures as a solution to energy security, unsustainable congestion and transport-related pollution, and the possibilities for capturing global markets in green goods. In both the Californian and Korean cases, then, the initial push for environmental policy was secured through a set of bargains that brought industry inside the coalition and created near-term and acute incentives for policies that otherwise generated only long-term, diffuse benefits.

Thus the real policy challenge at the heart of green growth lies in securing effective, stable alliances for industrial redevelopment. Those alliances must support a broad transformation of the energy system. Stabilizing that transformation will require compensating those who will lose from the transformation to a low-carbon, high-efficiency energy system. That compensation, in turn, must come from the economic opportunity and value created by the transformation itself. In short, the same challenges that confront economic restructuring in other guises—whether during industrialization, or in response to changing international competition, or technological change—will challenge the transformation of today's energy system.

"Thus the real policy challenge at the heart of green growth lies in securing effective, stable alliances for industrial redevelopment"

9: Governments, markets and green growth: concluding remarks

There are compelling and varied arguments for moving to low-carbon, high-efficiency energy systems that include climate change and energy security. The notion of "green growth" expresses the hope, or ambition, that such a transformation can be compatible with, or could even drive, sustained economic growth. We argue here that the concept of an energy systems transformation must underpin discussions of and policy for climate and green growth. By system, we refer here to an array of separate elements complementary to one another and tightly inter-linked. In economic terms, the widespread adoption of some technologies requires investment in related, complementary, technologies and policy innovations to facilitate or permit their diffusion. It is this complementary series of technological, economic, and regulatory changes that we refer to as an energy systems transformation.

There are three significant implications of our argument.

- First, with limited resources, policymakers should seek points in the energy system where limited interventions can change the trajectory of development, by altering the choices of actors throughout the system. We defined such a lever to be "a change or set of changes to part of the system that, if carried out, will induce or enable complementary changes in the rest of the system."

- Second, enduring economic and political success at a green energy-led systems transformation can only come from the possibilities it would create for the broader economy. Emissions reduction is principally motivated by the need to avoid the damaging consequences of the existing energy system. But achieving emissions reduction presently provides few immediate benefits. "Green" electrons differ from brown electrons largely by being more expensive and requiring the expensive replacement of a significant infrastructure. Green jobs will often simply replace brown jobs. The acute costs and diffuse benefits of emissions reduction pose serious challenges to sustained progress. Consequently, policy discussion must also focus on the advantages of a low-emissions energy system. Those advantages, if they exist, will come from enabling the broader economy to discover and express the presently unknown—and often unknowable—opportunities that such a new system may create.

- Third, achieving this transformation will require a complex set of offsetting deals that often compensate those discomfited or disadvantaged while allowing market incentives to induce the enormous private investments that will be required. Governments will need to play a role: setting technology standards and market rules, balancing losers from the transition, investing in technology development and often in the deployment of critical infrastructure.

In sum, moving green growth from religion to reality, and thereby exploiting the redeployment of the energy system as the basis of sustainable prosperity, will require a technological and economic transformation akin to those of the emergence of steam, or rail, or—more recently – information technology. That transformation will not come through a focus on one technology or another. Rather, it will require attention to the restructuring of the energy system as a whole, and the role that policy must play in structuring and facilitating that systems transformation.

Works Cited

Aral, Sinan, Erik Brynjolfsson, and Marshall Van Alstyne. 2007. "Information, Technology and Information Worker Productivity: Task Level Evidence". NBER Working Paper no. 13172. Cambridge: National Bureau of Economic Research.

Bradsher, Keith. 2010. "To conquer wind power, China writes the rules." The New York Times, 15 December, A1.

Cowen, Tyler. 2011. The Great Stagnation: How America ate all the low-hanging fruit of modern history, got sick, and will (eventually) get better. New York: Dutton.

Davidow, William. 1986. Marketing High Technology: an insider's view. New York: The Free Press.

DiNardo, John, and Jorn-Steffen Pischke. 1996. "The Returns to Computer Use Revisited: Have Pencils Changed the Wage Structure Too?" NBER Working Paper no. 5606. Cambridge: National Bureau for Economic Research.

European Green Party (2009) "A green new deal for Europe: manifesto for the European election campaign, 2009".

Huberty, Mark, Huan Gao and Juliana Mandell. 2011. Shaping the Green Growth Economy: a review of the public debate and prospects for success. Report prepared for the Mandag Morgen Green Growth Leaders Forum. http://greengrowthleaders.org/wp-content/uploads/2011/04/Shaping-the-Green-Growth-Economy_report.pdf. Last accessed 9 May 2011.

Hughes, Thomas. 1983. Networks of Power: electrification in Western society, 1880-1930. Baltimore: The Johns Hopkins University Press.

Hughes, Thomas. 1979. "The Electrification of America: the system builders", Technology and Policy pp124-161.

Integration of Variable Generation Task Force. 2009. Accommodating High Levels of Variable Generation. Washington, DC: North American Electricity Reliability Corporation.

Jones, Van. 2008. The Green Collar Economy: how one solution can fix our two biggest problems. San Francisco: HarperOne, 2008.

Kammen, Daniel M., and Detlev Engel. 2009. "Green Jobs and the Clean Energy Economy." Thought Leadership Papers Series No. 4. Copenhagen: Copenhagen Climate Council. At http://www.copenhagenclimatecouncil.com/dumpfile.php?file=ZmlsZWJveC8xODk=&filename=VExTMDQgX0dyZWVuSm9icy5wZGY=.

Katz, Michael, and Carl Shapiro. 1985. "Network externalities, competition, and compatibility". The American Economic Review 75(3) 424–440.

Katz, Michael, and Carl Shapiro. 1986. "Technology adoption in the presence of network externalities". The Journal of Political Economy 94(4), 822-841.

Katz, Michael, and Carl Shapiro. 1994. " Systems competition and network effects." The Journal of Economic Perspectives, 8(2) 93–115.

Katz, Randy, David Culler, Seth Sanders, Sara Alspaugh, Yanpei Chen, Stephen Dawson-Haggerty, Prabal Dutta, Mike He, Xiaofan Jiang, Laura Keys, Andrew Krioukov, Ken Lutz, Jorge Ortiz, Prashanth Mohan, Evan Reutzel, Jay Taneja, Jeff Hsu, and Sushant . 2011 "An Information-Centric Energy Infrastructure: the Berkeley View." Journal of Sustainable Computing 1(1) 1-17.

Krueger, Alan. 1993. "How Computers Have Changed the Wage Structure: Evidence from the microdata, 1984-1989" The Quarterly Journal of Economics 108(1) 33-60.

Leatherman, John. 2005. "Internet-based Commerce: Implications for Rural Communities" Review of Economic Development Literature and Practice 2000:5.

Noll, Roger. 2011. "Encouraging green energy R&D: a comment" Energy Economics 33(4) 683-686.

Nordhaus, William. 2010. "Designing a Friendly Space for Technological Change to Slow Global Warming." Energy Economics 33(4) 665-673.

Obama, Barack. 2011. "State of the Union Address", 27 January. Washington, DC: The White House. At http://www.whitehouse.gov/the-press-office/2011/01/25/remarks-president-state-union-address.

Perez, Carlotta. 1985. "Microelectronics, Long Waves, and World Structural Change: New Perspectives for Developing Countries." World Development 13(3) 441-463.

Schepelmann, Philip, Martin Stock, Thorsen Kosta, Ralf Schüle, and Oscar Ruetter (2009) "A Green New Deal for Europe" Green New Deal Papers Series vol. 1. Brussels: Green European Foundation.

Scott, Mark. 2010. "GE, Vestas fall behind in China's 'Tough' wind market." The New York Times, 14 May.

Rai, Varun, David Victor, and Mark Thurber. 2009. "Carbon capture and storage at scale: Lessons from the growth of analogous energy technologies" Energy Policy 38(8) 4089-4098.

Van Ark, Bart, Robert Inklaar, and Robert McGuckin. 2002. "Changing Gear: Productivity, ICT, and Services: Europe and the United States" Research Memorandum GD-60. Grönigen: University of Grönigen Growth and Development Center.

Sudarshan, Anant and James Sweeney. 2008. "Deconstructing the 'Rosenfeld Curve'". Precourt Energy Efficiency Center Working Paper, 2-17. Palo Alto: Stanford University Precourt Energy Efficiency Center.

The Danish Government. 2011. "Danish Energy Strategy 2050." Denmark: Danish Climate and Energy Ministry.

The European Commission. 2007. "An Energy Policy for Europe", Communication to the European Parliament and European Council. Document SEC(2007) 12. Brussels, Belgium: The European Union.

The European Commission. 2010. "Energy Infrastructure Priorities for 2020 and beyond – a blueprint for an integrated European energy network". Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Document COM(2010) 677. Brussels, Belgium: The European Union.

Woody. 2010. "China snaps up California Solar Market", The New York Times Green Blog. 14 January, at http://green.blogs.nytimes.com/2010/01/14/china-snaps-up-california-solar-market/#more-38129.

Zysman, John and Abe Newman, eds. 2006. How Revolutionary was the Digital Revolution. Stanford: Stanford University Press.

Zysman, John and Nina Kelsey, eds. 2011. "The Green Growth Economies Project, Part Two: Country Cases and Analysis." Prepared for the Mandag Morgen Green Growth Leaders Forum.

AN ANALYTICAL OVERVIEW

The Green Growth Leaders Country Study

June 15, 2011
Prepared by John Zysman and Nina Kelsey

1 Overview: The country cases

This set of five green growth cases (with two forthcoming) explores the variety of green growth strategies countries and states are putting into practice: how they define success; what obstacles they face; and what kinds of policy outcomes they produce. In essence, what is the political and economic logic underpinning different strategies and their success?

1.1 Cases presented

The cases presented include:
Europe, including:
1. An analysis of the European Union policy environment
2. An analysis of the Denmark case

The United States, including:
1. An overview of the federal policy environment
2. An analysis of the California state case
3. An analysis of the Colorado state case

Korea
China
Brazil

2 Key lessons

Some key lessons seem to emerge from this set of cases. We propose these points for discussion:

2.1 Each green growth story is unique

The case variation, not surprisingly, turns on two questions:

First, what are the core energy problems or key objectives that a country seeks to solve – energy availability? Independence? Predictability or affordability of energy pricing? Economic growth? Particulate pollution? Emissions? Others?

Second, what is a country's energy system endowment? In other words, what are the domestic resources it is given to work with? Is it well endowed with coal, gas, sun, wind, or some other resource or mix of resources?

Consider the contrast between Denmark and China: Denmark's core problems and objectives have to do with (1) ensuring predictable availability of energy at an acceptable long-term cost, ideally by achieving energy independence, (2) driving economic growth, and (3) lowering emissions. Choosing to make green industry a core of Denmark's economy – and choosing to structure its economy and infrastructure to take full advantage of this industry – creates a unified solution to all of Denmark's problems.

China, by contrast, needs to do the following: (1) achieve massive, near-future increases in energy availability, (2) continue growing economically at a rapid rate, and (3) very much secondarily, deal with a growing particulate emissions problem. Moreover, it is well-endowed with coal, a cheap-but-dirty energy source. Given the current state of technology, these objectives mandate both green technology and brown growth. Denmark's solution would not solve China's problems.

2.2 But there are overarching patterns in how green growth stories play out

We see two different patterns by which green growth policy develops:

1) ***Evolution:*** in this pattern, green growth policy is the result of a slow evolution. Early energy usage and/or pollution challenges prompt initial policy moves that begin to decouple energy growth from economic growth (green-compatible growth). These early policies build comfort and create constituencies for themselves. Policymakers can then proceed to more aggressive attempts to eliminate fossil fuel usage and reorient toward green industry as a economic power (green-driven growth). In effect, each phase creates the political will for the next phase, and progress toward more aggressive green policy thus becoming self-sustaining. In both the California and Denmark cases, this evolutionary process begins with an energy crisis, perhaps because such a crisis provides the impetus to override initial obstacles.

2) ***Political realignment:*** in this pattern, seen in Colorado and Korea, aggressive policy for green-driven growth can spring forth abruptly rather than proceeding evolutionarily from more humble beginnings. These kinds of rapid policy developments are the result of political will and leadership (such as those exhibited by the Lee Myung-bak administration in Korea or a set of Democratic policymakers in Colorado) combined with an environment in which a set of key interests align to support this leadership (as, for instance, the electoral movement in Colorado found support both in urban liberal populations and in rural conservative populations).

"In general, an alliance between policymakers and strategic parts of industry seems to be a critical part of the aggregation of interests necessary to achieve green growth,"

2.3 Whether and how policy-makers ally with industry is critical

In general, an alliance between policymakers and strategic parts of industry seems to be a critical part of the aggregation of interests necessary to achieve green growth, whether it is the result of an evolutionary process or part of a rapid political realignment. There are two probable reasons for this. First, opposition from industry may be particularly effective at blocking action, in which case an alliance with industry is necessary to defuse or disrupt such opposition. Second, when the goal is economic (as green growth is) buy-in from strategic partners in industry is necessary to make the goal credible and attainable.

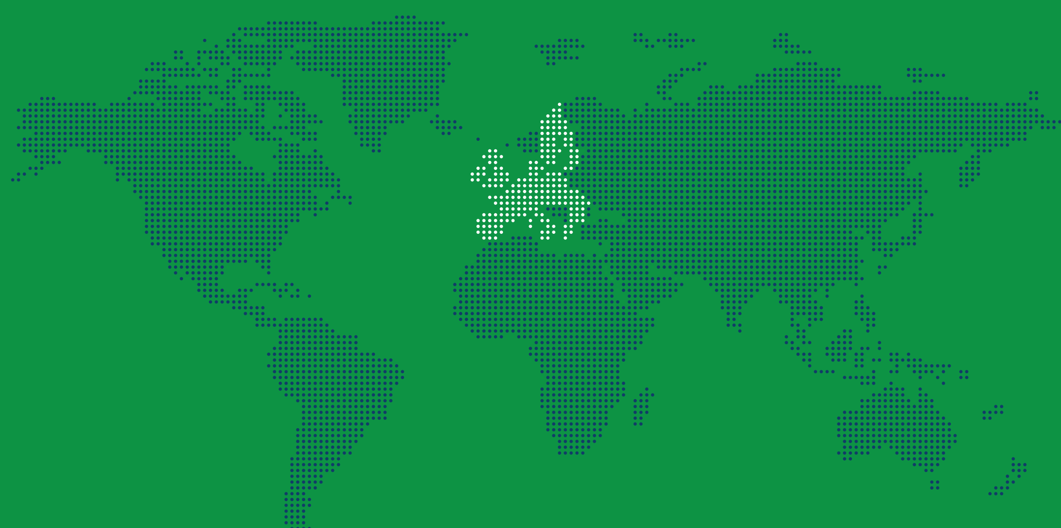
COUNTRY CASE ANALYSIS

EUROPEAN UNION
DENMARK
UNITED STATES
CALIFORNIA
COLORADO
KOREA
CHINA
BRAZIL

EUROPEAN UNION: GREEN GROWTH AS NECESSITY AND LIABILITY

The Political Economy of a Low-Carbon Energy Systems Transformation in the European Union
Case Analysis

May 17, 2011
Prepared by Mark Huberty[1]



1 Doctoral candidate, University of California, Berkeley; and Research Associate, Berkeley Roundtable on the International Economy. Research for this paper has received support from the Fulbright-Schumann Fellowship and the United States Environmental Protection Agency STAR Fellowship program.

1 Introduction

In the last decade, energy systems transformation has become the new and unheralded frontier of European deepening. Starting in 1996, the European Union mandated the liberalization and integration of national energy systems, put a price on greenhouse gas emissions from electricity generation, established binding targets for renewable energy adoption, mandated the breakup of state energy monopolies, and sponsored the creation of EU-level regulatory and standards-setting bodies for energy infrastructure and markets. Most recently, the Europe 2020 program has established enforceable goals for the integration, liberalization, and decarbonization of the European electricity supply system, and ambitious but aspirational targets in energy efficiency.

Most analysis of this European policy history has emphasized the role of environmental politics in driving progress on emissions reduction. Appeals to environmental politics in this context appear to explain the apparent willingness of the European economies to trade off the economic costs of climate change mitigation for the perceived ecological and social benefits it might bring. Consistent with this understanding of the politics of European energy policy, green parties and social movements have been given significant explanatory weight.

"Appeals to environmental politics...appear to explain the apparent willingness of the European economies to trade off the economic costs of climate change mitigation for the perceived ecological and social benefits it might bring."

This paper argues that the environmental politics approach falls well short of a satisfying explanation for both the evolution of European policy and the characteristics of the policy suite. The attention to environmentalism, rather than to the details of European energy policy and the constraints of the current European energy system, over-emphasizes the role of environmental concerns. It also leads to the conclusion that the European policy suite may be fundamentally unstable–prone to reversal when the costs of environmental action exceed the altruism of European publics. This poses particular problems when faced with the fact that progress on emissions and renewable energy continued even after European enlargement added 12 member states with significantly less enthusiasm for climate change mitigation and significantly greater reliance on fossil fuels.

Instead, European policy must be understood as an attempt to transform the energy system amidst, on the one hand, the need to maintain a stable political coalition of EU member states supportive of the transformation; and, on the other, the technological and economic complexity of the energy system. This trifecta of constraints–political, technological, and economic–complicates the process of policy design. But it also improves the prospects for sustaining policy through cross-subsidization across policy domains. These constraints and opportunities arise from the common role played by energy in emissions, security, and technological change. That role is closely intertwined with the possibilities for technological change in the energy system. Thus only by understanding both the technological challenge of energy systems transformation, and the political conflicts implicit in that transformation, can we understand the resulting policy suite.

2 Green parties for green energy? Competing explanations for EU policy leadership

While the energy sector itself accounts for only 2-4% of European GDP, the central role of energy in modern industrial society gives changes to the energy system importance far in excess of their immediate economic valuation. Today, Europe's energy system provides abundant, reliable, relatively inexpensive energy. Disruption of any of these characteristics would pose major challenges to the rest of the economy. Thus it is not surprising that both the European Union and its member states have approached climate and energy policy as an attempt to restructure the inputs to the energy system while leaving the outputs untouched. Technologically, that has meant switching away from imported fossil fuels towards domestic renewable energy. Economically, this has meant marketization of the energy system; dismantling of vertically-integrated state-owned energy firms; and differential regulation of energy production, distribution, and use. These initiatives all seek to accomplish the decarbonization of European energy supplies and the integration of European energy markets while leaving the industrial superstructure of the European Union unperturbed.

On their own, these technical and regulatory changes pose significant challenges. Ongoing changes in the political landscape of the European Union have only compounded these challenges. Europeanization of energy policy has taken place amidst an enlargement program that has made Europe's climate and energy interests more, not less, diverse. The industries of eastern Europe and the Baltic states in particular were more dependent on greater quantities of less expensive carbon energy than their Western counterparts. The publics in those countries were less enthusiastic about climate change mitigation, and more likely to support exploitation of domestic fossil fuel resources–many of which, like Polish lignite coal, were particularly dirty energy sources. Yet despite the increased diversity of interests, the EU continued to make progress after enlargement on the decarbonization of the energy supply and the deployment of more expensive renewable energy.

Explaining this ongoing progress poses two challenges for policy analysts. First, most contemporary accounts of European progress in energy systems transformation or climate change mitigation have relied on either domestic party structures–the role of green parties in particular–or foreign policy entrepreneurship–chiefly leadership in the United Nations COP process–to explain ongoing progress.[2] Yet energy reform has continued despite the enlargement of the EU to include countries without strong green movements; and amidst the return of center-right parties to government in countries like Denmark, Germany, and the United Kingdom.[3] Furthermore, the failure of EU policy leadership to secure binding emissions targets at the 2009 COP-15 negotiations has made no appreciable difference to the goals of EU climate policy.

Second, these political accounts of Europe's energy systems transformation have little to say about the particular contours of European policy. The choice of a policy suite that includes a carbon emissions trading system, a renewable energy mandate, and energy market liberalization is in many cases at odds with European green parties' preferences. Indeed, if the green parties were as important to policy outcomes as is claimed, we would expect to see much more radical policy than we do: more aggressive targets, less dependent on market-based instruments like carbon pricing, founded on a stronger critique of the ecological and equity costs of capitalism.[4] Moreover, progress on both energy market reform and emissions reduction has continued despite, as in Denmark and Germany, the return of center-right parties to government.[5]

"To a great degree, the stability of the European energy policy suite relies on spillover benefits in energy security and competitiveness to justify ongoing emissions reduction."

Beyond these theoretical arguments, an improved understanding of the policy rationale at work in Europe is critical for two purposes. First, it provides a response to the self-styled "price fundamentalism" of economic analysis.(Nordhaus, 2010) Such fundamentalism usually leads to the conclusion that the EU policy mix represents an inefficient departure from a ideal price-based emissions control mechanism. But this conclusion arises from an emphasis on emissions reduction to the exclusion of other policy prerogatives, and in doing so obscures the potential reality that, absent this policy suite, the political economy of energy and climate policy would not have tolerated a carbon price at all. The choice, in other words, was not between the first- and second-best, but between the second best and nothing.

Furthermore, a better understanding of the policy rationale will improve our ability to predict the success and longevity of the policy itself. To a great degree, the stability of the European energy policy suite relies on spillover benefits in energy security and competitiveness to justify ongoing emissions reduction. This "green growth" strategy promises to turn on its head the core problem of climate change mitigation–the tradeoff of present consumption for future benefits–by reconciling emissions reduction to economic growth in the present. If successful, this would mark a radical shift in the potential for serious emissions reduction. If not, it marks a critical weak point in European ambitions and an implicit limit to the tolerance for the costs of emissions reduction.

3 The european energy policy suite

As of 2010, the EU has deployed a range of policy mechanisms to reduce emissions, secure energy supplies, and incentivize energy sector innovation. This suite of policies should be seen as an attempt to simultaneously address three energy-centered externalities: global climate change; energy security and price instability; and competitiveness and technological innovation. The existence of multiple energy-related externalities complicates the problem of policy formation. But it also provides a means to build sustained policy coalitions through linkage of objectives in one domain to action in others. That linkage generates policy stability in two ways: first, the beneficiaries develop acute interests in ongoing progress that allow emissions reduction policies to move beyond mere cost minimization; and second, linkage provides for cross-subsidization of transition costs among political and economic actors both within the member states and between them. Indeed, whether intentional or not, the policy suite that has developed in Europe over the last decade shows all the signs of fulfilling these political economy functions.

3.1 Progress in European energy policy, 2000-2010

As of 2010, the European energy policy suite consists of four major initiatives:

1. The Emissions Trading Scheme, which sets a price on energy-derived carbon emissions for approximately 40% of the European economy via annual limits on emissions and a secondary market for emissions permits within that limit.
2. The Renewable Energy Directive, which puts binding targets on member states to consume, as an EU average, 20% of their electricity from renewable sources by 2020.[6]
3. The Energy Market Liberalization Program, which mandates the breakup of vertically integrated national energy markets into separate domains of production, distribution, and retail; and which sets new terms for market competition in wholesale and retail energy provision(Jamasb and Pollitt, 2005).
4. The SET-Plan and Framework Programmes, which

2 See, for instance Jacobsson and Lauber (2006) on German renewable energy policy, Christiansen and Wettestad (2003) on the origins and content of the Emissions Trading System legislation, and Schreurs and Tiberghien (2007) on EU climate and energy policy.

3 Indeed, amidst extreme austerity measures in the United Kingdom under the Conservative-Liberal Democratic coalition after 2010, one of the few things that has not been cut is the UK's aggressive plan for energy investment and market restructuring.

4 See, for instance, the European Greens' 2009 election manifesto, which called for sweeping environmental reforms and an explicit tradeoff of productivity for employment in environmental goods industries (European Greens Party, 2009; Schepelmann et al., 2009).

5 Indeed, in early 2011 the Danish center-right government released a highly ambitious domestic energy and climate policy platform that exceeded the expectations of nearly every major opposition party. Interviews in Denmark shortly after the platform was released indicated that this will probably set the terms of the debate for the 2011 election and subsequent energy policy choices. See Danish Ministry of Climate and Energy (2011).

6 A 20% improvement in energy efficiency accompanies this goal, but as of April 2011 has no legal force behind it.

provide significant European and Member state funding for research, development, and deployment of new energy technologies (European Commission Staff, 2009; The European Commission, 2007; European Commission, 2009).

Figure 4 shows that this policy suite did not arrive at once–rather, it evolved over time. As it did so, the political justification for each policy evolved as well. The liberalization of the energy market began in 1996 as a fairly standard extension of the Common Market, in parallel with other EU attempts at services and goods market integration.[7] In its initial form, the European Commission justified the program on the basis of more competition in energy markets, lower prices for retail and industrial customers, and improved investment in energy infrastructure.(The European Commission, 2001) By 2003, the Parliament and the Council had adopted the second gas and electricity directive to begin the process of integrating national markets via network connection and market reform. Those reforms were extended and deepened via the 3rd market directive, issued as part of the 2008 Climate and Energy Package.

In contrast to these market reforms, which have a long history in European widening and deepening, the Emissions Trading Scheme was a direct response to external events. At the Kyoto talks in 1997, EU member states had committed to emissions reductions of 8% below the 1990 baseline by 2012.[8] The EU believed that it could achieve these reductions more efficiently acting as a body, than if each member state did so on their own. Economic costs figured heavily in this decision. Since the majority of European Union trade takes place among the member states themselves, a pan-EU emissions regulation mechanism would minimize potential distortions to the Common Market that state-level policy regimes could have introduced. It also had the potential to lower compliance costs, by allowing member states to invest in emissions reductions (via the indirect mechanism of emissions permit purchases) where the marginal cost of reduction was lowest. The Emissions Trading Scheme thus began largely as a carbon market, intended to price carbon and so incentivize emissions reduction via efficiency, investment, and innovation.

In 2007, two years into the operation of the ETS, the Commission proposed strengthening the ETS and implementing aggressive targets for renewable energy deployment. In what became the so-called 20/20/20 goals, the 2007 Commission white paper (The European Commission, 2007a) proposed that, by 2020, Europe obtain 20% of its energy from renewable sources, use energy 20% more efficiently, and reduce emissions by 20% relative to 2005 levels. To do so, it proposed moving beyond the emissions trading scheme to use direct subsidies to renewable energy–so-called feed-in tariffs or other support schemes–to incentivize renewable energy adoption and decarbonization of energy production.[9] This proposal was eventually adopted in December 2008 as a set of legislation known as the 3rd Climate and Energy Package.[10] In addition to the renewable energy and emissions targets, the Package also provided for EU-level coordination of national energy market regulations, established an EU-level energy regulator, and reinforced the mandate for the breakup of vertically-integrated national electricity monopolies into separate markets for production, transmission, distribution, and retail.

Finally, the EU has moved to implement significant support for energy R&D relative to its budget. The Strategic Energy Technology Plan (European Commission, 2009) laid out a series of innovation and pilot program investments seeded with EU funding but completed by consortia of private corporations and member states. Those investments complemented existing investments in energy R&D in the 7th Framework Programme, which invested €2.3 billion in energy-related research over the period 2007-2013.

3.2 Policy redundancy in the EU emissions reduction suite

This energy policy suite marks a major accomplishment for the EU. It has significantly expanded EU authority over a major sector of the European economy. It has created new EU institutions that usurp some member state authority over energy market regulation. It has led to the formal or legal dismantling of state-owned energy monopolies, foot-dragging by Germany and France notwithstanding. All these developments have given the EU new influence of the evolution of the rest of the economy, via regulation of how energy is produced, distributed, and used.

But, theoretically, much of this policy should not be necessary for the EU's climate policy goals. Emissions reductions, in particular, should not require parallel programs to incentivize renewable energy, energy efficiency, or research and development. Rather, the consistent message from economic analysis has emphasized the primary of the carbon price alone.[11] Given the right emissions price, market actors should of their own accord determine the most efficient way to optimize their investment in greenhouse gas emissions reduction. By this argument, separate policies to promote renewables and push energy efficiency may constitute market-distorting industrial policy.[12] Indeed, it now appears that most of the 2020 emissions goals in the EU will be satisfied through widespread deployment of renewable energy, even though many cost estimates (such as Enkvist et al. (2007)) show that energy efficiency improvements are often much cheaper.

This problem only compounds other issues of the design of the ETS itself: rights to emit are granted via the member states, rather than auctioned by the EU, leading to all kinds of chicanery among the member states[13]; allocation is based on prior-period emissions, providing perverse incentives to over-emit and thus keep the baseline high; and the price of emissions permits on the secondary market has proven somewhat volatile and unpredictable. All of these institutional designs raise the price of emissions and reduce the effectiveness of the ETS.[14]

This gap between theory and policy implementation is puzzling in light of the political economy of climate

7 This is true with one significant exception: unlike most goods industries, electricity does not permit integration via mutual recognition. Rather, integrated electricity markets require common standards for operation of the electrical grid. Some regions–notably the Nordpool market in Scandinavia–had accomplished electricity market integration outside of the European Union. Now that grid policy has become a European competence, the ENTSO-E body has been tasked with this process. But the EU has relatively little experience in standards-based market integration.

8 The Kyoto Protocol's carbon market mechanism was actually something foreign to the European Union. The EU member states had traditionally preferred top-down regulatory instruments for environmental policy. They agreed to the permit trading concept at the insistence of the United States. Despite the latter's withdrawal from the Kyoto Protocol, the European Union continued with the framework and its price and quantity instruments.

9 The European Court of Justice played a critical role in the evolution of feed-in tariffs. Many of the member states had adopted feed-in tariffs in the 1990s, but doubts remained as to whether they constituted illegal state aid under the Common Market regulations. A 2001 ECJ decision (European Court of Justice, 2001) confirmed the legality of feed-in tariffs and paved the way for their adoption across the EU.

10 Timing here proved critical. 2009 saw a rapid worsening of the European economic situation and financial crises in a series of peripheral economies. Interviews with a variety of EU and member state policymakers in late 2010 and early 2011 confirmed that the Climate and Energy package would not have passed under those circumstances. The decision of the French Presidency to push for ratification at the end of its term played a critical role in institutionalizing the Commission's white paper.

11 This has developed into a self-styled "carbon price fundamentalism." Nordhaus (2010) notes that "under limited conditions, a necessary and sufficient condition for an appropriate innovational environment is a universal, credible, and durable price on carbon emissions." The potentially infinitesimal intersection of the limited economic conditions he refers to, and the limited political conditions that would lead to a "universal, credible, and durable" price, poses major problems.

12 For public criticism of such parallel efforts, see Schmalensee and Stavins (2011). For attempts to quantify the differential cost of emissions reduction via renewable energy incentives versus emissions pricing, see Palmer and Burtraw (2005).

change action. Climate change poses fundamental policy problems because it imposes immediate, acute costs to achieve diffuse benefits far in the future. Achievement of 50-80% reductions in absolute emissions levels over the course of the 21st century will require significant investment in new energy infrastructure[15], as well as potentially large changes in the structure of cities and suburban areas, the methods used in agriculture, and the operations of a wide range of other sources of emissions. Because global climate change depends on the stock, rather than the flow, of carbon emissions, those changes must begin fairly soon, even if their unabated effects would not occur until far in the future. Finally, when implemented, they would result in nothing more than a world that looks largely like the one we know today–perhaps a bit warmer, given damage already done. In other words, the benefits as classically conceived come entirely through relative, and largely invisible, cost-avoidance, rather than absolute and tangible improvement.

This structure of costs and benefits has led other major emitters–notably the United States in the developed world, and China and India in the developing–to reject climate action. In the case of the EU, they are powerful arguments for choosing the least-cost means of action. Indeed, interviews with the European Commission in late 2010 suggested that the EU abandoned earlier ideas for a command-and-control approach to emissions regulation largely because of fears about cost. Despite those concerns, however, they have subsequently added to the carbon price framework a range of policies regarded as more costly, and less efficient, than a carbon price alone.

This is all the more surprising given that the Renewable Energy Standard was adopted after the accession of the new member states. As figure 2 shows, these new member states were considerably more reliant on energy and on fossil energy than the EU-15. Given that the EU-15 were already concerned about potentially detrimental effects of carbon pricing on competitiveness, the addition of 12 new members with even greater concerns should have made progress even more fraught. Under any theory of policy formation that gives primacy to efficiency and cost minimization, we would expect that this would make the EU more likely to pursue carbon pricing as the low-cost option. But this did not occur.

4 Complementarity, not redundancy: climate policy as energy policy

This portrayal of the puzzle of policy redundancy relies on viewing policy goals as *either* climate or energy focused. This is incorrect. European Union actions on climate and energy cannot be separated. Analytically, such a separation fails to account for the vital role played by the energy system in any serious attempt at emissions reduction. Politically, this separation ignores the immediate conflation of climate and energy goals and interests–and the political battles this brings–that occurs as soon as an emissions price is introduced. Substantively, it fails to recognize the underlying technological characteristics of the European energy system, the profound barriers to change those characteristics pose, and the actions required to overcome these barriers.

4.1 Climate between energy and security

Resolving these analytic failures must begin with the recognition that EU policy is optimizing across three separate externalities: emissions, energy security, and economic competitiveness.[16] But those externalities are closely connected to each other via mutual dependence on the energy system. Implicitly, solutions to any one of them suggest

Variation in national energy markets

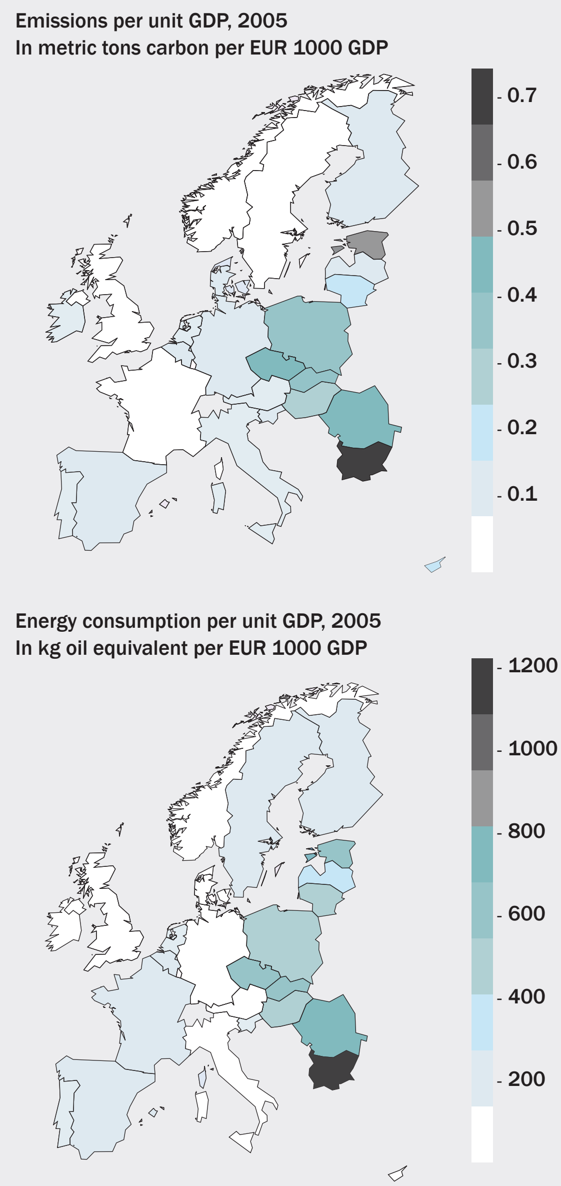


Figure 1: : Emissions and energy intensity in the EU-27 + Norway, 2005. Greece omitted due to lack of data. Energy intensity data from Eurostat. Emissions intensity data based on author's own calculations using GDP data from Eurostat and emissions data from the Carbon Dioxide Information Analysis Center at Oak Ridge National Lab.

Source: National Bureau of Statistics (2010, 2-7)

13 Germany and Poland both had their drafts of the Phase II National Allocation Plan denied by the European Commission, on the grounds that they used allocation as a kind of de facto state aid policy that interfered with the functioning of the internal market.

14 The EU has recognized many of these problems. The Third Phase of the trading system, beginning in 2013 will use auctioning rather than free allocation to improve the efficiency of the system and reduce opportunities for collusion. Much of the demand for a shift to auctioning appears to have come from firms, who could not rely on smooth adjustments to their allotment quotas under the free allocation system.

15 Energy Commissioner Öttinger has called for €1 trillion in energy infrastructure investment alone.(The European Commission, 2010) Whether this will materialize in an age of budget austerity remains to be seen.

16 This mantra has become a common feature of energy policy documents originating in the Commission, starting with the 2007 energy strategy white paper. Interviews with Commission staff in late 2010 suggested that, even within the Commission itself, opinions as to the relative importance or attainability of each goal varied greatly; and that the emphasis on any one of the three varied over time.

some form of energy systems transformation.

This has two important consequences. First, because of the variation in national energy markets, summarized in figure 1, the importance of each externality varies by member state. Spain and Portugal are energy islands due to the isolation of the Iberian peninsula; most of eastern Europe remains dependent on fossil fuels, either domestic coal or gas imported from Russia; Denmark is, at least for the near term, a net energy exporter that has decoupled GDP growth from energy consumption; France has already decarbonized 80% of its electricity supply through reliance on nuclear energy. These national differences in the structure of energy production, distribution, and use alter the importance that each member state attaches to the goals of competitiveness, energy security, and emissions reduction.

Second, isolated solutions to one externality may well exacerbate the others. Thus pursuing individual solutions to each of these externalities could well fracture the coalition required to maintain policy at all. The climate policy mix, therefore, should be viewed not as an attempt to resolve the emissions externality alone, but to optimize policy within the constraints imposed by these three energy-related externalities.

Those constraints come in two parts. Politically, each externality has its own constituency inside the EU. Energy security is most salient for the new member states, whose exposure to Russian influence through their dependence on energy was made clear by the 2005-2006, 2007-2008, and 2009 Ukraine gas crises. The western European states, who depend less on Russian energy, are correspondingly less concerned (though balance-of-payments concerns over imported fossil fuels remain salient). Emissions reduction is most important to some states with strong green parties, and to those who view European climate leadership internationally as vital. But states with relatively high carbon energy shares view emissions reduction as a potential drag on economic competitiveness. Competitiveness, of course, is a universal concern: but states with strong renewable energy technology industries (like Denmark or Germany) stand to benefit substantially from EU-wide emissons reduction programs, while other states may become net importers of these technologies. Thus each policy domain has separate, though sometimes overlapping, member state constituencies.

Optimizing along any one externality would risk fracturing the coalition along these lines. Pursuing emissions reduction through a high emissions price would have two immediate effects: first, it would substitute Russian gas for domestic coal in electricity generation, at an immediate 40% reduction in carbon per unit energy. Second, it would raise retail electricity prices substantially, and disproportionately in high-carbon-share economies. These developments might lead to defection by member states concerned about energy security and reduced economic competitiveness.

Likewise, pursuit of energy security alone would lead to significantly greater use of domestic EU coal. Much of the remaining coal in Europe, such as that around Si-

Emissions and energy intensity

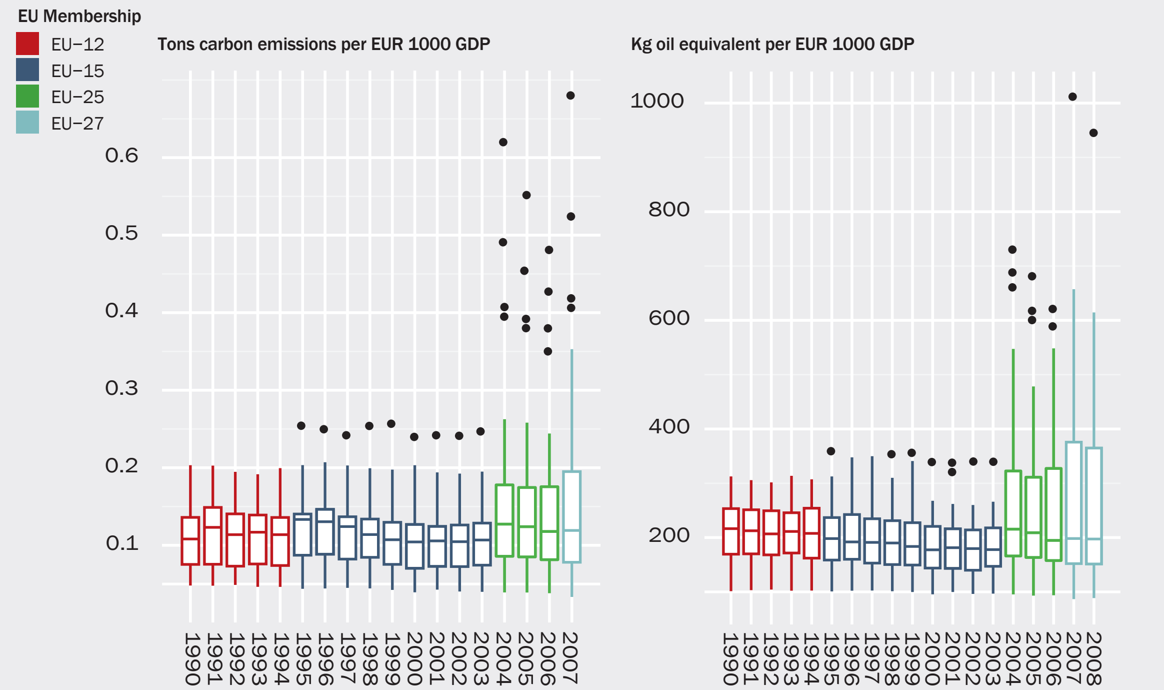


Figure 2: Emissions and energy intensity of economic activity in the EU across enlargements. Emissions data are expressed as MMT carbon per constant 2005 €. Energy data are taken from Eurostat and are expressed as kg. oil equivalent per real €1000.

Source: Emissions data are taken from the Carbon Dioxide Information Analysis center and are expressed in MMT Carbon.

lesia in Poland, is of the soft brown ligniteWorld Energy Council (2010) variety, which in addition to its carbon emissions carries a much higher share of other pollutants compared to the hard coal of earlier generations. This would alienate member states more committed to emissions and pollution reduction, and frustrate EU attempts to achieve its commitments under the Kyoto protocols.

Furthermore, a renewables target alone would generate signficant benefits for member states with strong wind and solar power industries. Those countries would stand to benefit from increased exports of capital goods, such as wind turbines and solar cells, to other member states lacking domestic production capacity.[17] But that would come at large costs to technology-importing countries, both in absolute terms and in the secondary effects on trade balances.

Finally, linkage of security, competitiveness, and climate change goals was made easier by energy market reform. Adoption of significant volumes (> 20%) of non-hydroelectric renewable energy–a cornerstone of energy security, emissions reduction, and policy competitiveness–poses significant challenges to the power grid. Technologically, the intermittency of most renewable energy sources can destabilize the power grid and lead to supply disruption. Those problems can be offset through grid reinforcements and investments in new technologies. Making those investments, however, would not have been in the interest of older, vertically-integrated state power moonopolies. Their control of both production and transmission of electricity gave them large incentives to favor their own energy production assets in making new grid investments and allocating grid capacity. As a corollary, it also gave them few incentives to invest in new transmissions connections for renewable energy resources, or to harden the power grid to effectively manage intermittent generation. In this context, the breakup of the power monopolies and the creation of independent markets for production, transmission, distribution, and use was a critical step in pushing for the adoption of low-carbon energy sources.[18]

Thus each policy problem carries with it unique interests for and against that would frustrate attempts to pursue them in isolation. Instead, the EU energy and climate policy suite has evolved to yoke progress along any one policy dimension to progress along the others. The mix of costs and benefits to any one interest group varies by the policy instrument, implicitly cross-subsidizing policy compliance. Finally, the ability to pursue all of these policies was highly contingent on the market reforms that enabled their implementation.

4.2 Political economy as a rebuttal to price fundamentalism

This analytic framework suggests that the arguments of the price fundamentalists miss the forest for the trees. As emissions policy alone, the ETS may be inefficient and cumbersome compared to a pure carbon price. As energy policy, the renewable energy mandates crowd out other, cheaper emissions-reducing fuels and efficiency investments. As market policy, energy market liberalization makes only partial sense in a world of massive, highly centralized fossil fuel generation plants.

But in practice, the policies manage the tradeoffs between each of the three externalities. The renewables mandate accomplishes four ends: it provides emissions reduction largely through renewable electricity adoption; it expands domestic renewable energy markets, generating profits for firms in renewable energy leaders like Denmark and Germany; it provides indigenous energy substitutes not subject to Russian influence; and it shifts the cost incidence of emissions reduction from retail electricity prices to subsidies paid, at least partially, from general taxation.

"Thus the renewables mandate solves the security problems of new energy sources, and generates significant income for some member states"

Absent some means of subsidization, the renewables mandate might generate opposition among either those less concerned with emissions or those net renewable energy technology importers. But the Emissions Trading Scheme, together with reallocated EU Structural Adjustment Funds, provides a political framework for implicit cross-subsidization. As Zachmann (2011) has shown, the new member states–for whom energy security via renewables is more expensive than via domestic coal–receive relatively more permits than they should compared with historic baselines. Conversely, countries like Germany and Denmark–who stand to benefit from the expansion of the renewable energy market–receive relatively fewer.[19] Since those permits have value on secondary markets, this represents an implicit subsidy to the same member states who are most exposed to the costs of renewables-led emissions reduction. Thus the renewables mandate solves the security problems of new energy sources, and generates significant income for some member states. But some of that income is recycled via the ETS permit process, cross-subsidizing energy security via renewables rather than domestic coal.

Finally, the pursuit of emissions reduction raises concerns about European competitiveness in the face of high energy prices. To offset these concerns, both the renewable energy mandate and the ETS provide compensating incentives. First, renewable energy has become a significant area of European comparative advantage. Maintenance of that advantage will require ongoing innovation. As a range of studies have shown, many aspects of energy innovation respond better to learning by doing than by laboratory or "big science" research alone.(Heymann, 1998; Kamp et al., 2004; Meyer, 2007; Acemoglu et al., 2009) The renewables mandates, by expanding the market for installation of new technology, provide the means for that kind of innovative activity. Meanwhile the emphasis on energy technology support in the SET-Plan and the Framework Programmes underpins basic research. Economically, these programs intend, at least, to generate signficant innovation and job

17 This, of course, is limited to the case in which each member state had binding targets without tradeable certificates. In that case, member states could not satisfy their domestic targets through purchases of excess renewable energy production from abroad. As of 2011, the EU renewable energy goals permit only limited tradeability in renewable energy.

18 Huberty et al. (2011) analogize energy systems transformation to earlier technological transformations like information and communications technology (ICT). Cognizant of the differences between ICT and energy, the breakup of vertically-integrated energy systems bears some relationship to the United States government's antitrust actions against the AT&T telecom monopoly. In both cases, policy action has attempted to facilitate innovation on the network by separating control of the network from control of the devices and services that operate on it. Whether this will work for energy the way it did for ICT remains to be seen.

19 Note that this will persist even after the move to auctioned permits. Auctioning will only control initial allocation within member states, not between them. Burden-sharing will still govern member state quotas under the ETS, and the member states retain the rights to use auction revenues however they see fit.

growth via investment in new high-technology sectors. Politically, they create new constituencies of firms and workers supportive of emissions reduction, offsetting the acute costs of emissions mitigation with the acute benefits of industrial competitiveness.

5 Green growth and the European Union

This study has so far demonstrated that European Union climate policy cannot be understood in reference to emissions reductions alone. Were that the case, a range of simpler, and potentially even cheaper, alternatives for climate change mitigation might have emerged as preferred policy options. Instead, the European Union has, whether by design or not, embarked on a policy suite that couples progress on emissions reduction to action on energy security and economic competitiveness. Doing so has allowed the cross-subsidization of different policy goals between the member states, keeping political coalitions for action together where action on only one goal might have generated defection.

In doing so, the EU has embarked on a strategy that knits together many of the "green growth" proposals discussed in Huberty et al. (2011). Improved competitiveness from reduced reliance on imported fossil fuels, export-led growth in renewable energy industries via market promotion at home, and revenue recycling from emissions pricing to research and development all represent prominent green growth strategies. That the EU understands this is clear from statements by the Commissioners themselves. Commissioner for Energy Günther Öttinger argued for increased European spending on low-emissions energy technologies by stating that "in global competition we need to avoid that we start lagging behind China and the USA."[20] EU Commissioner for Climate Action, Connie Hedegaard, has also endorsed the growth potential of climate change mitigation. (Hedegaard, 2010)

Many of these strategies have worked well for individual member states. Denmark has profited from both export-led growth in the wind turbine industry and increased global competitiveness through insulation from fluctuating fossil fuel costs. Germany has done well through promotion of renewable energy firms like Siemens at home (though as Frondel et al. (2009) show, that has come at a very high cost, particularly for solar energy technologies). Portugal and Spain both sought to use domestic market expansion to drive export competitiveness abroad and industrial redevelopment at home. (Rosenthal, 2010) Finally, a range of countries, from the United Kingdom to Poland, view offshore wind energy as new source of demand for skilled labor displaced from declining sectors such as offshore gas and oil exploration (in Scotland) and ship building (in Poland). As Huberty et al. (2011) noted, though, each of these strategies remain limited in scope and potential duration. In the case of the European Union, two threats in particular stand out. First, the process of market integration, critical to cost containment, has run into various regulatory

Renewable power potential

Photovoltaic (PV) Potential in the EU Regions

PV Potential
PV output for a 1 kWp system mounted at optimum angle (kWh/y)

- 676,1 - 845,0
- 845,1 - 951,0
- 951,1 - 1.113,1
- 1.113,2 - 1.291,3
- 1.291,4 - 1.506,2
- No Data

Wind Power Potential in the EU Regions

Wind Power Potential (m/s*km²)

- 0 - 79180
- 79.181 - 204.546
- 204.547 - 487.852
- 487.853 - 1.031.076
- 1.031.077 - 1.795.408
- No Data

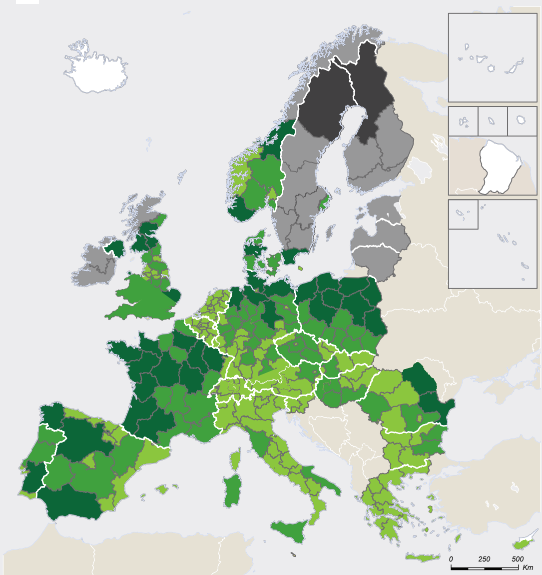


Figure 3: Wind and solar photovoltaic power generation potential maps for the European Union. Source: ESPON Regions at Risk of Energy Poverty (ReRisk) project.

Source: ESPON Regions at Risk of Energy Poverty (ReRisk) project.

20 Speech of Commissioner Öttinger at ENERI 2010, Belgian Presidency Conference on Infrastructure of Energy research. Brussels, 29 November 2010

problems on the ground. This is principally true in the case of power grid integration. Integration of renewable energy in the European power grid will be cheaper and less complex if accompanied by integration of the current regional energy markets. By averaging intermittency and resources over a wider geographic range, market integration can improve the stability of the power grid and lower the price of renewable electricity. As figure 3 shows, a European grid capable of drawing wind energy from northern Europe and solar energy from southern Europe would allow averaging of renewable power production across the entire European continent.

But actually building the power grid interconnectors required to make this a reality has encountered two significant problems. First, local resistance to new power lines has delayed new interconnector construction. Discussions with several European energy firms in late 2010 suggested that the time from project announcement to the start of operations could be as long as a decade. Second, potential solutions to local resistance–chiefly burying cables to minimize their aesthetic impacts–face signficant technical hurdles[21] and raise construction costs dramatically.[22] Thus despite ambitious goals for EU-level adoption of renewable energy and reform of power markets, the disconnect between EU-level goals and local regulatory and political reality may slow progress and increase costs.

The second potential problem comes from the political economy of the Common Market itself. Presently, significant disparities in competitiveness in renewable energy technology exist among different EU member states. Given the lack of tariff barriers inside the EU, mandates to adopt renewable energy technology may exacerbate, rather than even out, these disparities. This harkens back to earlier debates about the impact of the Euro and a common monetary policy on member state heterogeneity. Then, the debate over optimum currency areas turned on whether a common monetary policy would generate convergence of business cycles among the member states; or, alternatively, reduce transaction costs, and so increase the specialization and heterogeneity of the EU economies. Now, the question is whether renewable energy standards will provide new industrial opportunities to all member states, or instead generate substantial windfall profits for already-competitive firms in specific member states.

Timeline of EU Energy and Climate Policy

2000

- March, 2001 Commission proposes completion of the internal energy market via the 2nd Energy Market Directive
- September, 2001 Adoption of the Directive on the Promotion of Electricity from Renewable Sources
- August, 2003 Second Gas and Electricity Directive endorsed by the Parliament
- October, 2003 Emissions Trading Scheme (ETS) adopted
- May, 2004 "Big bang" enlargement creates EU-25
- January, 2005 First trading period of the ETS begins
- October, 2005 Climate and Energy prioritized at Hampton Court Palace summit under British Presidency
- January, 2007 Commission White Paper on EU Energy Strategy
- January, 2007 Romania and Bulgaria succession creates EU-27
- March, 2007 European Council adopts 20/20/20 targets
- January, 2008 Second trading period of the ETS begins; Commissions proposes legislation for 20/20/20 targets
- June, 2008 ENTSO-E establishes operations
- December, 2008 Climate and Energy Package endorsed by the Parliament
- July, 2009 3rd Energy Package endorsed by the Parliament
- November, 2010 ACER, the European coordinating body for energy regulators, established

2015

6 Conclusions: risks and opportunities for green growth in the European Union

The European Union, intent on climate change mitigation, has yoked emissions reductions to the cause of energy security on the one hand, and the promise of innovation-driven jobs and growth creation on the other. In doing so, it has created significant incentives for otherwise reluctant actors to maintain their commitments to emissions reduction in the face of the costs. Eastern European member states concerned about the price of renewable energy nevertheless benefit from reduced dependence on uncertain foreign suppliers, and receive subsidies to offset the costs. Northwestern European countries offset the costs of those subsidies with the expanded markets for the products of their high-technology industries. Emissions prices provide near-term signals for energy market evolution and efficiency, but not at levels that would generate significant political backlash. In contrast to recommendations for "price fundamentalism", this analysis would suggest that, given the interaction of the EU climate and energy policy suite with the political interests at stake, the superficial inefficiency of EU climate policy is a feature, not a bug.

"The European Union, intent on climate change mitigation, has yoked emissions reductions to the cause of energy security on the one hand, and the promise of innovation-driven jobs and growth creation on the other. "

Whether that translates into "green growth" is, of course, a different matter. As we have seen, EU policy faces obstacles to policy implementation and economic solidarity stemming from the dynamics of renewable energy adoption. Hopefully, the gains from "green growth" will remain large enough to help offset the costs implicit in these obstacles. If so, then the strategy of cross-subsidization of interests can remain viable and help sustain emissions reduction in the future. If not, however, EU policy will face significant challenges in sustaining the transition to a low-emissions economy.

21 This problem is unique to alternating-current transmission. The interface between the cable and the surrounding earth functions as a capacitor. Polarity-switching alternating current thus dumps most of its energy into charging and discharging that capacitor, to the point where line losses become very large. Solutions include use of direct current transmission (over very long distances) or shortening of the effective undergound cable length through periodic aboveground stations.

22 See, for instance, the 2008-2009 agreements among the Danish political parties and with the Danish network operator, Energinet.dk, on future construction of interconnectors in western Denmark. The agreement approved the construction of what will be Denmark's last new above-ground transmission line. It also set a framework for moving most of the high-voltage transmission infrastructure underground, albeit at significantly higher cost. See "Undergrounding of 132-150kV grids", at http://energinet.dk/EN/ANLAEG-OG-PROJEKTER/Infrastructure-projects-electricity/Sider/Cable-laying-of-132-150kV-grid.aspx. Accessed 5 April 2011.

Works Cited

Acemoglu, D., P. Aghion, L. Bursztyn, and D. Hemous (2009). The environment and directed technical change. NBER Working Papers Series 15451, National Bureau for Economic Research.

Christiansen, A. and J. Wettestad (2003). The EU as a frontrunner on greenhouse gas emissions trading: how did it happen and will the EU succeed? Climate Policy 3(1), 3–18.

Danish Ministry of Climate and Energy (2011). Energy strategy 2050: From coal, oil, and gas to green energy. Policy paper, The Danish Government.

Eichengreen, B. (1991, January). Is Europe an optimum currency area? NBER Working Papers Series 3579, National Bureau of Economic Research, Cambridge, Massachusetts.

Enkvist, P., T. Nauclér, and J. Rosander (2007). A cost curve for greenhouse gas reduction. McKinsey Quarterly 1, 34.

European Commission (2009, October). Investing in the development of low carbon technologies (SET-Plan). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions COM(2009) 514, The European Commission, Brussels, Belgium.

European Commission Staff (2009, October). A technology roadmap for the communication on investing in the development of low carbon technologies (SET-Plan). Communication from the Commission to the European Parliament, the Council, the European

Economic and Social Committee and the Committee of the Regions SEC(2009) 1295, European Commission, Brussels, Belgium.

European Court of Justice (2001, March). PreussenElektra AG v Schhleswag AG. Judgment of the Court Case C-379/98, The European Union, Luxembourg.

European Greens Party (2009). A green New Deal for Europe: Manifesto for the European election campaign 2009. Press release, The European Greens Party, Brussels, Belgium.

Frondel, M., N. Ritter, C. M. Schmidt, and C. Vance (2009). Economic impacts from the promotion of renewable energy technologies: The German experience. Ruhr Economic Papers 156, Rheinisch-Westfälisches Institut für Wirtschaftsforschung, Essen, Germany.

Hedegaard, C. (2010, September 30). Europe's view on international climate policy climate. Speech at the Kennedy School of Government, Harvard University, Cambridge, Massachusetts.

Heymann, M. (1998). Signs of Hubris: the shaping of wind technology styles in Germany, Denmark, and the United States, 1940-1990. Technology and Culture 39(4), 641–670.

Huberty, M., H. Gao, and J. Mandell (2011, April). Shaping the Green Growth Economy: a review of the public debate and the prospects for green growth. Copenhagen, Denmark and Berkeley, California: Mandag Morgen and the Berkeley Roundtable on the International Economy.

Jacobsson, S. and V. Lauber (2006). The politics and policy of energy system transformation—explaining the German diffusion of renewable energy technology. Energy Policy 34(3), 256–276.

Jamasb, T. and M. Pollitt (2005). Electricity market reform in the European Union: review of progress towards liberalisation and integration. MIT-CEEPR Working Paper 05-003WP, MIT Center for Energy and Environmental Policy Research, Cambridge, Massachusetts.

Krugman, P. (1993). Lessons of Massachusetts for the EMU. In Francisco Torres and Francesco Giavazzi, eds., Adjustment and Growth in the European Monetary Union. Cambridge University Press, Cambridge, United Kingdom.

Kamp, L., R. Smits, and C. Andriesse (2004). Notions on learning applied to wind turbine development in the Netherlands and Denmark. Energy policy 32(14), 1625–1637.

Meyer, N. (2007). Learning from wind energy policy in the EU: lessons from Denmark, Sweden and Spain. European Environment 17(5), 347–362.

Nordhaus, W. D. (2010, May). Designing a friendly space for technological change to slow global warming. Working paper, Yale University, New Haven, CT.

Palmer, K. and D. Burtraw (2005). Cost-effectiveness of renewable electricity policies. Energy Economics 27(6), 873–894.

Rosenthal, E. (2010). Portugal gives itself a clean-energy makeover. The New York Times Green Blog 9 August, A1.

Schepelmann, P., M. Stock, T. Koska, R. Schüle, and O. Reutter (2009, September). A green New Deal for Europe: Towards green modernization in the age of crisis. Green New Deal Series 1, Green European Foundation and the Wuppertal Institute for Climate, Energy, and the Environment, Wuppertal, Germany.

Schmalensee, R. and R. N. Stavins (2011). Renewable energy standards: less effective, more costly, but politically preferred to cap-and-trade? Grist.org 11 January.

Schreurs, M. and Y. Tiberghien (2007). Multi-level reinforcement: Explaining European Union leadership in climate change mitigation. Global Environmental Politics 7(4), 19–46.

The European Commission (2001, March). Completing the internal energy market. Communication from the Commission to the Council and the European Parliament COM(2001) 125, The European Commission, Brussels, Belgium.

The European Commission (2007a). An energy policy for Europe. Communication to the European Parliament and European Council SEC(2007) 12, Commission of the European Communities, Brussels, Belgium.

The European Commission (2007b, November). A European strategy energy technology plan (SET-Plan). Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions COM(2007) 723, The European Commission, Brussels, Belgium.

The European Commission (2010). Energy infrastructure priorities for 2020 and beyond - a blueprint for an integrated European energy networ. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions COM(2010) 677, The European Commission, Brussels, Belgium.

World Energy Council (2010). 2010 Survey of Energy Resources. World Energy Council.

Zachmann, G. (2011, January). Is European climate policy the new CAP? Bruegel Policy Brief 2011/01, Bruegel, Brussels, Belgium.

DENMARK
COUNTRY CASE ANALYSIS

June 15, 2011
Prepared by Jakob Riiskjaer Nygård

Introduction

In 2006 the Danish Prime Minister presented the ambitious goal of eliminating fossil fuels from the Danish energy mix. The recently published "Energy Strategy 2050" sets a target date of 2050 for achieving that goal and outlines a roadmap for getting there. What has enabled Denmark to pursue a strategy of eliminating fossil fuels from its economy without sacrificing growth? And why did Denmark adopt that objective? The answer to the first question is that a stable coalition between industry, civil society and government was formed following the oil crisis in the 1970s, and in a concerted effort it drove a relatively coherent transformation of the Danish energy sector over the following 30 years – today enabling the pursuit of fossil-fuel independence. The answer to the second question is that the emergence of a Danish cleantech sector, coupled with the building global awareness of disruptive climate change and related emerging clean tech markets, linked the policy objectives of energy security, economic growth and climate change mitigation under the overarching goal of realizing a fossil-free economy.

This paper will divide the story of Danish energy policy into four phases and argue that the policies of the first two periods fostered the industry, infrastructure and energy mix that, combined with domestic political pressure and international developments, caused the policy change that enabled the fourth, emerging period.

The first part of the story – covered below in "green growth part I: energy security" – emerges in response to a highly oil-dependant economy shocked by the oil crises of the 1970s. This led to the first explicit formulation of Danish energy policy. This first phase of the story is characterized by the primary political objective of achieving energy security, thus insulating the economy from future energy price shocks and sustaining economic growth. The second part of the story – covered below in "green growth Part II: The Auken years" – emerges from the election in 1993 and is characterized by the increasing importance of environmental priorities pursued by the new minister for energy and the environment, Svend Auken – not as a substitute for energy security, but as a layer on top of it. The policies pursued during the first two parts of the story had the derivative effect of decoupling emissions and economic growth.[1] As such we characterize this period as green growth in the sense of growth compatible with emissions reductions. The third part of the story – covered in "green growth part III: liberalization" – is a sort of intermezzo in the overall story of Danish energy policy. It emerges from a combination of EU liberalization pressure and the 2001 election of a right-wing government eager to further this liberalization agenda. The fourth and currently emerging part of the story – covered below in "green growth part IV: The fossil-free economy" – is initiated by the same right wing government's sudden shift in energy policy in 2006 toward elimination of fossil fuels from the energy mix. This emerging phase is characterized by the political objective of moving away from a fossil fuel-based economy, with the explicit objective of supporting a green export economy. As such, we characterize the emergence of this fourth part of the story as growth driven by emissions reductions.

Throughout the story, economic growth and energy security can be considered the primary policy objectives.

Throughout the story, economic growth and energy security can be considered the primary policy objectives. But where emissions reductions are a derivative effect in the first parts of the story, they are seen as a vehicle of the primary objectives in the final part of the story.

1 Green growth part I: energy security (1973 – 1993)

1.1 Initial policy drivers

The first Danish energy plan of 1976 emerged in the context of an economy highly dependent on oil, a civil society highly supportive of wind energy and critical of nuclear energy, and the limitations and opportunities inherent in Danish geography and existing infrastructure. Its primary objective was to achieve energy security for an economy highly dependent on imports of oil, in order to insulate the economy against any future shocks like the one caused by the oil crises of the 1970s. In other words, energy security was seen as a prerequisite for economic stability and growth.

1 Emissions in this case are computed according to the IPCC method, which does not reflect the emissions "hidden" in the outsourcing of heavy industries to Asia, etc., as a result of globalization. For a discussion of this issue see Wang and Watson (2008). This caveat of course applies to all western economies.

1.2 The toolkit: policy tools for energy independence

In the context of an economy 90% dependent on importing oil for its energy supply, it is easy to understand why the 1970s oil crises forced the issue of energy security onto the political agenda. The three energy plans enacted during this period (1976, 1981 & 1990) employed a range of policies to achieve energy security, which can be categorized under four headings: substitution and exploration; support for alternative sources of energy; energy efficiency; and infrastructure investment. (Mendonca, Lacey, and Hvelplund, 2009; Hadjilambrinos, 2000)

1.2.1 Substitution and exploration

The electricity industry responded independently to the oil crisis by beginning a transition from oil to coal as the primary fuel in electricity production. Oil and electricity taxes were enacted to support the shift and within a few years the electricity industry had almost completely substituted coal for oil, a condition that would persist until the mid 1990s. It can be argued that this substitution does not eliminate the issue of energy security, in that coal has to be imported as well. However, there is no OPEC in world coal markets, which makes dependence on coal

Electricity production by fuel 1994--2009

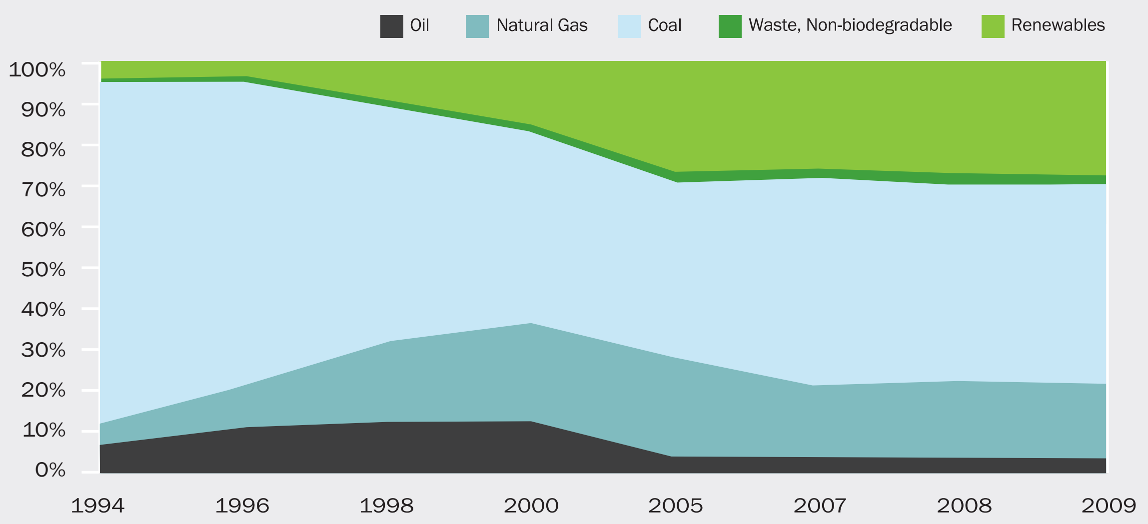


Figure 1: The historical development in electricity production by fuel reveals the integration of natural gas and renewables at the expense of oil and coal since 1994.

Source: DEA 2010:11

Gross energy consumption by fuel 1980-2009

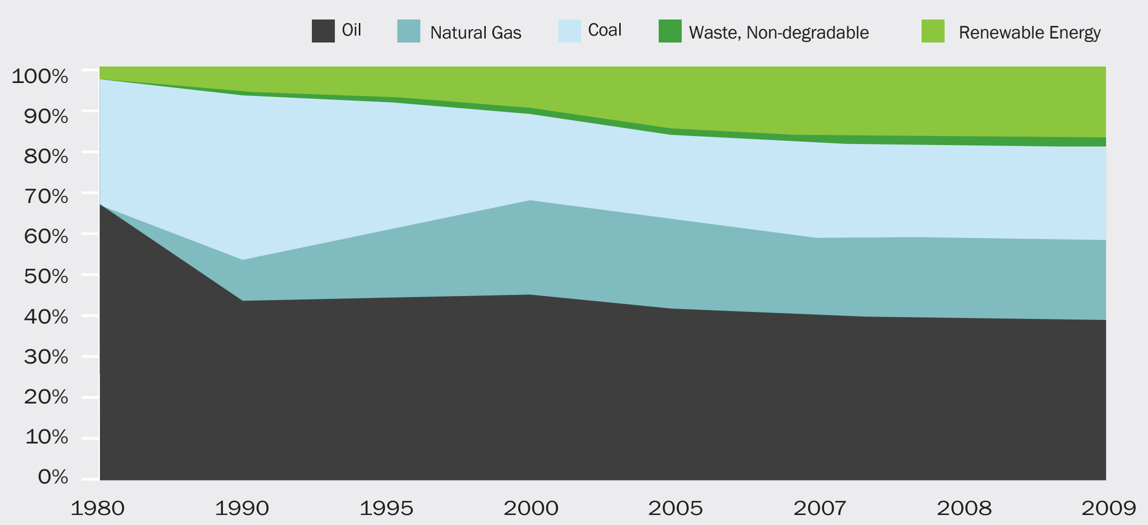


Figure 2: The actual historical energy use corrected for climate variability and energy use related to international electricity trade reveals the steady increase of renewables and natural gas at the expense of coal and oil since 1980.

Source: DEA 2010:18

imports significantly more desirable than dependence on imports of oil. In the 1990s the share of natural gas in electricity production and heat generation gradually increased. Figures 1 and 2 show electricity production and final energy consumption by fuel historically. (Hansen, 2003; Grohnheit, 2001; De Lovinfosse, 2008).

Related to the gradual substitution of fuel input, exploration of natural gas and oil in the North Sea was accelerated, which helped achieve the objective of energy security, as Denmark increased its production of both, and finally became a net exporter of oil and natural gas in 1995, see figure 3 below. According to the Danish Energy Authority, Denmark is expected to remain a net exporter of natural gas until 2020 and oil until 2018. (DEA 2010; DEA 2011:16)

1.2.2 Support for alternative sources of energy

Substitution and exploration largely achieved the objective of energy security. Another important element of the first energy plan however, was to explore alternative sources of energy. Initially, nuclear energy was the favoured option of policy-makers and the electricity industry, but a strong and broad coalition of civil society movements opposing nuclear power and supporting wind power successfully stalled plans to develop nuclear capacity, and in 1985 Parliament passed a moratorium on nuclear energy. “In 1979, energy and environmental politics, in that order, were the two policy areas (out of 20), which most Danes considered themselves ‘very interested’ in” (Andersen 2008:17).[2]

The coalition strongly favoured wind rather than nuclear energy, and with a geography that enabled wind – a flat country with lots of wind potential – and a history of experimenting with windmills dating back to the 1890s, the result was a gradual increase of wind as a share of electricity production (see figures 2, 3, 4 and 5).

Early policies supporting local cooperative ownership helped strengthen public support for wind power production and ease barriers to implementation of projects. By the early 1990s 120,000 people, out of a total population of roughly 5 million, were registered as owners of wind turbines – either individually or through cooperatives (Mendonca, Lacey, and Hvelplund, 2009). While the trend of local ownership has been reversed since the late 90s, it was a crucial part of the initial success of wind power deployment and helped build a foundation and broaden grassroots support for the strong wind power industry that exists in Denmark today spearheaded by the global leader in windmill markets, Vestas. Political support for renewables consisted of electricity taxing schemes, investment subsidies, and RD&D support for renewable energy. The total share of renewables gradually increased to roughly 27% of electricity production and 20% of final energy consumption in 2009. (Hansen 2003; DEA 2010; Hvelplund 1997; Toke 2002; Loring 2007; Karnøe and Buchhorn 2008; Toke, Breukers, and Wolsink 2008)

1.2.3 Energy efficiency

The third category of energy policies during the first period of Danish energy policy was energy efficiency policies. By mandating energy efficiency in buildings, taxing delivered energy, and subsidizing energy efficiency measures; Denmark reduced specific heat demand by nearly 40% between 1981 and 1997. Overall CO2 intensity has been cut by 50% from 1980 to 2006 (Grohnheit 2001; DEA 2009). Crucially, as pointed out above, the share of natural gas in electricity production and heat generation increased as energy efficiency policies rewarded combined heat and power (CHP) plants using natural gas and biomass. This brings us to the final category of energy policies during the first part of the story: infrastructure investment. (Grohnheit, 2001)

Primary energy production 1980-2009

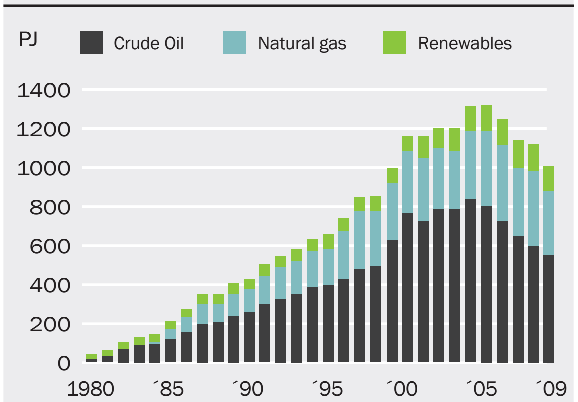


Figure 3: Production of primary energy measured by energy content. In other words: Oil and natural gas production are past their peaks and expected to be exhausted by 2018 and 2020 respectively.

Source: DEA 2010:6

Cumulative wind capacity 1980-2009

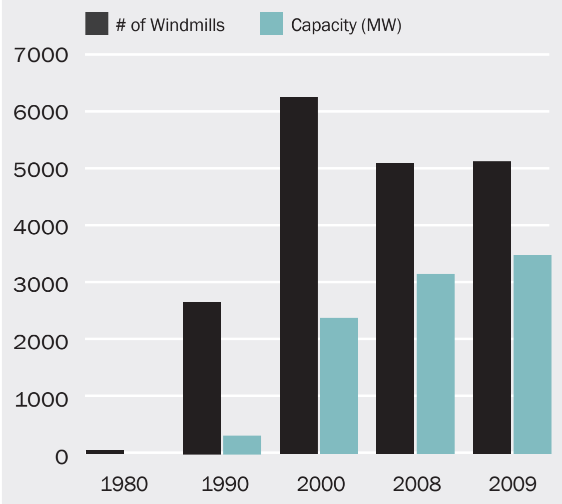


Figure 4: The number of windmills deployed increased steadily from 1980 to 2000 but began declining as development shifted to off-shore projects. The cumulative capacity however, kept increasing.

Source: DEA 2010:9

2 Translated by author.

1.2.4 Infrastructure investment

The development of district heating grids began in the 1950s but was accelerated as energy policy became explicit during this first part of the Danish energy story. Furthermore, it enabled the introduction of natural gas and CHP plants in electricity production, as a large distribution network for natural gas was unnecessary – the distribution grid was already in place in the shape of district heating and electricity grids, to which CHP plants could be connected (Grohnheit, 2001). This massively decreased the capital costs of a natural gas grid, thus rendering it a desirable policy option. As we shall see below, the widespread existence of district heating grids in Denmark becomes crucial in understanding the current policy shift.

1.3 Results

As alluded above, the exploration of oil and natural gas in the North Sea went a long way towards achieving the objective of energy security during the 1980s. This is not to say that energy security lost priority. Energy security in order to sustain economic growth remained the primary priority of Danish energy policy, and although becoming a net exporter of oil by 1995 meant that the Danish economy would now also benefit from future increases in the price of oil, the fact that oil is traded in a world market means that oil-consuming parts of the economy would still be exposed to any future 'oil shocks'. In that sense, becoming a net exporter of oil acted as a sort of hedge for the overall economy, but further diversification of the energy mix to ensure stable economic growth in the rest of the economy remained a central driver of energy policy.

2 Green growth part II: The auken years (1993 – 2001)

2.1 A new layer of politics: the rise of environmentalism

After the 1993 elections a new social democratic-led government came into power, and with it came a significant addition to energy policy. The policies of previous years were largely carried on, but following the the World Commission on Environment and Development's publication of "Our Common Future" (1987) – better known as the Brundtland Report for its chair, former Prime Minister of Norway Gro Brundtland – environmental concerns became an increasingly important issue in public debate. This led to increased focus on the environmental benefits of renewable energy under the tenure of Minister of Energy and the Environment Svend Auken (1993-2001). "The energy plan of 1996 "Energy 21", contained more than 100 initiatives designed to reduce CO2 emissions." (Karnøe & Buchhorn, 2008:76)

Among these were an annual target of 1% additional renewable energy in the energy supply, electricity taxes to finance energy efficiency programs, continued support for investments in district heating grids, and continued support for the development of oil and gas resources in the north sea (Danish Government 1996). As

Wind power's share of electricity 1980-2009

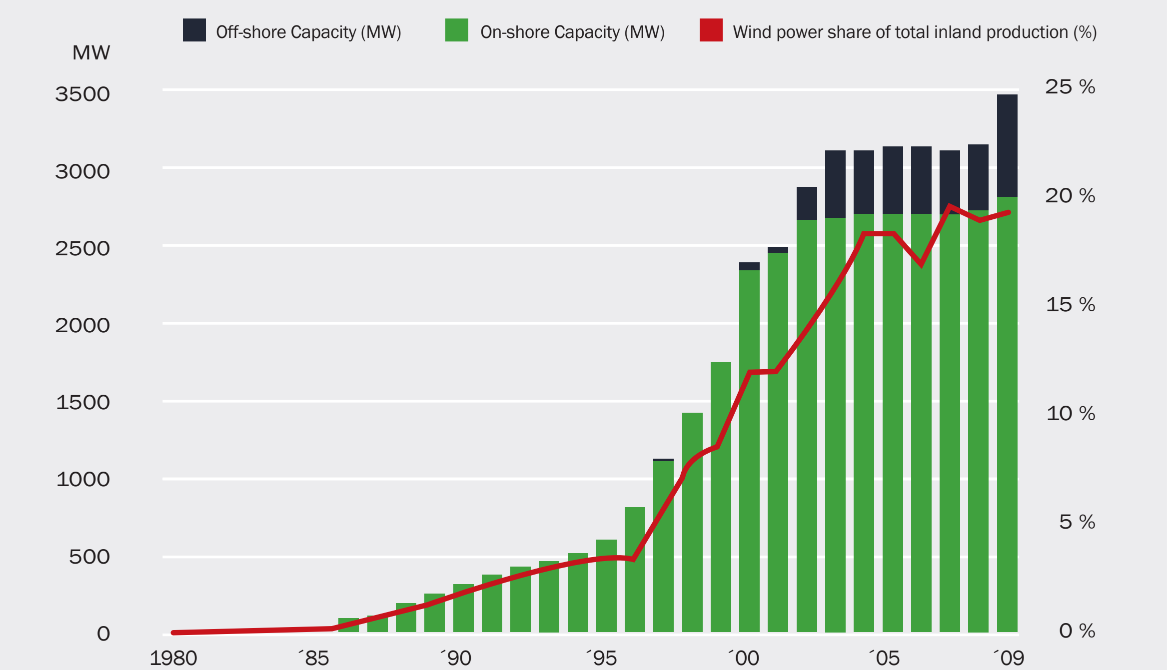


Figure 5: On-shore capacity increased rapidly during the 90s while off-shore capacity began increasing on the early 00s and again in the late 00s. The total share of wind in inland electricity production grew steadily until the mid 00s.

Source: DEA 2010:9

such the policies in the new plan represented a continuation of previous policies as described above with an increased focus on the GHG emissions associated with energy consumption.

As evidenced by figures 1 above and 5 below, the 1990s marked the golden age of wind power deployment in Denmark with rapidly increasing shares of wind power in electricity generation. The ministry of environment – Auken's initial portfolio – was merged with the ministry of energy in 1994, symbolic of the further integration of the two policy areas. (Hansen 2003; De Lovinfosse 2008t)

2.2 The birth of the green growth argument

The idea of supporting the clean tech sector to create export-led growth via 'green exports' can also be traced back to this period. The energy plan of 1996, Energi21, points to a Danish interest in positioning itself in international energy markets by investing in clean tech: "It is the Government's intention to support a continuation of this [the massive growth of Danish energy technology exports in recent years] positive trend through the initiatives in Energi21."[3] (Danish Government 1996:13)

2.3 Political context

The overall political context of the Danish energy story is described below in figures 6 and 7: During each election, voters were asked the open-ended question "What is the most important problem today that politicians should take care of?"[4]

Two things are important to note. First, the environment was never seen as the most important problem among the Danish electorate. While the data cited above in section 1.2.2 suggests that many Danes were interested in energy and environmental politics, the graphs here show that historically, only a relatively small minority has subscribed to the notion that 'the environment' is the most important problem facing politicians. Many, in fact most, thus considered themselves interested in

3 Translated by author.

4 Translated by author.

5 Four of the nine categories have been omitted here for clarity of presentation, as they have scored relatively low historically and are considered less important for the purposes of this analysis: balance of trade and payments; tax; EU, foreign & defence policy; other. The question is asked open-ended and researchers have then coded answers under these nine categories. This implies that energy issues might have been coded as an economy or unemployment issue because voters considered the economy and unemployment the problem – the major cause of both problems of course was the energy crisis.

Relative importance of issues in public opinion 1971-2009[5]

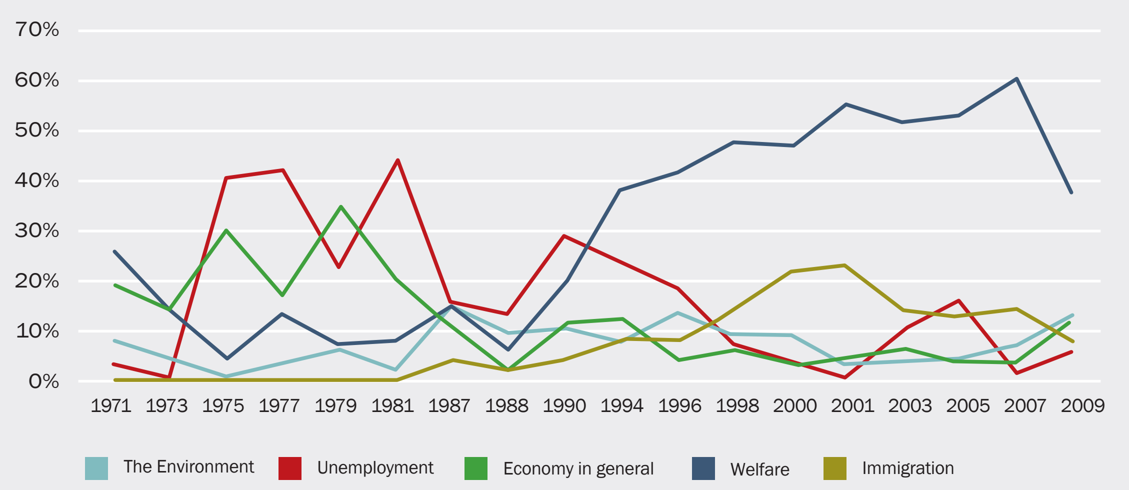


Figure 6: Voters generally regard economic issues (unemployment, the economy in general and welfare) as the most important issues politicians need to take care of.

Source: Andersen, 2002; Andersen, 2008; Arbo-Bähr 2010

Relative importance of issues in public opinion: the environment 1971-2009

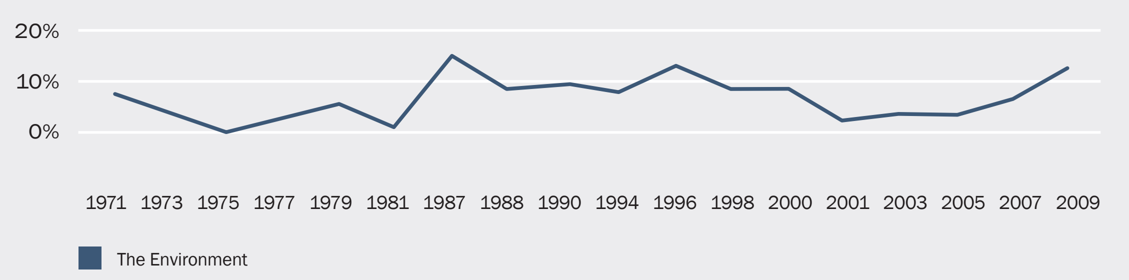


Figure 7: While the environment has never been the most important issue in the eyes of voters, it was generally seen as more important in the 90s and again towards the end of the 00s.

Source: Andersen, 2002; Andersen, 2008; Arbo-Bähr 2010 energy and environmental politics, but few considered it the most important problem facing the nation. It is not insignificant at all however, whether the group of people that do consider it the most important problem amounts to 3 % of the electorate, as in 2001, or 10 % and above as in most of the 90s and again in 2009. That is the difference between a statistically insignificant group of voters and a very significant group of voters, and thus for policy-makers, the difference between a 'good' and a 'bad' political sell.

Second, the major issues, aside from the recent advent of the immigration issue, have generally been issues of economic politics. The environment does however become a more important issue in the 1987 election following the publication of the Brundtland Report (WCED 1987), and after an intial dip in the 2000s again in the 2007 election. The report was published in May 1987 and propelled the issue of the environment and sustainability onto the political agenda of the september elections later that same year. The issue remains relatively important until the 2001 election with around 10 % of the electorate saying that it is the most important problem that politicians need to address. Subsequently, other priorities rise to the forefront of public attention, as discussed below.

"It would be more accurate to describe the new environmentalist drivers as creating a second, complementary layer of policy objectives layered on top of energy security objectives"

The environmentalist policies deployed during this period did not represent a break in the pursuit of long-term energy independence; this objective remained as a fundamental driver. It would be more accurate to describe the new environmentalist drivers as creating a second, complementary layer of policy objectives layered on top of energy security objectives. The ability of Auken to increase the focus on environmental policies in overall energy policy is a result of the increasing public awareness of the adverse impacts of environmental pollution and the developments during the first part of the story. The public awareness provides the political justification, and the bottom up support for renewable energy in the first part of the story had helped form broad public support for and acceptance of renewables as well as an industry, with which a strong coalition could be built to support further policies for renewable energy.

3 Green growth part III: Liberalization (2001 – 2006)

3.1 Liberalization: a political intermezzo

Following the Auken years of 1993-2001 a new right-wing government led by Anders Fogh Rasmussen[6] came into power in 2001. This resulted in a reversal of energy policy: funding for environmental and renewable energy programs was cut in favour of deregulating energy markets and privatizing state functions. Annually installed wind capacity rates dropped accordingly, cf. figure 4 & 5. Subsidies and other support mechanisms for renewable energy were seen as directly in conflict with the objective of liberalization. The election also led to the establishment of the Environmental Assessment Institute (EAI) under Bjørn Lomborg, which challenged the very rationale for supporting renewable energy – i.e. that climate change was 'worth' fighting – by questioning the science of climate change and suggesting that, for instance, supporting sustainable development in third world countries was a more cost-effective way of pursuing environmental priorities.

This rather sudden shift, from a political environment that was quite supportive of green policy to one where green policy initiatives were slashed, requires some explanation – particularly given that, as we discuss below in section 4, green policy was destined to reassert itself beginning in 2006. Why did this "intermezzo" occur? Andersen (2008) suggests that a 'lomborg-effect' explains the dip in the importance of the environment on the political agenda in the early 2000s. (Karnø & Buchorn 2008; Meyer 2004a; Meyer 2004b; Andersen 2008)

But it is also very likely that environmental issues were simply drowned out by other issues coming to the fore at the time. It is important to note, that energy and environmental politics played a very minor role in the 2001 elections, in which the core themes were the future of the welfare state and immigration. In an analysis of surveys conducted during the election[7], Jørgen Goul Andersen shows that the two major issues for voters in the 2001 elections were 'welfare' and 'immigration' (cf. figure 7 above). Only 3 % of voters thought that the environment was the most important issue compared to 9 % in the 1998 election.

Two key events, neither directly related to energy or green growth, shaped the outcome of the 2001 election. First, the incumbent social democratic-led government's highly unpopular 'third labour market reform' of 1998, which was viewed as a 'broken promise' to voters. Second, the terrorist attacks on the World Trade Centre in New York on 9/11. The former caused severe dissatisfaction among social democrat faithfuls and the latter helped propel the issue of immigration onto the agenda, which in turn helped boost the right wing nationalistic party, the Danish People's Party, to its best result yet, thus cementing the majority swing in parliament from left to right. (Andersen 2002:8; Larsen & Andersen 2009:255; Bille 2002)

This should not be interpreted as an exhaustive analysis of the Danish 2001 elections but rather a highlighting of core themes. The point is that energy and environmental politics was not an important issue for voters and that it was not a central issue in the election. Fogh's campaign was, among other things, based on a deregulation and privatization agenda to improve efficiency of the welfare state. Because of the unpopularity of the 'broken promises' of the incumbent social democrats, his campaign was also based on the idea of 'keeping promises' as expressed by his coining of the concept of contract politics. This

6 Henceforth referred to as Fogh to avoid confusing him with the following and current Prime Minister, Lars Løkke Rasmussen (07-?).

7 In Denmark, an election usually lasts three weeks. According to the constitution, the Prime Minister must call an election no later than four years following the last one and tradition dictates that he or she does so with 3-4 weeks' notice. This, of course, does not prevent parties and politicians to position themselves continuously, but formally, an election lasts three weeks.

concept became a central theme of his successful 2005 and 2007 re-election campaigns (Andersen 2008:19).

Part of understanding the sudden shift in policy is also to understand the very coalitional nature of the Danish multi-party system of politics. In a parliament where governments have historically depended on centre parties for parliamentary backing, the 2001 election marked the first time since 1929 that parties right of the middle held a majority in the parliament on their own (Bille 2002). In other words, the government did not depend on a centre party for parliamentary majority, which likely would have limited the subsequent deregulation and liberalization drive.

The following five years thus marked a period of Danish energy policy in which the political objective of liberalization was the main driver of policy. The change came about as a result of EU pressure that began the process of deregulating energy markets in the late 1990s, but with the election of 2001 the process received strong backing from the Danish parliament and government as well. The primary goal of energy policy was still to ensure stable economic growth, but in the eyes of the new government, liberalization of energy markets was crucial to ensuring this. (Mendonca, Lacey, and Hvelplund, 2009; Karnøe & Buchhorn, 2008; Jakobsen, 2010; Nørgaard and Tornbjerg 2002).

The following five years thus marked a period of Danish energy policy in which the political objective of liberalization was the main driver of policy.

Despite the significant change in policies away from alternative energy support and environmental priorities during this period, the foundation for another critical change in policy had been laid. The changes to the energy mix and the investment in industry and infrastructure had created a context in which the goal of the fossil-free economy could emerge.

Energy consumption, GDP, and energy intensity

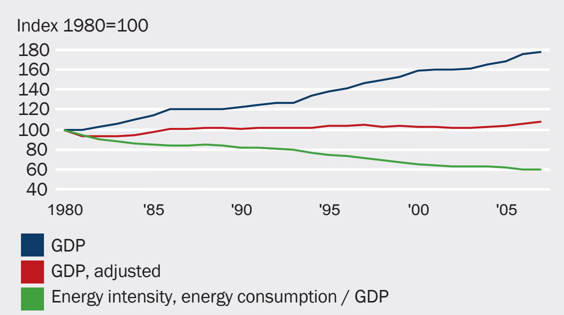


Figure 8: While GDP has grown substantially, the energy intensity of the Danish economy, i.e. energy used per unit of GDP, has decreased since 1980.

Source: DEA 2009

3.2 Summary – results of the first three phases of Danish green growth

"Green growth" was never an explicit goal of Danish energy policy during these first three parts of the story, but the combination of policy tools used to achieve the primary objectives of supply security and economic growth had the derivative effect of decoupling emissions and economic growth (Danish Government 1996; Grohnheit 2001). Thus, although emissions reductions did not attract substantial focus as a political objective until the 1990s, the decoupling of growth and emissions began in the 1970s. In the clarity of hindsight we can thus describe these first three phases as a form of green growth *compatible* with emissions reductions. (See Figure 8 below for an illustration of this decoupling.)

"Green growth" was never an explicit goal of Danish energy policy during these first three parts of the story, but the combination of policy tools used to achieve the primary objectives of supply security and economic growth had the derivative effect of decoupling emissions and economic growth

4 Green growth part IV: the fossil free economy[8] (2006 – 2050)

In 2006, a combination of international developments and the policies pursued during the first phases of green growth had created the industry, infrastructure, energy mix and global market conditions that enabled Denmark to commit to pursuing the goal of a fossil-free economy. This commitment occurred in spite of the fact that Denmark was still governed by the conservative administration that had initially slashed green policy support. How did this reorientation occur?

4.1 The politics of reorientation

The change can be traced to back to September 2006, when Fogh reversed the previous five years of liberalizing energy policy priorities by announcing the goal of a fossil-free society. (Vestergaard 2006)

Understanding how this policy shift came about means understanding the political climate and emerging industrial structure of 2006. We divide this story into two sets of factors: first, a set of specific, circumstantial political events and conditions that impacted Fogh's decision-making at the time. Second, the playing out of the on-going structural reorientation of the domestic and international market that began in the first three periods of Danish green growth.

4.1.1 Circumstantial political factors

During the government's attempt to liberalize energy markets it sought to adhere to environmental obligations via the EU Emissions Trading Scheme and joint implementation projects under the Kyoto Protocol. Meilstrup (2010), based on interviews with ministers and high level

8 This part of the story is still being written, and for obvious reasons telling it is associated with a certain amount of uncertainty. It should be noted that the strategies described in this section are just that – strategies. How they will actually play out remains to be seen. There are however, clear signs of a shift in direction of policies and industry onto a new and more 'green' path.

9 Translated by author.

civil servants, argues that Fogh decided he needed to 'green' the government in response to public pressure. He did this by appointing Connie Hedegaard as the Danish minister for energy and the Environment in 2004. In the heat of the cartoon crisis of 2006, she suggested to Fogh that pursuing the presidency of COP15, which was expected to deliver the next global climate change treaty, was a unique opportunity for Denmark to shift international focus away from the cartoon crisis. (Meilstrup, 2010) The change in policy then is seen as a way for the government to position itself in the race for the presidency of COP15, and later to bolster diplomatic efforts to achieve an ambitious treaty.

Secondly, the increasing scientific consensus on the adverse impacts of climate change clearly also had an impact on the change in policy – though whether it was direct or through increasing public awareness and pressure is unclear. As figure 7 above shows, by the late 2000s the environment was again becoming an increasingly important issue on the Danish political agenda. Moreover, according to public opinion polls, "already in May 2002, the environmental cuts were the most unpopular of the government's new measures (50 % against, 35 % for)"[9]. (Andersen 2008:17)

Thirdly, the Danish public service does not change with elections. That is, aside from natural turnover, ministerial employees largely remained the same as during the Auken years, except for people let go as a result of funding cuts after the 2001 election. This implies that the policy ideas created during Auken's tenure remained nascent in the ministries.

As it became apparent that COP15 would not produce the desired result, the government decided to link its environmental priorities to growth policies directly, which most recently has created the green growth strategy "Energy 2050", as described below in section 4.2.

"The best way to understand this shift is to see it as representing a structural shift in the expectations created by regulation and the market for energy companies"

4.1.2 Structural reorientation of the market

Simultaneously with the political reorientations, a sea change was occurring more broadly in the general economy. Structural changes were playing out in industry at international, domestic, and local levels. This is best exemplified by the decision of the major energy company, DONG Energy, to pursue a 'green' strategy in 2008. The main tenets of the strategy are to stop new investment in coal-fired power plants and increase the amount of wind and natural gas-fired power plants in its portfolio. The goal is to increase the ratio of renewables to fossil fuels in the portfolio to 85/15, to cut CO2 emissions per energy unit in half over ten years, and to reduce it to 15 % of current levels by 2040 (Bøss 2011).

In addition to this, DONG has also pulled back from coal-power activities generally, making the decision not to pursue any more coal-fired power plants in the future. Indeed, as of 2009 it has pulled out of all new coal fired projects – including projects to build coal power plants in Scotland and Germany – in spite of the fact that it has expertise in this area, had won these contracts, could potentially make money from them, and had already sunk some investment into them. This seems to us to indicate a uniquely strong commitment to pulling back from carbon-heavy power sources like coal. Why would DONG cancel projects it had already signed, secured, and invested in?

The best way to understand this shift is to see it as representing a structural shift in the expectations created by regulation and the market for energy companies. DONG's current strategy reflects a belief that coal is no longer a good investment – in any form. Pulling back from coal-fired plant projects that have already been won is a reflection of DONG's growing expectation that conditions in the market – ranging from increasingly stringent projected carbon regulation to public opinion trends – will make it increasingly difficult to bring coal projects to completion as countries shift away from coal as a desirable power source, and that (even if completed) such projects will have increasingly uncertain returns on investment. In part, this is because of the surrounding regulatory environment, which places a growing cost on CO2; free CO2 quotas will disappear as of 2013, meaning that full CO2 costs will be incurred from that point on. Pursuing a coal project – even one that is already in process – no longer makes good business sense to DONG because it could lead to an expensive waste of effort and uncertain profitability over the long lifetime of these projects. Given that funds for investment are limited, and that the alternative investment – renewable energy – is desired and stimulated from a societal perspective, DONG sees this situation as prompting a strategic re-orientation toward low-carbon investment (Bøss 2011). Once expectations within the market have altered to this extent, green growth policy becomes in a sense self-sustaining, as perceived incentives lead to the growth of constituencies with a vested interest in green energy, and shrinkage of constituencies with a vested interest in fossil fuels. Indeed, DONG itself has adapted to the transformed market structure, and now supports CO2 taxes and increasing emissions reductions goals, as these regulations incentivize the continuing transition to the renewable energy world DONG is structuring itself for (Bøss 2011).

Once expectations within the market have altered to this extent, green growth policy becomes in a sense self-sustaining, as perceived incentives lead to the growth of constituencies with a vested interest in green energy, and shrinkage of constituencies with a vested interest in fossil fuels.

4.2 The new toolkit: policy tools for a fossil-free economy

The policy suite used today to pursue Denmark's fossil-

Gross energy consumption by sector

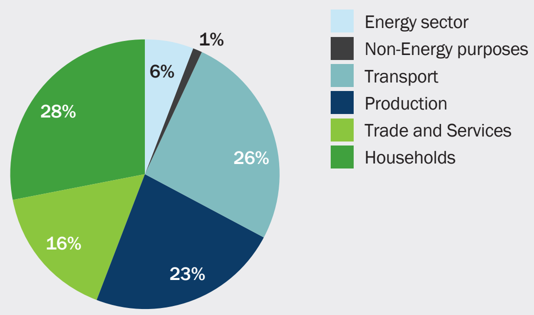


Figure 9: The major energy consuming sectors of the Danish economy are transportation, production, trade and services, and households.

Source: DEA 2010:18

Net energy consumption

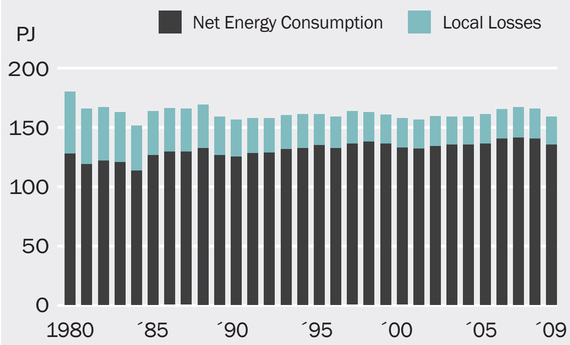


Figure 10: Energy consumption for household heating purposes has become significantly more efficient since 1980. The high amount of energy consumed however, speaks to the necessity of decarbonizing heating, to achieve the overall objective of the fossil free economy[12]

Source: DEA 2010:34

free goals represents a continuation of trends during the first phases of Danish green growth, but the linkage of growth and environmental priorities represents a re-imagining of policy priorities. As renewable energy and clean tech industry investments become a driver of economic growth, the political rationale for investing in these becomes significantly more robust, and crucially, the policy change occurs under a right-wing government, which has, historically, been more sceptical of environmental priorities and alternative energy sources. The question is no longer whether or not Denmark should invest in renewables, but how fast it can, and how it should, eliminate fossil fuels from the energy mix (Vestergaard 2006). Political resistance to green growth policies has virtually disappeared.

The recent "Energy Strategy 2050" (published in February, 2011) is the latest step toward Denmark's current goal of finally eliminating fossil fuel dependency in the Danish economy, thus achieving the complimentary objectives of energy security, environmental protection and green growth. The policies emerging in the second part of the Danish green growth story can be characterized under 4 headings: Support for renewable energy sources, electrification, infrastructure investment, and energy efficiency. (Danish Government 2011)

4.2.1 Support for renewable energy sources

The policy shift picks up the historic support for renewable energy and seeks to support further integration of wind, biomass, and biogas through subsidies, RD&D support, and calls for tenders on two new off shore wind farms (400 + 600 MW). As the rationale for this policy is now economic growth as well as environmental protection and energy security, it should be understood against the backdrop of the developed clean tech industry that emerged as a result of the first phases of green growth. Two government studies from 2006 and 2009 investigating the "green" business potential in Denmark identified a cluster of highly competitive clean tech businesses in Denmark producing and exporting "clean" solutions to environmental problems.[10] As of 2006 the sector comprised 720 companies employing roughly 120,000 people, with total added value in the sector amounting to DKK 86 billion – roughly 5 % of GDP (Andersen, Bertelsen, and Rostend 2006; FORA 2009).[11] Export and revenue in the sector have exhibited strong growth rates from 2000-2008 compared to the rest of the economy as well as the EU (Danish Government 2010). In other words, Denmark currently enjoys a strong position in parts of the global clean tech market. This position, in turn becomes interesting politically as the demand for green energy globally is high and projected to increase massively in the future. There is a huge global market potential for clean tech, and investments in the sector are projected to increase rapidly over the next 20 years. (Meilstrup et al. 2010)

At this point the integrated Nordic electricity markets also deserves mention. The integration of the Nordic electricity grids (Nordel) enables the further integration of wind power in Denmark, and has done so historically, by allowing imports of hydropower to offset imbalances

City-level green policy

Another part of Denmark's green growth story is the efforts undertaken at the city level. As of 2009, the municipal government of Copenhagen approved a plan to reduce CO2 emissions by 20 % compared to 2005 in 2015 and to be CO2-neutral by 2025. The highlights of the plan include support for renewable energy in energy supply (biomass and wind); Influencing the transportation sector by advancing bikes and collective transportation, imposing restrictions on traffic, and supporting energy efficiency in transport; Energy efficiency in buildings; and information activities aimed at behavioral change. (City of Copenhagen 2010)

10 For the purposes of the two studies cited here, clean tech is divided into technologies aiming to solve 8 distinct environmental challenges: climate change; air pollution; water; land use & biodiversity; chemicals in products; land contamination; waste; and raw material use. The survey was conducted using 'snowballing', which implies that there may well be companies not identified in the survey.

11 264 of the surveyed companies identified clean tech as a secondary area of business; amongst the remainder of companies clean tech is defined as the primary - not the sole - area of business. As the available data does not allow for a distinction between clean-tech-generated revenue and revenue generated from other areas of business, these numbers should be treated with some uncertainty.

12 Net consumption equals final consumption minus local losses in heating furnaces, etc.

13 Electric heat pumps use electricity to produce heat. They are currently being deployed in households not connected to district heating grids to replace oil furnaces. They are further envisioned to be deployed in district heating grids and as an alternative to industry use of fossil fuels. In all sectors they serve the dual purpose of using electricity rather than fossil fuels, and providing the ability for flexible use of energy, i.e. the ability to produce heat when wind electricity production peaks and use it, when it is needed. (Danish Energy Association, 2009:16ff)

between supply and demand in the context of fluctuating wind production (Grohnheit 2001). As penetration of volatile wind energy increases, there is a limit to how much the Nordel market can offset the fluctuations in Danish wind energy production. This leads to the idea of transforming the electricity grid by creating a Smart Grid (cf. section 4.2.3 below).

4.2.2 Electrification

Renewable energy has the potential to eliminate fossil fuels from electricity production, but so long as the internal combustion engine dominates the transport sector, fossil fuels will remain a component in the overall energy mix. This leads naturally to the idea of electrifying the transport sector. If the electricity supply can be produced primarily from renewables, and the transport sector becomes dominated by electric vehicles, Denmark will have gone a long way towards eliminating fossil fuels from the overall energy mix. See figure 9 below.

Household heating consumption still represents app. 20 % of final energy consumption. To eliminate fossil fuels from this part of the energy sector, the strategy seeks to further develop the Danish energy infrastructure, which brings us to the third component of the 2050 strategy.

4.2.3 Infrastructure investment

The strategy seeks to further investments in district heating grids and to further increase the use of biomass and electric heat pumps in district heating through subsidies. The increasing use of biomass helps eliminate fossil fuels in and of itself. The key here is that the ability to increase the use of biomass in CHP plants is facilitated by the development of the natural gas and district heating grids that occurred during the first part of the story. Electrification through dissemination of electric heat pumps achieves the same purpose, to the extent that electricity supply is transformed. Electric heat pumps however, also serve another important purpose: distributed battery capacity in a future Smart Grid.[13]

The development of a Smart Grid – an intelligent electricity grid – is a prerequisite to the further integration of wind energy. The Danish state-owned transmission systems operator and the Danish Energy Association envisions the Smart Grid in the Danish context as a transformation of the electricity grid, which enables an effective interplay between wind power production, heat pumps and electric vehicles (Dansk Energy Association and Energinet.dk, 2010). The combination of real-time dynamic pricing of electricity through smart meters and distributed battery capacity in the grid – in the form of electric vehicles and electric heat pumps – to offset the volatility of wind electricity production, is thus envisioned to enable Denmark to massively increase the share of wind production in electricity generation.

The EU-funded ECOgrid project will turn the island of Bornholm into a large pilot project for the national implementation of a Smart Grid. The population of the island is 50,000 people. Its virtue is its isolation, which enables it to be disconnected from other grids. By 2014, 50 % of its electricity supply will be covered by wind production (Wittrup 2010; Energymap.dk 2010).

4.2.4 Energy efficiency

The demand for fossil fuels is determined by the demand for energy in general. Energy efficiency presents an obvious complement to the policies above by reducing the extent to which development of renewables, electrification and infrastructure development is necessary. The strategy seeks to support energy efficiency advances in general and in buildings in particular through mandates, benchmarking and further support for district heating (cf. section 4.2.3 above).

4.3 Summary

All of the above policies conform to the goal of fossil fuel independence as well the complementary underlying objectives of environmental protection, energy security and Green growth. That 100 % renewables in the energy mix is good for the environment and for the security of supply is a straightforward proposition, but the green growth part of the story deserves special mention. The idea is to create green growth by supporting innovation in clean tech sectors. By turning Denmark into a "green growth lab" in which other countries look for ideas and inspiration for climate challenges, the triple policy objectives of stimulating growth, achieving security of supply, and mitigating climate change can be pursued – not only domestically but internationally as well.[14]

14 The concept "green growth lab" was coined by Monday Morning to describe the idea of supporting clean tech innovation, for the purpose of gaining a leading global position on innovation of sustainable solutions, with the explicit purpose of exporting these solutions. (Meilstrup et al. 2010)

5 Conclusion

The Danish strategy of energy independence, described in Part I & II, successfully achieved growth *compatible with* emissions reduction. It further created the industry, infrastructure and energy mix which, combined with international developments, enable Denmark's current attempt to achieve a fossil fuel-free economy (as described in Part IV). The idea is to create growth that is not only *compatible* with emissions reductions, but also *driven* by them, thus fulfilling the triple underlying policy objectives of energy security, climate change mitigation and green growth.

The current behaviour of Denmark's energy industry suggests that expectations have been fundamentally reconfigured.

The ability to move from phase to phase of this progression has been an evolutionary process, with early phases creating the conditions that make later phases possible. Over time, evidence suggests that this has led to a very real transformation of the structure not only of the Danish energy system, but of its industry and markets as well. The current behaviour of Denmark's energy industry suggests that expectations have been fundamentally reconfigured. Denmark's policy objectives have thus proven to be self-reinforcing in two ways: across objectives in the sense that they are intertwined, each contributing to the fulfilment of the others; and over time in the sense that policy actions taken at one point in time help create the context that enables and supports policies within the next phase.

From an international perspective, Denmark's experiments with the Smart Grid, electric vehicles, electric heat pumps, biomass use in district heating, etc. will provide important lessons on how to decrease an economy's dependence on fossil fuels. While these lessons must be understood in the context of the general Danish energy story as explained in this paper, they will provide valuable insights for nations looking to – not just talk the talk – but also walk the walk of a fossil-free economy.

Finally, the policies pursued by Danish governments distinguish themselves by being relatively coherent over a long period of time. The lesson here for any country seeking to reduce its carbon footprint is that it is crucial to secure a stable coalition to support policy change. Transforming the energy system in an economy is not something that happens overnight. It requires concerted efforts on the part of political, industry and civil society actors over time, and in the Danish case the latter part of the story takes place in the context of a EU that is also relatively eager to pursue green policies. While the specific policies pursued by Denmark since 1973 may serve as inspiration for countries seeking to reduce their carbon footprint, the key is to understand that any such effort has to be undertaken in the context of stable coalition to sustain it in the long term. It is this type of long-term progression that is likely necessary to create a transformation in societal and industry behaviour and expectations.

Works Cited

Andersen, Jørgen Goul. 2002. Valgkampen 2001: Vælgernes politiske dagsorden. Aalborg: Det Danske Valgprojekt.

Andersen, Jørgen Goul. 2008. "Et valg med paradokser: opinionsklimaet og folketingsvalget 2007." Tidsskriftet POLITIK no. 11 (3):10-26.

Andersen, Torsten, Marie Degn Bertelsen, and Jørgen Rosted. 2006. Miljøteknologiske styrkepositioner - En erhvervsanalyse af klyngedannelse. Copenhagen: FORA.

Arbo-bähr, Henrik. 2010. Samfundsstatistik 2010. Copenhagen: Forlaget Columbus.

Bille, Lars. 2002. "Denmark." European Journal of Political Research no. 41 (3):941-946.

Bøss, Jakob Askou. 2011. E-mail message to John Zysman. Berkeley, 3 May and 29 May.

City of Copenhagen. 2011. We want to be the first carbon neutral capital in the world. City of Copenhagen 2010 [cited 13 May 2011]. Available from http://www.kk.dk/sitecore/content/Subsites/CityOfCopenhagen/SubsiteFrontpage/LivingInCopenhagen/ClimateAndEnvironment.aspx. Last accessed July 28, 2011

Danish Government. 1996. Energi 21. Copenhagen: Ministry of Environment and Energy.

Danish Government. 2010. Grøn Vækst - Udfordringer, muligheder og dilemmaer i den grønne omstilling. Copenhagen: Statsministeriet.

Danish Government. 2011. Energistrategi 2050 – fra kul, olie og gas til grøn energi Sammenfatning. Copenhagen: Ministry of Climate and Energy.

Danish Energy Association. 2009. Power To The People: 09 I 06 I 09. Copenhagen.

Danish Energy Association, and Energinet.dk. 2010. Smart Grid i Danmark. Copenhagen.

DEA (Danish Energy Authority). 2009. The Danish Example. Copenhagen: Danish Energy Authority.

DEA (Danish Energy Authority). 2010. Energistatistik 2009. Copenhagen: Danish Energy Authority.

DEA (Danish Energy Authority). 2011. Resultatkontrakt 2011-2014 - mellem Energistyrelsen og Klima- og Energiministeriets departement. edited by Energistyrelsen. Copnehagen: Danish Energy Authority.

De Lovinfosse, I. 2008. How and Why Do Policies Change?: A Comparison of Renewable Electricity Policies in Belgium, Denmark, Germany, the Netherlands and UK: Peter Lang Pub Inc.

Energymap.dk. 2011. Intelligent Energy System on Bornholm Climate Consortium Denmark 2010 [cited 13 May 2011]. Available from http://www.energymap.dk/Newsroom/Intelligent-Electricity-System-on-Bornholm. Last accessed July 28, 2011

FORA. 2009. Kortlægning af miljøteknologiske virksomheder i danmark. Copenhagen: FORA.

Grohnheit, P.E. 2001. "Denmark: long-term planning with different objectives." In Climate Change and Power: Economic Instruments for European Electricity, , edited by C. Vrolijk. London: The Royal Institute of International Affairs.

Hadjilambrinos, C. 2000. "Understanding technology choice in electricity industries: a comparative study of France and Denmark." Energy Policy no. 28 (15):1111-1126.

Hansen, Rikke Munk. 2003. "Legislative measures for promotion of renewable energy: Wind energy development in Denmark as a case study." In Energy Law and Sustainable Development, edited by Adrian J. Bradbrook and Richard L. Ottinger, pp. 115-137. Gland, Switzerland and Cambridge, UK: International Union for Conservation of Nature and Natural Resources.

Hvelplund, F. 1997. "Energy efficiency and the political economy of the Danish electricity system." In European Electricity Systems in Transition. A Comparative Analysis of Policy and Regulation in Western Europe, 133-166. Oxford: Elsevier.

Jakobsen, M.L.F. 2010. "Untangling the impact of Europeanization and globalization on national utility liberalization: a systematic process analysis of two Danish reforms." Journal of European Public Policy no. 17 (6): 891-908.
Karnøe, P., and A. Buchhorn. 2008. "Denmark: Path creation dynamics and winds of change." In Promoting sustainable electricity in Europe: Challenging the path dependency of dominant energy systems, edited by William M. Lafferty and Audun Ruud, 73-101. Cheltenham: Edward Elgar Publishing Limited.

Larsen, C.A., and J.G. Andersen. 2009. "How New Economic Ideas Changed the Danish Welfare State: The Case of Neoliberal Ideas and Highly Organized Social Democratic Interests." Governance no. 22 (2):239-261.

Loring, ML. 2007. "Wind energy planning in England, Wales and Denmark: Factors influencing project success." Energy Policy no. 35 (4):2648-2660.

Meilstrup, P. 2010. "The runaway summit: the background story of the Danish presidency of COP15, the UN Climate Change Conference." In Danish foreign policy yearbook 2010, edited by Nanna Hvidt and Hans Mouritzen, 113-135. Copenhagen: Danish Institute for International Studies, DIIS.

Meilstrup, Per, Meik Wiking, Izabela Butenko-Olesen, Christian Eika Frøkiær, Sarah Pickering, and Emilie Hvidtfeldt. 2010. Danmark som globalt, grønt vækstlaboratorium. In Monday Morning, edited by Erik Rasmussen. Copenhagen: Monday Morning.

Meyer, N.I. 2004a. "Renewable energy policy in Denmark." Energy for sustainable development no. 8 (1):25-35.

Meyer, N.I. 2004b. "Development of Danish wind power market." Energy & Environment no. 15 (4):657-673.

Mendonca, M., S. Lacey, and F. Hvelplund. 2009. "Stability, participation and transparency in renewable energy policy: Lessons from Denmark and the United States." Policy and Society no. 27 (4):379-398.

Nørgaard, Niels, and Jesper Tornbjerg. 2002. "Finanslov: Sort dag for miljøet." Politiken, 30 January, 7.

Toke, D. 2002. "Wind power in UK and Denmark: can rational choice help explain different outcomes?" Environmental politics no. 11 (4):83-100.

Toke, D., S. Breukers, and M. Wolsink. 2008. "Wind power deployment outcomes: How can we account for the differences?" Renewable and Sustainable Energy Reviews no. 12 (4):1129-1147.

Vestergaard, Frede. 2006. "Foghs 180-graders vending." Weekendavisen, 29 September, 1,14.

Wang, T., and J. Watson. 2008. "Chinas carbon emissions and international trade: implications for post-2012 policy." Climate policy no. 8 (6):577-587.

WCED. Report of the World Commission on Environment and Development: Our Common Future. World Commission on Environment and Development. Oxford, Oxford University Press. (1987)

Wittrup, Sanne. 2011. Bornholm skal være hele Europas smart-grid laboratorium Ingeniøren 2010 [cited 13 May 2011]. Available from http://ing.dk/artikel/106994-bornholm-skal-vaere-hele-europas-smart-grid-laboratorium.

THE UNITED STATES FEDERAL GREEN POLICY OVERVIEW

June 15, 2011

Prepared by Nina Kelsey
with Jeremy Pilaar, Andrea Seow, and Pilar Fox

1 The US: A federation of green policy labs

The US can be thought of as a collection of 50 semi-independent policy laboratories. States are constrained – to degrees that vary by issue area – by overarching policy frameworks or limitations at the federal level. When the federal government passes explicit legislation, it binds the states. However, nested within the federal framework, the individual US states generally retain relatively broad powers to set state-level policy. And as discussed below, these state-level powers are particularly strong in the area of carbon emissions, where we see a lack of a coherent policy at the federal level to shape state action. This lack of extensive overarching structure is compounded by the willingness on the part of the federal government to grant waivers to states, like California, that are interested in experimenting with stricter environmental standards than those created at the federal level.

The boundary between US and state-level policy-making is therefore fuzzy, fluid, and prone to shift as policy-making proceeds in this area.

The boundary between US and state-level policy-making is therefore fuzzy, fluid, and prone to shift as policy-making proceeds in this area. But in practice, the result is that the US's 50 states have the potential to act as separate green growth experiments, each implementing different policy mixes in response to different situations and goals.[1] The US story is really 50 stories – some of more analytic interest than others.

Therefore, telling the United States' green growth story means addressing two questions. First, what set of policy choices has the federal level made (or failed to make), and how and to what degree do these choices shape state policy-making? Second, nested within the federal context, how do state-level stories play out? How are states constrained and influenced by the federal policy they collectively receive; and what happens at the state level that creates the individual green-growth policy stories of the states? We explore these issues below. It is important to note that much of what we discuss may be familiar to readers from the United States; because our audience is international, we cover some detail that may seem obvious to Americans.

2 Political gridlock

The general tendency of US policy-making to allow for state-level control is particularly strong in the area of climate and energy policy. This is because political gridlock currently makes national-level legislative action on emissions reduction nearly impossible in the US. A brief review of obstacles to legislative policy creation in the US federal government structure is included here for readers not familiar with the details of the US political system.

The political system of the US requires that legislation pass both the House of Representatives and the Senate. In law, the Senate requires a majority vote to pass legislation. However, in practice, on many controversial issues the Senate requires 60 votes to pass legislation, due to procedural requirements. This is an extremely difficult bar to clear. It is rare for either major political party to gain a full 60 seats in the Senate. Moreover, politics in the US is currently highly polarized, meaning individuals from one party are reluctant to vote for legislation supported by the other party unless the legislation is routine. Far from being routine, legislative action on climate change remains quite controversial in the US. The controversial nature of this type of legislation stems from three sources. First, many interests in the US have legitimate concerns about reduced competitiveness and job loss relative to jurisdictions that do not implement carbon controls; second, the US has significant coal and oil interests, and local interests are highly reluctant to abandon these resources; and third, the topic of climate change itself has become highly politicized in the US.

1 In fact, the story is somewhat more complex than this; policy can also play out at the regional level, with multiple states banding together on action as in the Western Climate Initiative. For clarity, in this initial statement we focus on policy at either the federal or individual state level.

3 What green growth policy is possible at the federal level?

These conditions, taken in sum, mean that it is extremely difficult to pass legislation leading to even moderate action on climate change at the federal level. In practice, this has meant that action at the federal level has been limited to a few specific areas.

3.1 Official channels for federal energy policy

First, some legislation has passed as crisis response. **The American Recovery and Reinvestment Act**, passed to provide stimulus during the recent economic crisis, included significant *funding* of various forms for renewable energy and efficiency measures.

Second, the US executive branch does have relatively wide-ranging powers over many areas of regulation and federal policy; in some cases these are, at least potentially, comparable to those found in the elite bureaucratic organizations in nations such as Japan or France. In areas relevant to energy policy, these include:

1) **The Department of Energy**: The Department of Energy handles US energy-related policy issues; its mission is to "Ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions." (DOE 2011) In practice it is a major distributor of clean energy- and efficiency-related funding, administers green energy loan guarantee programs, and acts as a sponsor of basic and applied research in energy (the DoE operates a variety of research institutions including, for instance, the Lawrence Berkeley National Laboratories). It also oversees the Energy Information Agency, an extremely useful storehouse of domestic and international energy information.

2) The **Federal Energy Regulatory Commission (FERC)**: FERC has authority over the national energy grid. *In practice*, however, its actual authority is limited largely to truly national-level issues, such as the regulation of the transmission, reliability, and wholesale sales of electricity between states. More local distribution systems and pricing are administered at the local level, with FERC holding advisory powers at best. Thus, FERC's powers over important grid and generation issues are very limited, with even multi-state, regional planning handled by state consortia (FERC 2011; Fox-Penner 2010; NERC 2011).

3) The **Environmental Protection Agency (EPA)**: Courts have ruled that the EPA has the power to regulate greenhouse gases. But how this power will be deployed[2] is still being determined. It has not, thus far, been a major influence. The EPA also currently administers some focused programs with emissions impact, such as the Energy Star program, an energy efficiency standards program.

4) Various **R&D units** such as the newly created Advanced Research Projects Agency – Energy (ARPA-E), as well as existing units in the national labs, EPA, and Department of Defence, support basic research, innovation, and commercialization of products relevant to energy. The assistance provided by these programs can range from very basic research to testing to creating demand for prototype or early-stage products and helping innovations to overcome the "valley of death" between initial innovation and early commercialization.

The direct effects of executive-branch action are thus quite limited overall, relative to the more sweeping programs in some European nations. They are also not well coordinated from the perspective of overall strategy. They represent instead a somewhat haphazard concatenation of various programs initiated at different points in time in response to different stimuli. In practice, this all boils down to four major areas of effect on the state environment.

"In other words, we see no obvious bias that suggests the US is using stimulus funding to effectively favor any particular macro-level strategy on how to reduce emissions"

3.2 Practical effects of federal energy policy on the state policy environment

1) **Funding:** Various channels – such as stimulus funding, guaranteed loan programs, and support for research and development, as well as a variety of indirect funding routes such as tax credits and deductions – channel meaningful amounts of subsidy into all stages of the research and commercialization chain for energy technologies. The largest chunk of direct funding in the recent past has been the stimulus bill; "green stimulus" funds have dwarfed other on-going non-stimulus direct green energy spending. Stimulus spending seems to have been fairly evenly distributed, with major sums in all the important emissions reductions areas – renewable energy, efficiency and weatherization, transportation, grid technologies, and carbon capture and storage all received large chunks of funding. In other words, we see no obvious bias that suggests the US is using stimulus funding to effectively favor any particular macro-level strategy on how to reduce emissions.

While we do not see any major redistributive biases in how funding is allocated by state, there is a reinforcing effect on the existing distribution of industry and research in the US. For example, Michigan, with its automobile industry, has received the largest share of transportation stimulus funds from the DoE. Similarly, states with major national research labs and strong university systems (like California and Colorado) have been particularly successful in competing for research funds. Thus, the distribu-

2 Or even if it will be deployed, given legislative efforts to strip this power from the EPA.

tion of funds seems to reinforce or amplify what states are already doing, rather than shifting or constraining.

The effects of this support are a double-edged sword. On the one hand, they can be hugely supportive to emerging industries and their markets. Sources in Colorado tell us the stimulus funds received by Colorado were enormously helpful. They both kickstarted programs that might have been slow or difficult to start without funding assistance, and provided a rescue for programs that would otherwise have been vulnerable to cuts during the severe recession. Similarly, stimulus funding and loan guarantee programs have likely had a synergistic effect with venture capital interest in cleantech, turbocharging California's cleantech investment wave and helping to grow the market for these technologies. (See Colorado and California State Case Study reports (Green Growth Leaders 2011a and 2011b) for further discussion.)

However, funding, particularly funding delivered directly to industry like guaranteed loans, may not be well-targeted and may create large distortive effects by subsidizing the recipient firm and/or particular technological solutions that are not inherently competitive without the subsidy. If this effect is large enough, it could swamp or distort better-targeted state-level policies to shape green industry. For instance, one source for this project suggested that federal funding has tended to push venture capital investment in California toward large-scale, capital-intensive areas rather than the smaller, more easily scaled, lower-capital technologies it is better suited to (Kenney 2011). Such an effect would apply broadly across states, though the level of effect might depend on success in capturing funding.

2) **Innovation:** Federal research investment has created a pool of innovation and new technology. Much as direct federal funding for industry has done, this resource pool of emerging technology has served as an accelerating force for the creation of green industry. If the research pool were biased, with most resources directed toward a particular technology, this could create a de facto influence on the development directions available to states. However, the spread of funding across solution categories appears diverse enough that this is not an issue (Prabhakar 2011).

   Research takes place in a variety of units in the federal government and institutions funded by the federal government, often through the Department of Energy, including the national labs, research universities, and the struggling ARPA-E unit. One less obvious but significant home for non-fossil fuel energy research and demonstration is the Department of Defense. Rising fossil fuel prices and the difficulty of protecting massive liquid fuel supply lines in operations both make the DoD interested in alternative energy options. Some particular areas the DoD is investing in include green aviation fuels, hybrid-electric ground vehicles and ships as well as alternative energy vehicles, battery storage, prediction modeling software for renewable resources, insulation technologies, microgrid technologies, solar thermal and portable solar arrays, and geothermal energy (Hourihan and Stepp 2011). The DoD can be a particularly important player in technological innovation because it is not just an R&D funder. It often also provides an initial purchaser for expensive prototype or early-stage products, helping them bridge the "valley of death" between initial innovation and commercialization. In later stages of commercialization, military procurement can help new products build scale. The military has provided an initial bridge to commercialization for many US technological advancements in the past.

3) **Failure to coordinate:** The fact that national/regional policymaking is not strategically coordinated with state-level policymaking makes attempts to transform state-level systems that are linked to national systems problematic. This serves as an obstacle to success in some policy areas. This effect is seen, for instance, in the California deregulation story, where California state policy clashed with regional energy market policy, creating problems for successful deregulation (Sweeney 2002). (See the California State Case Study report (Green Growth Leaders 2011a) for further discussion.) This has a de facto effect on states' abilities to deploy certain types of policy measures.

4) **Freedom to experiment:** The federal government has been willing in some cases to actively increase the freedom of states to incubate policy at the local level. An important example is the waivers received by California, allowing it to experiment with pollution regulations more stringent than those imposed by the federal government. This type of action increases the potential of states to act as green policy labs.

The bottom line is that the federal government provides enabling inputs in the form of funding and research, and creates some distortive effects via funding. But the particular evolution of state green growth stories, and hence the US green growth story collectively, owes more to state-level conditions, resources, and political/economic history than it does to federal interference. We therefore briefly consider the general question of how state-level policy evolves, before turning to our two in-depth case studies of individual states: California and Colorado.

4 Green growth policy evolution at the state level: an example

As we have stated, US states, collectively, constitute a green policy laboratory that allows for the testing of many approaches simultaneously – although in a highly unstructured and uncoordinated way. Strategies chosen by states are shaped by each state's particular history, political and social profile, resource mix, legacy infrastructure, and industrial breakdown. This effect is exemplified in a comparative study of the wind industries across states carried out by a Minnesota research group in 2010 (Fischlein et al., 2010). The study examined the dynamics of the wind industry in four states – Massachusetts, Minnesota, Montana, and Texas – that exhibited a variety of levels of wind resources, legislative support, and actual installed capacity. We recap three of these stories as illustration:

Massachusetts has a promising energy industry profile (a lack of local fossil fuel resources to create blocking interests), environmentally friendly citizens, and a strong history of supportive legislative policy, including renewable portfolio standards. In spite of this, citizen-level resistance to wind (due to aesthetic and environmental concerns), infrastructure problems, and burdensome existing regulation have largely blocked wind development.

Minnesota uses a high proportion of coal for power. Nonetheless, Minnesota has both a renewable portfolio standard and a community-based energy development program that includes incentives for community wind development with local ownership. This program has helped reinforce green policy by building support for local wind farming, which is well suited to Minnesota's sparse population patterns.

Texas already has significant wind resources deployed, in spite of a citizen base that is relatively uninterested in environmental concerns. Texas is one of the few US states to have successfully created a deregulated, highly competitive electricity industry. Wind development looked like a particularly competitive option in Texas for two particular reasons. First, wind was made more economically viable by the fact that Texas' major competitive energy source was natural gas, and natural gas was (at least at the time) typically more expensive than coal – so winds prices looked more competitive in Texas than they did in states reliant mainly on coal. Second, deregulation did trigger some worries about potential trends toward pollution, and constituents thought wind might help guard against that risk.

We can derive a number of implications for state-level policy simply from looking at this bounded example of the wind industry:

First, states' individual decisions about whether to pursue particular green growth policy options differ a lot. This is obvious in the wind cases discussed above, and holds generally for state-level green policy mixes.

Second, policy choices differ partly because the particular characteristics of states differ – in terms of resource profile, industrial profile, infrastructure, geography, and political and policy history. None of these characteristics is individually determinative: politics may trump resource profiles (and vice versa), economics may trump politics (and vice versa), and so on.

Third, there are a wide variety of *veto points* at the state level. These can range from physical blocks like unsuitable infrastructure to political blocks like resistant citizens. They may be specific to the particular policy under consideration. State-level veto points emerge from the particular political and economic structures of states and are separate from the veto points found at the federal level.

Fourth, similarly, individual states have individual sets of relevant *key players or groups* acting as green policy supporters and gatekeepers. These players may be linked to key players at the federal level, but can function independently at the state level.

"Fifth, successful green growth stories happen when (a) a high enough proportion of relevant key players support specific green growth policies, and (b) veto points are avoided or overcome"

Fifth, successful green growth stories happen when (a) a high enough proportion of relevant key players support specific green growth policies, and (b) veto points are avoided or overcome.

Sixth, individual moves toward green growth policy (such as energy efficiency and renewables policy) can be self-reinforcing. This occurs if green policy moves create observable benefits and learning effects, and increase comfort levels, in ways that increase the proportion of key players that are willing to support or tolerate green growth policy.

In sum, what the points above suggest is that the evolution of green growth policy is path-dependent, with prior history shaping the tools accessible to policymakers. Particular choices regarding infrastructure or policy at one point in a state's history serve to enable or choke off access to subsequent choices in the next phase of policy-making.

5 Conclusion

We see these points play out in more detail in the in-depth state cases that follow. The California case is a story that begins with policy actions triggered by crises that create political opportunity. Events such as the air pollution crisis of the 1940s and 1950s or the oil shock of the 1970s created windows of opportunity where blocks to action were low, allowing California to initiate multiple rounds of de facto[3] green growth policy. These rounds of policy in turn created or expanded the size of green-friendly key players and groups, by creating learning effects and by creating new interest groups that benefit from green policies. Each succeeding phase of policy laid the groundwork for the next phase.

The Colorado case is a story that begins with a geographic and economic profile that created obstacles in the form of a thriving fossil fuel industry. It also created opportunities – a huge, exploitable wind resource located within a conservative rural constituency, creating an argument for renewable energy policy within this otherwise skeptical constituency. Colorado also has a

3 As the term de facto suggests, "green growth" per se has, until recently, not been California's goal in taking emissions reduction actions; however, the effect in practice has been to drive, first, the decoupling of emissions from growth and, later, the attempt to link growth to green technology.

political structure that allowed a citizen's movement to work around veto points – the conservative governor and conservative-controlled legislature – that had blocked legislative attempts at green policy. Together, these characteristics created the opportunity for a determined group of leaders to assemble a set of interests around deployment of green growth policy. This story now shows signs of becoming self-reinforcing in the way that the California story has, as utilities become comfortable with renewables standards and a green business constituency becomes a growing part of Colorado's economic and political reality.

Please see our California and Colorado State Case Study reports (Green Growth Leaders 2011a and 2011b) for further discussion of the California and Colorado cases.

Works Cited

Department of Energy. 2011. "Department of Energy – About Us." Accessed May 15, 2011. http://www.energy.gov/about/index.htm

FERC. 2011. "Federal Energy Regulatory Commission." Accessed March 17. http://www.ferc.gov/

Fischlein, Miriam, Joel Larson, Damon M. Hall, Rumika Chaudhry, Tarla Rai Peterson, Jennie C. Stephens, and Elizabeth J. Wilson. "Policy Stakeholders and Deployment of Wind Power in the Sub-National Context: A Comparison of Four U.S. States." Energy Policy 38 (2010): 4429-4439.

Fox-Penner, Peter. 2010. Smart Power: Climate Change, The Smart Grid, and the Future of Electric Utilities. Washington: Island Press.

Green Growth Leaders. 2011a. "California State Case Analysis." White paper prepared for the Green Growth Leaders Project in collaboration with CRESTS. May 17, 2011.

Green Growth Leaders. 2011b. "Colorado State Case Analysis." White paper prepared for the Green Growth Leaders Project in collaboration with CRESTS. May 17, 2011.

Hourihan, Matt, and Matthew Stepp. 2011. "Lean, Mean and Clean: Energy Innovation and the Department of Defense." The Information Technology and Innovation Foundation. March 2011. Accessed May 15, 2011. http://www.itif.org/publications/lean-mean-and-clean-energy-innovation-and-department-defense.

Kenney, Martin. Interview by Nina Kelsey and Juliana Mandell. Telephone with notes. Berkeley, California, March 16, 2011.

NERC. 2011. "NERC – North American Electric Reliability Corporation." Accessed March 17. http://www.nerc.com/

Prabhakar, Arati. Interview by Nina Kelsey and Juliana Mandell. Telephone with notes. Berkeley, California, March 29, 2011.

Sweeney, James L. 2002. The California Electricity Crisis. Stanford, California: Hover Institution Press.

CALIFORNIA
STATE CASE ANALYSIS

June 15, 2011

Prepared by Juliana Mandell and Nina Kelsey
with Jeremy Pilaar, Andrea Seow, and Andrew Willis

1 Introduction

California's current bid to become a global leader in clean -tech reflects a history of leadership in energy and climate policy. In the last quarter of 2010 the state captured 50 percent of global venture capital funding for clean-tech. In 2006 it passed AB 32 the most aggressive climate bill of any state in the nation. These developments were made possible by a historical trajectory of policy and business community development dating back to the 1940s. Early successful energy legislation laid the foundation for future policy, created a precedent for unique cross-sector relationships and shaped policy tools available for future action. Building upon this foundation California's already established venture capital community, supported by the state's top-tier research universities and policy makers, is investing in clean tech as an attractive green growth initiative. Whether these investments will realize the economic gains venture capital and policy makers hope for, however, remains an open question.

California's green growth history began in the mid twentieth century as a period of green growth compatible with emissions reductions. While emission reductions were achieved during this early period, the primary focus of policy was air pollution and emissions reductions only a derivative effect. Relevant energy movements during this period were comprised of *two strands*: (1) successful energy efficiency programs and [2] unsuccessful deregulation of the electricity industry. Energy efficiency programs, in combination with structural factors, were able to keep California's per-capita electricity use relatively flat, while permitting significant economic growth (discussed below). On the other hand, deregulation of the California electricity industry was riddled with unintended consequences and was largely unsuccessful.

Recently, a *third strand* of green growth development in California began taking hold. This movement represents (3) a more emissions-aware energy movement, based around the idea that growth could be driven by emissions reduction, and that the clean-tech industry could represent the next major new source of economic growth for California. Below, we explore each of these three

Chronological Overview

1941	Los Angeles experiences severe air pollution
1947	State creates first ever county-level Air Pollution Control Districts
1959	Through collaboration with the university research community, policy makers require the State Department of Public Health to set motor vehicle air quality standards
1961	Emission regulations for vehicles are passed into law, first in the nation
1967	The statewide regulator agency the California Air Resources Board is created
1967	California wins the legal right as the only state allowed to deviate from national policy and impose more stringent air pollution regulation
1973	OPEC oil embargo creates political support for energy efficiency programs
1974	Creation of the California Energy Commission with the authority to regulate building and appliance efficiency standards
1977	Sate adoption of wide spread efficiency standards for appliances and buildings
1977	An amendment to the national Clean Air Act allows California to regulate fuels and fuel additives without EPA approval and gives other states the option to choose between adoption of California or national standards
1996	California implements aggressive electricity deregulation policy
2000	Deregulation leads to fiscal and energy crisis
2002	State legislature passes Assembly Bill 1493 regulating GHG emissions reductions in California motor vehicles manufactured after 2009
2002	State Legislature passes SB 1078 mandating 20% of state electricity be generated from renewable sources by 2017, the most aggressive standard in the nation
2006	California Legislature passes Assembly Bill 32: the California Global warming Solutions Act

strands. For reference we have included a chronological overview of relevant state history.

2 Three strands of green growth

2.1 Energy efficiency

From the late 1970s onward electricity use per capita in California stayed flat, while increasing by 50% nationally. Over the same time period the state experienced long-term economic growth—*successfully decoupling growth and electricity consumption* (Roland-Holst 2008). In this scenario California was able to successfully capture significant green-compatible growth – that is, growth in which economic growth is compatible with emissions reduction or control. (Note, however, that this was an unintended consequence of energy efficiency policy; at the time, carbon emissions were not a policy focus.)

This success was due at least in part to deliberate energy efficiency policy measures and to a legacy of pioneering air pollution regulation and infrastructure already in place in California as a response to serious air pollution problems in the 1940s and 1950s. In the later part of the 1970s the state put into effect an aggressive energy efficiency policy package comprised of building and appliance standards and utility programs. In addition, to encourage utilities to adopt energy efficiency technologies and programs, the state introduced policies to decouple utility profits from total electricity generation. These policies provided a compensatory revenue stream and performance incentives for utilities that met or exceeded efficiency savings. Regulators used a new investment metric – "cost of conserved energy" – to calculate savings from avoided use and thus justify the program costs (Rosenfeld and McAuliffe 2008; Rosenfeld and Poskanzer 2009).

The political will and successful implementation of these policies stemmed from a myriad of inter-connected factors, including a history of air pollution problems and the resulting established regulatory infrastructure and grants of regulatory latitude to the state by the federal government; the OPEC embargo and rising fuel prices; and an absence of an entrenched fossil fuel sector. In the 1940s California began experiencing severe air pollution problems in the LA Basin area resulting in an acrid haze. The geography and quickly expanding population in the auto-centric city helped explain the unique severity of the pollution. California created a series of administrative bodies to regulate and address this problem, developing finally into the California Air and Resource Board 1967. In conflict with less stringent national air pollution regulation passed a decade later, California was the only state awarded the legal right to pass more stringent air pollution regulation that at the national level due to the state's "extraordinary conditions" and "pioneering efforts." These existing regulatory bodies and legal rights played a central role in the later implemented energy efficiency measures (Hanemann 2007).

Momentum for further clean-air regulation was initially unable to overcome Republican and industry objection until the critical juncture of the OPEC oil embargo and resulting rocketing oil prices. An absence of coal

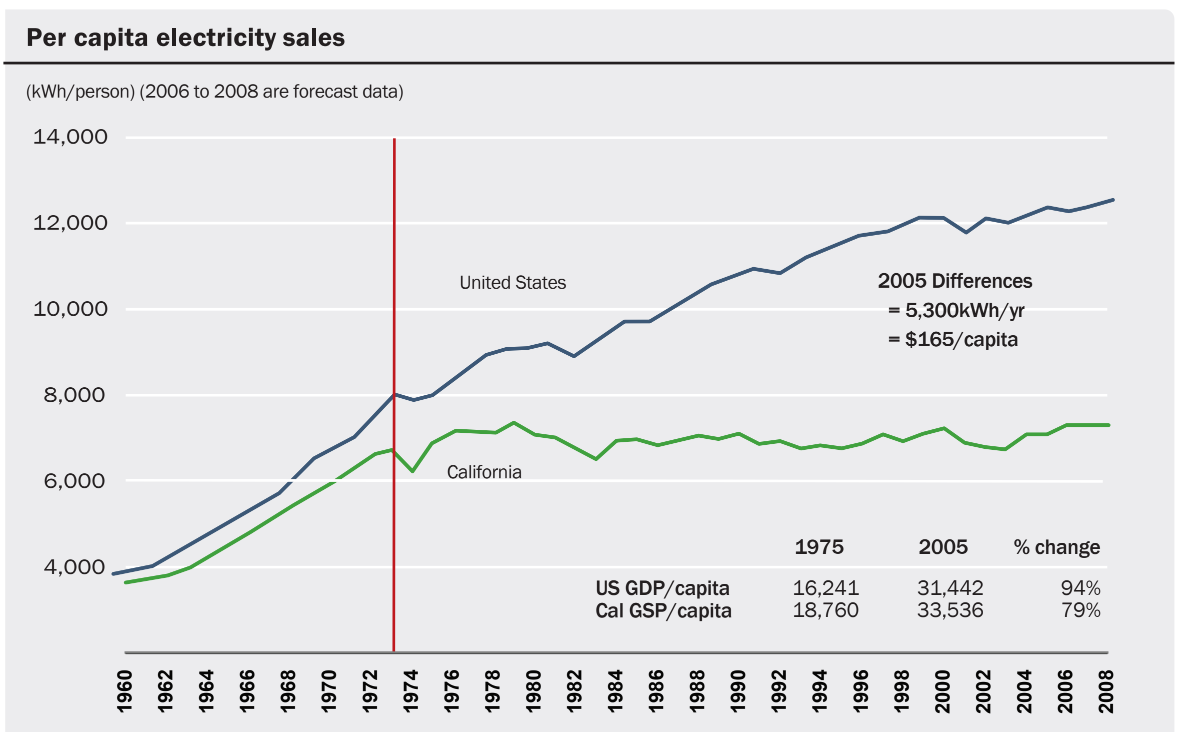


Figure 1: Per Capita Electricity Sales comparisons between California and the U.S. as a whole over the last 30 years.

Source: Rosenfeld 2008.

reserves further contributed to more limited resistance to regulatory policies than seen in coal states (Sweeney 2002). Finally, policy makers were also able to take advantage of the established research universities in the area, forming a symbiotic relationship between regulators and the researchers in which regulators funded research that in turn greatly benefited policy implementation (Hanemann 2007; Rosenfeld and Poskanzer 2009). This partnership has continued over the last 40 years and played a role in shaping future climate policy.

Approximately 25% of the reduction in per capita electricity consumption growth patterns can be attributed to the policy measures described above. The remainder was driven by a combination of, on the one hand, demographic and structural effects; and on the other, changes to industrial profile. In the first category, postulated demographic and structural effects include: an overall rise in electricity prices which continued beyond the OPEC oil embargo and resulted in prices correspondingly higher than those seen in other states; a mild climate; state trends toward increased urbanization and household size; and a perceived environmental ethic in California. Industrial factors are largely composed of the shift away from heavy industry toward non-energy-intensive firms: light industry, services, and IT (Mitchell 2009; Sudarshan and Sweeney 2008). These characteristics are much less amenable to policy manipulation than is efficiency (Rosenfeld and Poskanzer 2009).

"Meanwhile, the California business community's ability to successfully weather and profit from technological change and business innovation during this period, along with the lack of resistance from a powerful fossil fuels lobby, made California unusually open to enacting further pollution and energy policy"

Meanwhile, the California business community's ability to successfully weather and profit from technological change and business innovation during this period, along with the lack of resistance from a powerful fossil fuels lobby, made California unusually open to enacting further pollution and energy policy. This openness led both to policy measures, and to support for research and modeling that confirmed the practicality of efficiency policy and increased political will for it, in something of a virtuous circle (Hanemann 2007).

Some economists argue that California's history of energy efficiency policy in fact exemplifies emissions reductions as a *driver* of growth rather than simply being compatible with growth. From 1972- 2006 it is calculated that Californians saved $56 billion dollars in household energy savings due to increased energy efficiency. First, California households redirected expenditures towards consumption of goods and services with a higher employment density and away from energy sector that has low employment density. Second, these goods and services usually had in-state supply chains creating a multiplier in local employment and Gross State Product (GSP) growth. This expenditure switching is estimated to have contributed over 1 million jobs to the state economy over the last 30 years. Moreover, energy efficiency programs disproportionately benefited low-income demographics who were found to generally spend a significantly higher portion of their income on energy than more affluent demographics and live in less efficient homes with less efficient appliances. Finally, jobs were created in less energy-intensive sectors further contributing to emissions reductions (Roland-Holst 2008). It is important to note that this conception of green growth plays out partly as a competitive local strategy as well as a tool for global growth. While the distributional benefits to employment present in this expenditure switching could be globally duplicated, the move towards in-state supply chains implies a loss of wealth elsewhere.

2.2 Deregulation

Rising electricity prices, declining capacity relative to per-capita use, and federal policy trends all made deregulation an apparently attractive prospect to California in 1996. Although the deregulation movement was not primarily designed to address issues of climate change or green growth, it has relevance as an example of an attempt to restructure an existing energy system, and of the types of obstacles that may be encountered in such an effort.

Proponents of deregulation argued it would lower prices through the introduction of competition and greater efficiency into the market. It would create greater market incentives for building out generation capacity and create more options for consumers with a more flexible market. At the time of deregulation, electricity prices in California were the highest of any state in the nation. High rates could be traced back to a myriad of policies implemented following the Oil Embargo of the 1970s, as well as the limits of the state's natural resources. Rocketing oil prices in the 1970s and 80s reduced the attractiveness of oil as an electricity generation source. Following national directives and incentives the state began looking

Average electricity prices by year

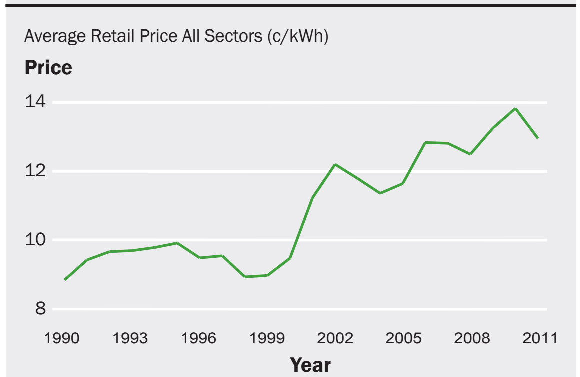


Figure 2: Average Annual Electricity Price in California, 1990-2001 (EIA 2009)

Source: http://www.eia.doe.gov/cneaf/electricity/page/sales_revenue.xls for other fuel sources. Nuclear was not a generally attractive option due to numerous fault lines, limited access to cooling water, and political opposition. The state pursued renewable and cogeneration options instead. To promote alternative forms of energy, regulators set high prices on traditional fossil fuel based energy. The state did also embark on several nuclear projects that later proved to be significantly more expensive than expected. By the early 1990s the state could boast both the highest renewable generation capacity *and* the highest energy prices in the nation.

In the 1990s electricity supplies in the entire Western region of the United States became tight as per-capita consumption outpaced growing generation capacity. In California an unusually lengthy application process to situate plants further exacerbated the issue. Given the sources of the problems California faced, deregulation was from the start unlikely to address high rates and capacity issues. These problems resulted from previously incurred high costs and long application processes rather than a lack of market forces. In 1996, however, the state nonetheless passed aggressive deregulation policies. These new policies separated generation and distribution within utilities, required all electricity produced from fossil fuel-fired plants to be sold on the power exchange, and promoted more open access to transmission. The California Power Exchange only provided for spot-market and day-ahead transactions, preventing utilities from signing more long-term supply contracts. While wholesale markets were deregulated, retail rates remained regulated in a policy attempt to both safe-guard consumers and address "stranded costs" if prices fell too quickly.

"Moreover, the isolation between the different electricity supply networks in the nation meant that even with the incentive of high prices electricity could not move from the Midwest or other regional networks"

California's electricity deregulation further tightened already tight electricity supplies in the West. Growth in demand had begun outpacing growth in supply throughout the Pacific region over the decade leading up to the electricity crisis. While most states responded by ensuring electricity supply through generation facilities or medium-to long-term contacts, California utilities were mandated to use spot markets. Deregulation policies specifically disallowed use of long-term supply contracts by Investor Owned Utilities (IOUs). IOUs had previously used such contracts as a hedging method to buffer against price and supply volatility. This was compounded by the fact that unlike many of the other states in the region, which were either self-sufficient or net exporters, California imported about 25% of its electricity. When electricity supply fell considerably in 2000 due to drought in the hydro-powered Pacific North West, a lack of capacity, and political uncertainty, California was left particularly vulnerable.

Moreover, the isolation between the different electricity supply networks in the nation meant that even with the incentive of high prices electricity could not move from the Midwest or other regional networks.

While the policy did initially boost the number of applications submitted for new plants it did not address the slow application process at the root of the problem and so had little effect. Moreover, policy uncertainty following the legislation began to discourage private companies from investing in new electricity generating facilitates. Amid this tight market, utilities were forced to bid on even the electricity produced from their own generators and prices began to rise. Prices were further exacerbated by flaws in the market structure that allowed traders with multiple interests in the transaction to engage in market manipulation to drive up prices for their own gain. In essence, deregulation policies combined with market manipulation and political incapacity greatly exacerbated California's electricity concerns and plunged the state into crisis.

California politicians proved unwilling to make the difficult and unpopular choices needed to avoid deepening the crisis. As deregulated wholesale prices reached record highs retail prices remained regulated forcing utilities to take substantial losses in the transaction. Despite pleas from the utilities, the Governor and Legislature refused to deregulate retail prices, fearing consumer backlash. This culminated in one of the state's largest utilities, Pacific Gas and Electric, filing for bankruptcy. Then as prices spiked the state choose to reverse course and negotiate long-term electricity contracts, thereby locking in unfavorable rates for several decades.

"Local deregulation can go very badly if it is not supported by policy at the regional and/or national level."

Two implications relevant to green growth policy can be drawn out from this story. First, restructuring energy markets, necessary for many states' green growth plans, is a difficult process fraught with the potential for unintended consequences. Second, and related - one particular difficulty is that trying to transform one part of a system without a full assessment of how that part will interact with the rest of the system can create problems. California is part of a national and regional energy system, and this link provided a troublesome conflict between local and regional practices. Local deregulation can go very badly if it is not supported by policy at the regional and/or national level.

2.3 The next generation: venture capital, green policy, and green energy markets

California arrives at the present day with two major legacies from its past. The first is the result of the narrative that has occupied the previous two sections: California's history of successful leadership, within the context of the US, in pollution and energy efficiency policy and resulting regulatory infrastructure. This experience has made it more willing and able to enact green policy that will lower emissions and build green markets. This enables the passage of market-creating green policy such as AB32, discussed below.

The second derives from California's general economic history of successful innovation and new business creation. This background and its commercial infrastructure legacy prepares California to undertake a new wave of business creation in a highly technical field such as clean tech, embarking on a new stage of growth where emissions reductions drive growth. Below, we discuss California's business legacy – the venture capital community and associated resources. We then review AB32 and the green policy that this environment makes possible. We next discuss how the clean tech venture capital industry has grown over the last few years in tandem with green policy. We conclude by discussing some challenges facing California.

2.3.1 Finding a new home for venture capital

California's venture capital (VC) community is a prominent part of its economic landscape. The state's tradition of tech-based entrepreneurship, venture capital investment, and innovation means California has in place the financial expertise, related services, and intellectual infrastructure to support a thriving high-tech VC community, and constituencies in place who stand to profit from VC activities (Randolph 2011; Lecar 2011). This VC community has a strong backing in technical know-how local to the state: in the last half century production in the state has increasingly shifted away from heavy manufacturing and increased emphasis on innovation and high-tech light manufacturing (Sudarshan and Sweeney 2008). In addition, California's strong network of research and innovation centers, such as the national labs and the University of California system, support research and discovery at a basic level and help nurture a community of scientists and engineers.

This existing VC community was a critical and fully involved participant in the information technology industry boom in California. As that wave of new industry growth drew to a close, however, the VC machinery was in a sense left idling. With the community and its economic infrastructure ready and waiting, VC participants began searching for the next major investment wave (Lecar 2011). This search has led business interests to focus on green technology as a possible new engine of growth in the state. The potential to capture even a small portion of the $5 trillion global energy market with the rising demand for clean tech has proved seductive to many venture capital firms. Firms hope to earn high returns by being able to provide the most advanced clean tech technologies to a rapidly growing, policy driven, market (Huberty et al. 2011). California's existing VC community thus provides a driving force for California's involvement in clean tech, as well as a fertile environment in which to begin new high-tech businesses (with some caveats, discussed below).

AB32 and associated green policy

Assembly Bill 32 orders the reduction of California GHG emissions to 1990 levels by 2020, a 30 percent reduction from projected business-as-usual levels. The bill further requires an 80 percent reduction in GHG emissions by 2050. It intends to meet these goals through the oversight and implementation of a suite of new and existing state laws and policy (CARB 2008).

Key policy initiatives under or further supportive to AB 32:

- Development of California cap-and-trade program to interact with regional market system the Western Climate Initiative
- Increase of Renewable Portfolio Standard to 33 percent
- California Energy Efficiency Strategic Plan
- High Global Warming potential gas reductions
- Implementation of Light-Duty Vehicle GHG Standards
- Implementation of Low Carbon Fuel Standard

Regional efforts:

The Western Climate Initiative

Formed in 2007 Western Climate Initiative (WCI) sought to set regional green house gas emission targets and implement a multi-state cap-and-trade program. The initiative would regulate the electricity sector, most large industrial plants, and transportation in the region (WesternClimateInitiative 2010). Political opposition to the program, however, has halted ratification of the initiative in many of the key U.S. states. Of the original seven states: California, New Mexico, Oregon, Washington, Utah, Montana, and Arizona, only California and New Mexico have passed legislation to move forward with the initiative. Elected officials in the states that have pulled away indicate concerns over budget costs and political opposition. New Mexico may yet reverse its support of the initiative, as "anti-business" (Roosevelt 2010; LA Times 2011).

Regional initiatives such as the WCI can aid in the transition to a low-carbon economy in the U.S. by providing the scale, coordination, resources, and knowledge, absent in individual state initiatives, while bypassing the political gridlock on the national level. They can help overcome cross-jurisdictional issues, eliminate duplication of work, and provide greater levels of policy expertise (Lutsey and Sperling 2008). As the WCI demonstrates, however, in the current polarized political climate of the U.S. even regional initiatives may prove challenging.

2.3.2 Creating a clean tech market: green policy and AB 32

As noted above, California's history has created a dynamic in which its business community has come to see economic opportunity in green policy and has thus chosen to back such policy. The narrative of successful pollution and energy efficiency policy discussed in section 2.1 above means there is a broader array of players that feel comfortable with, in favor of, and equipped with the innovative skills necessary to handle future green policy measures. This makes constituencies across the state more broadly tolerant or supportive of green policy than those in many other states (Randolph 2011).

These conditions set the stage in 2006 for the passage of AB32, California's landmark climate legislation. AB32 established binding emission reduction targets and further entrenched support for renewable energy portfolio standards, required vehicle efficiency, and a statewide carbon cap-and trade program. It is the most expansive and well known of a spectrum of green growth-supportive policies that California has passed, which range from building and appliance energy standards to investment vehicles to the California Solar Initiative.

As the VC clean-tech industry has grown in California, a community of advocates for climate policy has grown in the business sector.

California's general receptiveness to green energy policy was amplified by VC community interest. AB32 found ample support in California's business and VC communities (Hanemann 2007; Prabhakar 2011), in contrast to attitudes toward climate legislation seen in the business communities of many heavy manufacturing and coal-producing U.S. states. California's VC community advocated climate policy as a means to establish a market for clean-tech and to ensure continuity and stability of expectations. It has defended AB32 against challenges, contributing to a multimillion-dollar campaign to defeat Prop 23, a ballot initiative intended to repeal AB 32 (Walsh 2010; Prabhakar 2011). As the VC clean-tech industry has grown in California, a community of advocates for climate policy has grown in the business sector. AB32 has in turn fed back into the growing support for green policy, creating a local, predictable, growing market and hence strengthening its own business constituency. In essence, California's VC industries exist in a symbiotic relationship with California's green policy; each supports the other and helps it grow.[1]

To achieve its goals of 30 percent GHG emission reductions by 2020 and 80 percent by 2050 the state has begun implementing and building upon a suite of policies with far-reaching impact. Those policies projected to have the most significant impact on GHG emission reduction are analyzed briefly below:

Cap and Trade: Intended to initially last from 2012 to 2020, the statewide carbon cap-and-trade program will initially cover power plants, electricity importers and industrial combustion and processes that emit more than 25,000 tons of CO2 equivalent a year. It is estimated that during the first compliance period, 37% of economy wide emissions will be covered. Beginning in 2015, coverage will extend to transport fuel and fuel distributors and is estimated to cover 85% of aggregate emissions.

Emission allowances will be allocated based on previous emissions history with an auction for additional allowances and a portion of allowances held as reserves in order to stabilize price. Offset credits, basically emission reducing projects, will also be used alongside allowances. Finally, there will be linkages set up with other GHG cap-and-trade programs. Firms will be able to buy and sell carbon credits issued by another cap-and-trade program. The state is in the process of attempting to link to other similar programs to create a regional market (CARB 2010). (See Box 3 for discussion of regional efforts in this vein.)

Renewable Portfolio Standard (RPS): The Renewable Portfolio Standard expands on the previous standard to mandate that 33% of state electricity come from renewable sources by 2020 and is estimated to address 12% of the state's emission reduction goals.

Energy Efficiency Strategic Plan: The Energy Efficiency Strategic Plan builds upon the state's previous work with a more synchronized and long term effort with greater focus on outreach, more stringent standards, and innovation and will address 15% of GHG emission reduction goals.

Light-Duty Vehicle GHG Standards: Implementation of the California Light-Duty Vehicle GHG Standards will set more stringent GHG standards for in-state sales of all non-commercial light duty autos manufactured after 2008 and will achieve 18% of GHG emission reduction goals.

Low Carbon Fuel Standard (LCFS): Finally, the Low Carbon Fuel Standard requires major distributors of transportation fuels to reduce the carbon intensity of their fuels by 10% in 2020 and is expected to achieve 8.6% of the state's emission reduction goals (CARB 2008).

In addition to their impact on emissions, it is hoped that these polices will play an important role in creating long-term growth in the California economy. AB 32 sent a clear signal to clean tech venture capital of policy stability and support for low-carbon technologies. While clean tech venture capital had started to grow in California prior to AB 32 with a more global market focus, investment numbers in California following the initiative grew considerably (Randolph 2011). The Berkeley Energy and Resources (BEAR) economic model provides detailed scenario predictions on the economic adjustments and emissions reductions of AB 32. The model, unlike previous models used for this purpose, factors in the role of innovation at a rate consistent with California's history. The rate of innovation used for the model may actually prove conservative as it reflects a period with lower fuel costs and less compelling policy than the current period. The BEAR model finds that the state's Draft Scoping Plan for AB 32 will increase Gross State Product (GSP) by about $76 billion, create up to 403,00 new jobs, and increase real household incomes by about $48 billion (Roland Holst 2008). These policies may also affect the national or international economy. Due to the size of the California economy, the 8th largest economy in the

1 Though note that our venture capital expert argues that the VC story is very much a global story. The local California market is a useful, but by itself not enough. Clean tech investors are very much driven by critical global markets (Prabhakar 2011).

world, standards set for the California economy have a significant ripple effect (Lifsher 2010).

Partly because of their national or international implications, the policies have not been free of opposition. For instance, vehicle GHG Standards have been challenged by national automakers in federal courts, but have thus far not found success. The LCFS has also received criticism from US ethanol interests, oil and trucking firms, Brazilian ethanol producers, and Canadian officials (Bhanoo 2010; Power 2009). But thus far, California has maintained its legal right, built upon the state's earlier energy efficiency work, to implement more stringent environmental legislations than national standards.

2.3.3 VC growth: California's clean tech industry responds to an expanding market

California has established a leading role in clean tech VC both nationally and internationally and its market dominance is growing.

In 2009 California captured 57% of U.S. clean tech venture investments totally 3.3 billion and 25% of worldwide investment. By the last quarter of 2010 California had captured 70% of all U.S. clean-tech venture investment and 50% of global venture investment (BACEI 2010). The state leads the U.S. in clean tech patents with 458 registered clean tech patents between 2007-2009, 30% more than that of the second place state. Clean tech and green business have had positive gains on California employment as well. Between 1995-2008 it is estimated that employment in green business in the state grew 36%. Moreover, during the 2007-2008-recession period in California where total state employment fell by 5%, green jobs grew 5% (BACEI 2010).

Capturing funding

The California clean tech industry has thrived in part as it has managed to capture a disproportionate amount of federal funding in the sector. The number of top-tier research universities exploring the issue, and their established connection to a network of early developers and venture capital has enabled the state with a competitive edge (Randolph 2011). Federal support has boosted the already present resources and further charged clean-tech development.

"In the last ten years, however, DOE funding has rapidly increased, supercharged by the U.S. stimulus in response to the 2008 financial crisis"

Federal funding for Clean Tech has come in boom and bust cycles over the last 30 years. Following an initial fervor of investment in the 1970s following the OPEC oil embargo, federal funding for research, development, and deployment of renewable energy technologies fell significantly (Nemet and Kammen 2007). The Congressional Budget Office indicates that since 1978, adjusted for inflation, federal spending on all fields of energy research

DOE spending by state, excluding contracts

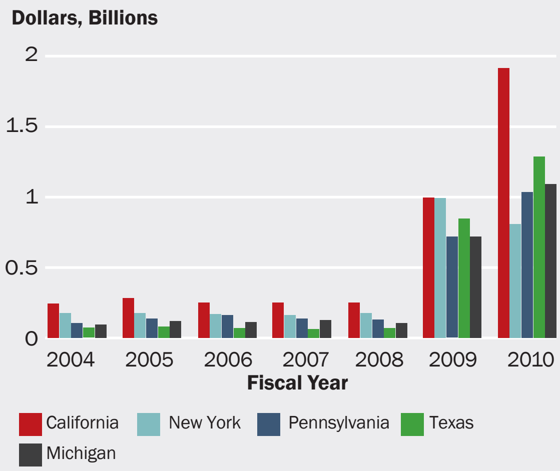


Figure 3: DOE spending, contracts excluded. Note the five states shown above are the recipients of the largest percentages of gran money from the DOE. (OMB 2011)

Source: Xhttp://usaspending.gov/

has decreased by over seventy-five percent (CBO 2010). In the last ten years, however, DOE funding has rapidly increased, supercharged by the U.S. stimulus in response to the 2008 financial crisis.

California received the lion's share of US stimulus funding in a number of green initiatives. Out of the 34.19 billion of stimulus funds available through the national Department of Energy (DOE), California received more funding than any other state in the categories of: renewable energy, modernizing the electricity grid, and science and innovation. It also received large sums of funding for energy efficiency work. It should be noted that with about 10 percent of the United States population living in California the per-capita percent of funding the state receives is at times actually lower than if evenly distributed (www.recovery.gov; US Census Bureau 2010). California did, however, receive almost ¼ of total DOE stimulus funding on Science and Innovation, although a significant section of this funding takes the form of contracts earmarked for security and maintenance of nuclear arsenals in the state.

DOE funding supports both R&D basic research and contracts at the national laboratories in the state and more advanced stages of clean tech development. Between 2008 and 2010 The Lawrence Berkeley National Laboratory and Lawrence Livermore National Laboratory received between 49 and 76 percent of total DOE funding to California (usaspending.gov). These facilities are currently most concentrated in focus on energy efficiency, biofuels, batteries, and nuclear fusion (LLNL 2009). DOE funding for more developed stages of clean tech takes the forms of loan guarantees, tax credits, energy bonds in the forms of grants in place of tax credits, and direct grants (dsireusa.org). A number of clean tech VCs have profited indirectly from recent DOE loan guarantees of considerable size. In 2011 California solar generation firm Solar Trust received a 2.1 billion dollar loan guarantee, the same year fellow solar generation firm Sunpower received 1.18-billion loan guarantee. Over the last few years further large DOE loan guarantees to California clean tech firms have included: 1.6 billion to Bright Source Energy, 16 million to Nordic Wind Power, and 535 million to Solyndra (lpo.energy.gov).

Federal funding has assisted in the initial development of clean tech, addressing investment gaps for basic research and possibly helping to overcome the otherwise potentially crippling capital intensity required to scale up many of these technologies. However, whether the DOE should structure funding by picking winners, as it is currently doing, or consider other funding mechanisms remains questionable. Some of these programs may also have distorted markets and reduced the healthy competitive environment essential to the long-term commercial success of firms receiving VC funding (Kenney 2011). We discuss this issue further in Section 3.2.

3 Challenges

Despite the perceived synergistic relationship between state climate policy and business interests, the success of this new phase of green growth in California remains to be seen.

3.1 Policy stability

Cleantech, to a far greater degree than its IT predecessor, relies on policy and regulation for market creation, and thus finds itself at the whim of political climate. Changes in the policy environment can lead to collapse of investment, as seen with the first failure of renewable energy policy in the 1980s (Kenney 2011). There may be exceptions – firms able to carve out a competitive niche market regardless of overall trends. Alternately, while renewable policy in the 1970s and early 80s tied to energy security concerns fell with the price of oil, current policy tied to climate change concerns may prove more permanent, since the climate problem will not disappear in the near future. However, the success of California's current phase of green growth depends on its ability to maintain political will and positive feedback over time – and how the current policy experiments will play out is difficult to predict. The defeat of Prop. 23, which would have suspended AB32, is one positive sign.

"However, the success of California's current phase of green growth depends on its ability to maintain political will and positive feedback over time – and how the current policy experiments will play out is difficult to predict"

3.2 Suitability of technology to funding models

Venture capital generally works best when it enters markets that are large and rapidly growing, with technology that is scalable, non-capital-intensive, and which provides large and rapid profits. With the exception perhaps of size (the energy market is large, at 5 trillion dollars), cleantech holds up to none of these characteristics. Energy technology, particularly generation, tends to be slow growing, slow and expensive to scale, and capital-intensive, with long-term investment horizons and conservative buyers (Hargaddon and Kenney 2011; Lecar 2011).

In light of this, the tendency of early VC investment in clean tech to ignore these limitations, making major investments in renewable energy technologies ill-suited to the VC model, seems odd. One possible explanation is that the availability of federal funding and loan guarantees has had a distortive effect, encouraging VCs to pursue investments that might otherwise not make sense (and which remain unsuited to VC's strengths). Large infusions of federal funding into the clean-tech industry may thus have temporarily overcome these obstacles, but the VC model could prove incompatible with clean-tech development in the long term if it continues to pursue technological pathways not well suited to its strengths.

However, it appears that there is something of a shift underway. As results come in from early rounds of investment, VC is in a "period of reassessment;" many are shifting their focus to more scalable, less capital-intensive, more rapidly profitable technologies such as efficiency technologies (Prabhakar 2011). This kind of learning will be critical to making VC-led green growth successful in the long-term. Below, we discuss the creation of new investment strategies.

3.3 Creating new models and success strategies

As VCs have struggled with the long investment timelines, high capital intensity, policy dependence, and low, slow returns of clean tech, many of the more diversified general VC firms have begun to pull out of clean tech. 2008 saw a significant reduction in clean tech investments from more diversified firms compared with the period between 2003 and 2008 (Moore 2011). However, the same period saw an increase in activity from clean-tech-specialized VCs. This trend has led some to label the current period "Stage Two" in clean tech investment. These clean-tech-specific firms are prepared for the investment horizons and capital investments of the sector and in some cases have adopted new investment models (Moore 2011). Rather than following projects to completion in the more traditional VC model, these firms are instead focused on capturing a part of the clean tech supply chain. These strategies include either work on early stage development that is then bought out, or by functioning in a model similar to hedge funds and with a focus on later stage development (Redman 2011).

The clean tech VC industry has also witnessed the entrance of a number of large corporate players and smaller family funds. Corporate players include Hewlett Packard, GE, Sony, Google, Intel, IBM, Chevron, and Coca Cola (among others). These large companies may prove better suited to handle the capital intensity and long investment horizons of clean tech. Some of these investments take a more traditional corporate investment form while others are invested in third party venture funds focused on clean-tech (Reuters 2010). The funds in question are significant, Energy Technology Ventures, a joint venture between GE, NRG, ConocoPhilips, is set to invest $300 million in 30 clean tech venture and growth-stage companies over the next four years (Danko 2011). Intel has announced plans to partner with a number of VC firms and other corporations to invest a total of $3.5 billion into with a focus on clean tech (Kanellos 2010).

3.4 Retaining created value

Finally, regardless of funding mechanism, California must retain enough of the economic value it creates to make current policy worthwhile. There are two perspectives on this issue. The first is that while the breakthrough innovations may be generated in California, evidence suggests that clean-tech may follow traditional patterns of global trade with the majority of production taking place abroad (Glaeser 2011). Current California policy lacks a specific link between market creation and creation of local manufacturing jobs, and it is unclear that California is positioned to capture these gains. The second perspective, however, is that creation of a large local market means gains at other points in the value chain, such as innovation, installation, construction, marketing, and services. These functions are more likely to remain local, and could generate significant value in their own right. This perspective highlights the value of policy creating local markets, and not merely supporting the competitiveness of industry in global competition (Prabhakar 2011).

4 Conclusion

Two key lessons emerge from the California green growth case.

"The first is that green growth policy can be an iterative process in which each round of green or environmental policy helps to broaden the set of constituencies that are tolerant or supportive of further green policy steps"

The first is that green growth policy can be an iterative process in which each round of green or environmental policy helps to broaden the set of constituencies that are tolerant or supportive of further green policy steps. Thus, initial (successful) rounds of pollution and energy efficiency policy are credited with building familiarity and support among consumers and industry that created a permissive environment for green policy like AB32. AB32 is, in turn, helping to swiftly create a significant industry group with a direct stake in seeing green policy survive and expand. This lesson is echoed in the Danish case; and we see the possible beginning of a similar process in the Colorado case.

Second, green growth policies and initiatives must take into account and coordinate with existing systematic and environmental characteristics. In the case of deregulation, California's deregulatory moves failed partly because they were mismatched with conditions in the regional electricity system California participated in. In that case, mismatch led to failure. California's clean tech venture capital community now stands at a critical juncture. The current VC investment model may prove mismatched to the characteristics of clean-tech development. However, it appears that the business community may be adapting; continuing to capitalize on the supportive environment created by clean tech market-creating policy while experimenting with new investment models. How well these investment models are able to adapt to clean tech characteristics may determine their success.

California green policy works best when it can build industry coalitions and ensure long-term policy stability. Industry coalitions work to create sustainable policy across partisan shifts. Long-term policy stability provides investment models the time and incentive to experiment until they find success. Energy systems and the economy are large, complex, slow-moving systems, which means that designing well-matched policies for these systems is an inherently difficult problem. This suggests green policy moves will work best when they are relatively simple and open-ended, supporting experimentation.

Works Cited

Bay Area Council Economic Institute (BACEI). 2010. "Global Competitiveness, China and California's Emerging Clean Energy Economy." White paper. Last accessed July 28, 2011. http://www.bayeconfor.org/media/files/pdf/CaliforniaChinaCleantech.pdf

Hanoo, Sindya A. 2010. "Trucking and Oil Industries Protest Fuel Mandate in California."

New York Times, February 5. http://green.blogs.nytimes.com/2010/02/05/trucking-and-oil-industries-protest-fuel-mandate-in-california.

California Air and Resources Board (CARB). 2010. "Cap and Trade 2010." Last accessed July 28, 2011. http://www.arb.ca.gov/regact/2010/capandtrade10/capandtrade10.htm

California Air Resources Board for the State of California. 2008. "Climate Change Scoping Plan (a framework for change pursuant to AB 32)." Last accessed July 28, 2011. http://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf

Danko, Pete. 2011. "Cleantech Sees Big Players Investing," Earthtechling, February 9. Last accessed July 28, 2011. http://www.earthtechling.com/2011/02/cleantech-sees-big-players-investing/.

Energy Information Administration, Department of Energy. 2009. "The Current and Historical Monthly Retail Sales, Revenues Database Electric Utility Sales and Revenue Data." Last accessed July 28, 2011. http://www.eia.doe.gov/cneaf/electricity/page/sales_revenue.xls

OMB. 2011. Executive Office of the President of the United States, Office of Management and Budget. Usaspending.gov. Washington, DC: 2011. Last accessed July 28, 2011. http://usaspending.gov/trends.

Glaeser, Edward L. 2011. "Why Green Energy Can't Power a Job Engine." The New York Times: Economix. January 18. http://economix.blogs.nytimes.com/2011/01/18/why-green-energy-cant-power-a-job-engine/.

Hanemann, W. Michael. 2007. "How California came to pass AB 32, the Global Warming Solutions Act of 2006," Working Paper No. 1040. Berkeley, CA: Department of Agricultural and Resource Economics, University of California.

Hargaddon, Andrew, and Martin Kenney. 2011. "Misguided Policy? Following Venture Capital into Clean Technology." Working paper. April 5.

Huberty, Mark, Jany Gao, and Juliana Mandell. 2011. "Shaping the Green Growth Economy: a review of the public debate and the prospects for green growth." Copenhagen, Denmark and Berkeley, California: Mandag Morgen and the Berkeley Roundtable on the International Economy.

Kanellos, Michael. 2010. "Intel Heads Up $3.5 Billion Green/Clean Tech Investment Fund," Wired, February 23. http://www.wired.com/epicenter/2010/02/intel-heads-up-35-billion-greenclean-tech-investment-fund/.

Kenney, Martin. 2011. Interview by Nina Kelsey and Juliana Mandell. Telephone with notes. Berkeley, California, March 16.

Lecar, Matt. 2011. Interview by Nina Kelsey and Juliana Mandell. Telephone with notes. Berkeley, California, March 16.

Lawrence Berkeley National Laboratory, U.S. Department of Energy. "Recovery Act Activities." Last accessed July 28, 2011. http://www.lbl.gov/Publications/recovery/projects.html#energy

Lawrence Livermore National Laboratory. 2009. "A Tradition of Excellence Continues: 2009 Annual Report." Last accessed July 28, 2011. https://www.llnl.gov/annual09/excellence/pdf/2009AnnualReport.pdf

Lifsher, Marc. 2010. "California Economy Still World's Eight-Largest, Despite Recession," LA Times. December 2. http://latimesblogs.latimes.com/money_co/2010/12/ california-economy-ranking.html

Lutsey, Nicholas and Daniel Sperling. 2008. "America's bottom-up climate change mitigation policy," Energy Policy 36: 673-685.

Moore, Galen. 2011. "Cleantech-focused funds take over as general VCs back off cleantech." Mass High Tech, April 27. http://www.masshightech.com/stories/2011/04/25/weekly12-Cleantech-focused-funds-take-over-as-general-VCs-back-off-cleantech.html

Mitchell, Cynthia. 2009. "Stabilizing California's Demand: The Real Reasons Behind the State's Energy Savings," Public Utilities Fortnightly.

Nemet, Gregory F., and Daniel M. Kammen. 2007. "U.S. Energy Research and Development: Declining Investment, Increasing Need, and the Feasibility of Expansion."

Energy Policy 35.1: 746-55.

Power, Stephen. 2009. "Ethanol Groups Sue California Over Low-Carbon Rule," The Wall Street Journal. December 24. http://online.wsj.com/article/SB126169282611304857.html

Prabhakar, Arati. 2011. Interview by Nina Kelsey and Juliana Mandell. Telephone with notes. Berkeley, California, March 29.

Randolph, Sean. 2011. Interview by Nina Kelsey and Juliana Mandell. Telephone with notes. Berkeley, California, March 8.

Redman, Elizabeth. 2011. "Shifts in the Cleantech Investment Landscape." Reuters, April 13. http://www.reuters.com/article/2011/04/13/idUS74705167920110413.

Recovery Accountability and Transparency Board, 2011. "Track the Money." Last accessed July 28, 2011. www.recovery.gov.

Roland-Holst, David. 2008. "Energy Efficiency, Innovation, and Job Creation in California." Research Papers on Energy, Resources, and Economic Sustainability, UC Berkeley.

Rosenfeld, Arthur H. 2008. "Energy Efficiency: The first and most profitable way to delay climate change" EPA Region IX, California Energy Commission.

Rosenfeld, Arthur H. and Patrick K. McAulliffe. Edited by David W. Hafemeister. 2008. "Opportunities in the Building Sector", Physics of Sustainable Energy: Using Energy Efficiently and Producing it Renewably1044: 3-14.

Rosenfeld, Arthur H., with Deborah Poskanzer. 2009. "A Graph Is Worth a Thousand Gigawatt-Hours: How California Came to Lead the United States in Energy Efficiency." Innovations 4 (2009): 57-79.

Roosevelt, Margot. 2011. "New Mexico threatens a U-turn on environmental regulations," Los Angeles Times. January 5.

Roosevelt, Margot. 2010. "California, New Mexico and 3 Canadian provinces outline regional cap-and-trade." Los Angeles Times, July 28, 2010.

Sudarshan, Anant and James L Sweeney. 2008. "Deconstructing the 'Rosenfeld Curve.'" Working Paper Precourt Energy Efficiency Center.

Sweeney, James L. 2002. The California Electricity Crisis. Stanford: Hoover Institution Press.

U.S. Census Bureau. 2010. Washington DC. http://www.census.gov/.

U.S. Congressional Budget Office. 2010. "Federal Climate Change Programs: Funding History and Policy Issues." Washington, DC: Pub. No. 4025.

U.S. Department of Energy, Database of State Incentives for Renewables and Efficiency. Dsireusa.org. Washington, DC: 2011. http://www.dsireusa.org/, 2011.

U.S. Department of Energy, Energy Loan Programs Office. Lpo.energy.gov. Washington, DC: 2011. https://lpo.energy.gov/
"Venture Beat's best and worst of cleantech in 2010." 2010. Reuters, December 29. http://www.reuters.com/article/2010/12/29/idUS120422778120101229.

Walsh, Bryan. 2010. "Prop 23 Is Defeated," Time. December 9. http://www.time.com/ time/specials/packages/article/0,28804,2035319_2034098_2034140,00.html

Western Climate Initiative. 2008. "Clean Energy: Creating Jobs, Protecting the Environment." Westernclimatein.org.

COLORADO
STATE CASE ANALYSIS

June 15, 2011

Prepared by Alice Madden
with Jany Gao, Kate Goldman, and Nina Kelsey

1 Introduction

Colorado's move toward green growth policy is relatively new. Colorado does not have the iterative history of multiple, mutually reinforcing phases of green growth seen in California. Rather, its movement toward green growth policy has developed recently through the relatively rapid creation of a supportive coalition behind it. Colorado's story, which effectively begins around 2000, is a short but exciting one. So here, we analyze the Colorado case by laying out the fascinating question of what has begun to happen in Colorado, and why it has happened.

Despite its vast reserves of fossil fuel,[1] the state of Colorado has recently embarked on a surprising green growth path. In 2004, a grassroots advocacy movement in support of renewable energy put a renewable portfolio standard (RPS) on the ballot. Despite opposition from major stakeholders like the utility company Xcel, the measure passed by slightly more than fifty percent (Broehl 2004). In this citizen-led Amendment 37, Colorado pledged to increase the share of electricity generated by major utilities[2] from renewable sources[3] to 10% by year 2015. Colorado has met this goal ahead of schedule, and has since raised the standard twice, to 30% renewable energy[4] by 2020. Among US states, this is second only to the 33% renewable energy by 2020 goal in California passed in 2011 (Minard 2010).

The government of Colorado has subsequently unveiled a series of other progressive environmental legislations enabling the transition to a low-carbon economy. The latest Clean Air Clean Jobs Act, which led to the early retirement of two urban coal plants that will be closed or refueled to natural gas, is an example of such progressive legislation (2010). Colorado's green industries have been booming in the past few years; the state has attracted global green technology leaders like the wind turbine maker Vestas, who already has 1,600 workers in the state and expect to reach 2,200 (Ritter 2010).

Colorado seems to be turning its fossil fuel-based economy toward a path of slow but steady emissions reduction, while growing green industries and creating jobs. Although the full economic effects of legislations like the RPS or the Clean Air Clean Jobs Act are not yet clear, one can still conclude that the government of Colorado is trying to drive employment and economic growth through emissions reduction measures. Of course, this green growth strategy is a very recent development. Before Amd 37 passed, Colorado's legislature rejected RPS bills four times; but in the six years since Amd 37, Colorado has embraced emissions reduction. Understanding the reasons behind this turnabout is not only important for ensuring a low-carbon future in Colorado, but may also hold answers for other states.

2 Colorado timeline

Timeline

Prior to 2004: Multiple attempts to pass clean energy and RPS legislation through Colorado's Republican-controlled General Assembly; all are defeated in either the state House or Senate, and would likely have been vetoed by then-Governor Owens if not.

2004: Amd 37, a citizen ballot measure calling for renewable energy standards as well as several related measures, passes in the general election. This same election gives Democrats a majority in both the state House and Senate.

2004 – 2006: Attempts at additional green legislation are passed but vetoed by Governor Owens.

2006: Governor Bill Ritter is elected after making green energy a primary issue in his campaign.

2007 – 2010: Colorado passes over 50 pieces of legislation intended to advance the "New Energy Economy." In March 2007, the legislature increases the RPS to 20% by 2020.

2010: The legislature increases the RPS again to 30% by 2020.

2011: Shrinking federal funding and cuts to state funding begin to create future challenges for green policy.

1 Colorado has 8% of American dry natural gas reserves, and roughly one third of US coal-bed methane reserves, as well as oil-shale reserves equivalent to the world's proven oil reserves, though it is currently uneconomic to exploit (Burnell, Carroll and Young 2008).

2 Those serving more than 40,000 customers.

3 In Amendment 37, renewable energy was defined as wind, solar, geothermal, biomass, hydrogen fuel cells, and small hydro power.

4 The latest RPS legislation adds recycled energy, which is power generated from waste heat of industrial plans, as a renewable energy on top of those defined in Amendment 37.

3 Explaining Colorado's green growth

The critical questions in the Colorado story are: First, what allowed Colorado to pass a citizen-supported measure like Amd 37 – making it the first US state to do so, and a particularly startling achievement given that similar legislation had repeatedly died in the state's General Assembly? And second, once Amd 37 passed, what drove Colorado on the relatively fast track of green policy that it has seen, from a 10% RPS to 20% to 30%, with accompanying growth in installed energy base and local green business? Below, we argue that the answer lies in a combination of 1) a public advocacy program that successfully showed several very different constituencies in Colorado how clean energy could meet their different needs, thus building support among several communities; 2) a fertile environment provided by local centers of research and business innovation in cleantech; 3) coincidental funding assistance from the federal government, and 4) immediate reinforcement generated by early successes.

3.1 Public advocacy

Public awareness and support for renewable energy, as well as advocacy efforts from various NGOs, were indispensable to the formation of Colorado's green growth strategy. It was, after all, a citizens' initiative that produced Colorado's first RPS. The widespread popular support for renewable energy (compounded by early successes) is also evident in the fact that Governor Bill Ritter's successful campaign in 2006 emphasized what he called "a new energy economy", a green growth strategy aiming to create jobs by promoting renewable energy (Ritter 2010). Popular support for renewable energy in Colorado spans geographical regions and political spectrum, and this breakdown is considered in finer detail below. Support stems from a variety of sources; background characteristics include the obvious ready availability of renewable energy resources; citizen pride in Colorado's natural resources; an independent political streak that favors energy independence; and more specific reasons discussed below. This emerging state-wide popular pressure paved the way for the recent green movement.

"Public awareness and support for renewable energy, as well as advocacy efforts from various NGOs, were indispensable to the formation of Colorado's green growth strategy"

Colorado's population can be divided into three major geographic groups, each of which has its own economic and ideological make-up regarding renewable energy. The **front range area** in central Colorado, which includes major urban centers like Boulder, Denver, and Fort Collins, tends to be more progressive and Democratic-leaning than the rest of the state. A survey of county commissioners across Colorado shows that urban, Democratic administrators are more likely to implement renewable energy projects (Davis and Hoffer 2010), which may reflect the stronger public concern for the environment in these areas (and, if successful, may also tend to build support). Eight out of the thirteen coal-fired power plants in Colorado are also near these more progressive cities in the front-range area. Aside from greenhouse gas emissions concern, many people are affected by pollutants, like nitrogen oxides and mercury, that these power plants emit. This may stir public opinion against coal; there have been many protests in Coloradan cities against coal-fired power plants in the past two years (Finley 2009; Espinoza 2010).

The counties in the rural plains of eastern Colorado tend to be more conservative and Republican, but farmers and ranchers could still find reasons to support the RPS. Agricultural communities have a history of utilizing wind as an important power source (Davis and Hoffer 2010). With an RPS, they can increase their income by selling homegrown renewable energy back to utilities or by leasing land to wind farms. According to one Democratic legislative leader – Alice Madden, who participated in the advocacy movement – RRepublican support for renewable energy remains relatively narrow. However, the support of Republican former Speaker Lola Spradley, who represented a rural constituency in eastern Colorado, during 2003-2004 was indispensable to the eventual creation and passage of Amd 37, and provided significant rhetorical support for the effort (Plant 2011).

Finally, **the western mountain counties** are rural and relatively independent politically. Tourism is a major industry in these areas, meaning that protecting the natural landscape is important. However, these areas tend to have less in the way of exploitable wind energy.

As can be seen from these descriptions, advocates of Amd 37 had plausible arguments to offer voters in each of these areas. Precisely how critical arguments made to each constituency were to the success of Amd 37 is difficult to determine definitively. It is clear that support from urban Front Range and western mountain counties formed a core part of the vote. Voting returns show that all of the Colorado counties in which Amendment 37 received more than 50% of the vote were Front Range or western mountains counties.

In the rural eastern plains counties, the amendment faced not only general ideological opposition from conservatives, but direct, specific opposition from rural power generation coops that felt threatened by the measure (Baker 2011). A poll roughly a month before election did show that a plurality of Republicans in the state supported the measure (45% favoring and 33% opposed (Frates and Cox 2004)) and Speaker Lola Spradley in particular made a concerted effort to reach these voters based on an economic message about the potential monetary benefits they could accrue from local wind installations (Olinger 2004; Paulson 2004; Purdy 2004). However, ultimately, the measure failed to win any of the eastern plains counties, outright; and in fact, eight of the eleven counties, in which 37 polled at less than 1/3 of the electorate were in the eastern plains. Nonetheless, selling 37 to these voters was inherently an uphill battle, ideologically. It is difficult to tell whether, without efforts to court these voters, 37 might have done even worse in these areas, potentially resulting in a statewide loss. These efforts may also have paved the way for a subsequent quick turnaround to acceptance of the benefits of RPS in following years (discussed below).

Finally, a factor potentially affecting all constituencies was the fact that rate payers in general could look to gain from the RPS. Amd 37 mandates a $2 per watt rebate to consumers for solar installation. It also dictated that Xcel and Black Hills, the state's two investor-owned utilities, must produce half of their solar standards by buying back power produced at customers' facilities. Amd 37 also capped the rate increase for a customer per month at 50 cents, forcing the utilities to shoulder any additional cost increase. The legislation thus offered consumers rebates, potential buy-backs of homegrown renewable energy, and guaranteed low impact on rates. Later renewable energy legislation, like Net Metering HB08-1160 (2008) and Renewable Energy Financing Act SB09-051 (2009), expanded rebates to consumers for solar installation and utilities buyback of homegrown electricity. All of these measures benefit the average ratepayer.

Amd 37's popular support thus came not only from the progressive, environmentally-minded part of the population, but also from a variety of independent and conservative rural sources across the state. The consumer-friendly rebates and rate caps may have helped to render the RPS even more acceptable to the general public. This state-wide public support eventually led to Colorado's first RPS.

3.2 Research, development and green industries

Colorado has a somewhat longer history in the area of green innovation and industry than in green policy per se. Colorado has long provided an encouraging environment for the research, development and commercialization of energy technologies, fostering many successful renewable energy and energy efficiency firms even before the state's legislative move towards green growth. So it is not surprising that with new legislation offering even more incentives to green industries, Colorado has become a hub for clean tech and has attracted global players like Vestas.

Colorado houses multiple national laboratories, including the National Renewable Energy Laboratory (NREL), National Oceanic and Atmospheric Administration, and National Center for Atmospheric Research, all of which contribute to research and development in climate change mitigation technologies. These national laboratories are located very close to each other, as well as to three higher education institutions in Colorado. The state of Colorado has encouraged collaboration among these education and research institutions via memorandums of understanding in order to ensure the rapid transfer and commercialization of new technologies. A fourth national laboratory, the National Institute for Standards and Technology, is playing a leading role in establishment of Smart Grid standards.

"The nurturing environment in Colorado saw many large and successful renewable energy and energy efficiency firms spring up in Colorado long before the key legislations of the mid-2000s"

The nurturing environment in Colorado saw many large and successful renewable energy and energy efficiency firms spring up in Colorado long before the key legislations of the mid-2000s. For example, Architectural Energy Corporation, headquartered in Boulder, was founded in 1982; it generates $10 million annual sales by providing energy efficiency consulting and services (ASES 2009, 57). Since Governor Ritter's "New Energy Economy" program began to take off, green industries have been expanding rapidly. The research community in Colorado directly helped the creation and growth of new firms. One example is AVA Solar Inc., a thin film solar panel producer with a new 500 worker, 200 MW capacity factory developed at Colorado State University with the support of NREL (ASES 2009).

As early as 2007, the renewable energy and energy efficiency industries had generated $10.2 billion in revenue and hired 91,285 workers (Bezdek 2009, 47). During the same year, the total revenue for the oil and gas industry was $17.2 billion, and the industry employed 70,779 workers (MacDonald et al. 2007, 55). Though green industries generated less revenue than the oil and gas industry, it hired more workers.

In addition to existing strengths in renewable energy and energy efficiency industries, Colorado also has a generally attractive business environment, featuring low corporate and income tax rates and a highly educated workforce. According to Forbes, it is the fourth best place to do business in the US (Badenhausen 2010). Once low-carbon policies were in place and the state began to focus on green growth in earnest, it is no surprise that global clean tech leaders like Vestas and its suppliers were attracted to Colorado.

3.3 Funding

Colorado also benefited, at least in the short term, from a coincidental conjunction with federal funding trends. Green policy took off in 2007 and 2008 with incoming Governor Ritter. Shortly thereafter, the global economic downturn led to the passage of the US stimulus bill, the American Recovery and Reinvestment Act (ARRA). Since a meaningful percentage of ARRA funds were focused on renewable energy and efficiency in both new and existing programs, the sudden influx of funding from the federal government in areas like efficiency, weatherization, and renewable energy provided both a safety net for existing programs (which might otherwise have been cut in the face of state budget difficulties) and a kick start for programs that would otherwise have been slower or impossible to start, providing levels of funding larger and faster than those that states had envisioned for themselves (Plant 2011).

The corollary to this, however, is the potential challenge facing Colorado and other states as ARRA winds down. Funding for many of these programs, such as weatherization, are expiring or being cut. The need to replace them at the state level as the influx from the federal level ebbs will be a huge challenge in the near future, and it is uncertain how effectively states will respond. An inability to find replacements could slow industry growth down (Plant 2011).

3.4 The Post-37 shift: turning opponents into allies

In addition to the growth of its green industry sector, Colorado's green policy support was ultimately strengthened by the tolerance or active support of several critical allies in the conventional energy industry, spurred by the configuration of policy proposed. In several cases, the immediate outcomes of Amd 37 – which turned out to be easier to achieve than utilities expected, and provided tangible benefits to rural plains voters – significantly raised support for renewables and green policy, particularly in the eastern plains counties.

3.4.1 Energy industry

Given Colorado's extraction industries, it should not be surprising that there was significant initial resistance to low-carbon legislations from energy industry stakeholders. The RPS was rejected by Colorado's Republican controlled senate twice in 2003 and 2004, before Amd 37 passed as a ballot initiative.

Xcel Energy, the most influential utility company in Colorado, opposed the 10% RPS in the beginning, but quickly had a change of heart and ultimately supported the increase of the RPS, first to 20% and then to 30%. Xcel realized that it would not be difficult to meet the 20% target, as federal tax credits after 2008 made wind energy affordable (Minard 2010). With Colorado's significant wind potential, improving technologies, and increasing fossil fuel prices, wind energy may become competitive faster than envisioned. In fact, as early as 2001, Colorado's Public Utilities Commission ordered Xcel to build a wind farm in Lamar as part of its conventional generation capacity despite Xcel's protests. The PUC claimed to base this decision on purely economic grounds – wind energy at Lamar would be cheaper than natural-gas power (Laird 2008). In the end, cost and profitability would be the only things to bring firms truly on-board.

"A large sector of Colorado's oil and gas industry has also jumped on the green-growth wagon, offering full support for Colorado's latest Clean Air Clean Jobs Act"

A large sector of Colorado's oil and gas industry has also jumped on the green-growth wagon, offering full support for Colorado's latest Clean Air Clean Jobs Act. Under implementation of this act, Xcel will retire two old coal-fired power plants and retrofit one of them to burn natural gas. Given that coal provided for 65.2% of Colorado's electricity in 2008 while natural gas only provided 25.2% (EIA 2010), natural gas producers stand to gain a much bigger market share at the expense of the coal industry. Indeed, there has been a publicity battle between the coal and the oil and gas industry over the Clean Air Clean Jobs Act.

The creation of stricter gas drilling rules, paired with the RPS, allowed environmental organizations to feel more comfortable lobbying for natural gas over coal.

Although natural gas burns cleaner than coal, it is a non-renewable energy source that produces greenhouse gas emission. Its longer term viability may depend on continued affordability and the development of extraction technologies that are acceptable to the public. Support from the oil and gas industry is recent and tentative. Many in Colorado feel that natural gas can hitch its wagon to wind to enhance public support and also may be compensated by self-reinforcing effects of green policy-created constituencies like those seen in the California case.

3.4.2 Consumers

Meanwhile, experience with renewables and particularly wind has increased support for green policy among rural consumers. By 2006, some of these constituencies had begun to receive tangible benefits from local eastern plains wind installations. Observers familiar with the Colorado politics suggest support has risen throughout the state, but especially among Republicans and in the eastern plains counties.

A possible demonstration of this effect is found among electoral returns for races that touched on this issue. For instance, Governor Bill Ritter was well known for making renewable energy a critical part of his campaign platform in 2006, making 2006 something of a referendum on the program's success thus far. Gov. Ritter did well in the 2006 election, and notably, he did significantly better amongst eastern plains state voters than Amd 37 had done two years before. Although Gov. Ritter generally did not receive a majority in these politically conservative areas, he was competitive; in eastern plains counties that had major wind installations in place or under construction by 2006 (Bent, Logan, Prowers, and Weld), he received between 47 and 57% of the vote. In the eight eastern plains counties that had given Amd 37 less than 1/3 of their vote, Gov. Ritter typically received around 13% more of the vote than Amd 37 did.

4 Conclusion

Though a state with vast fossil-fuel reserves, Colorado has embarked on a surprising green growth path. Success stems from the combination of three elements: (1) the public advocacy movement leveraging both progressive support for environmental protection from Democratic urban regions and mountain counties as well as farmers' and ranchers' support for an RPS that offers them economic benefits; (2) the nurturing environment created by a collaboration of research and education institutions in Colorado, policies favorable to green industries, and a generally good business environment; (3) an assist from high federal funding at a critical period; and (4) the subsequent increase in support from important industry stakeholders like Xcel Energy and key natural gas companies, as well as rural consumers, based on perceived advantages offered them by green policy.

"Second, Colorado's story demonstrates the importance of policy moves that have immediate, tangible, on-going benefits for constituencies that otherwise might be skeptical of green policy"

There are two key lessons to draw from Colorado's success. First, Colorado was able to make a relatively rapid shift toward a green industry path because key policy leaders identified a potential partnership between multiple very different constituencies who all had interests that could be served by similar green growth policies. This provided the basis for a policy realignment based on an informal partnership between these groups.

Second, Colorado's story demonstrates the importance of policy moves that have immediate, tangible, ongoing benefits for constituencies that otherwise might be skeptical of green policy. Such policy moves can fundamentally alter the political landscape, creating new supporters for green policy and hence broadening the potential coalition for green policy. In a conceptual sense, this is the heart of the "green growth" or "green industry" policy: environmentalists have always supported renewables, but the "green growth" argument focuses on showing other groups that they have real economic interests in green policy as well.

Of course, Colorado's green growth faces potential obstacles down the road; the depth of future support from the natural gas industry is an unknown. Also, Colorado lacks the transmission capacity to best exploit renewable energy. Xcel Energy is trying to kick start solar projects in southwestern Colorado, but an influential local landowner is fighting placing transmission lines on his land (Minard 2010). Public resistance is especially pronounced against transmission lines crossing residential areas or private lands (Davis and Hoffer 2010). The promotion of distributed generation at customers' facilities also requires the grid to be able to accommodate distributed, intermittent power sources. As it is everywhere, upgrading to a renewable-friendly transmission grid will be a major challenge for Colorado.

Colorado, like most other states, also faces some political and structural challenges to green policy. These include uncertainty over future federal funding (Plant 2011); potential exhaustion of the renewable energy "low-hanging fruit," leading to higher future costs; a return to partisanship after a honeymoon period of general support; and some internal fracturing of the green energy community (Baker 2011). The critical question for Colorado going forward is to what extent the strong successes of existing policy have created a stable, embedded constituency for green industry – from new manufacturing installations to rural landowners that have made wind leasing a part of their income base to houses that have invested in solar panels – that will carry it forward through funding uncertainties and the challenges of increasing scale.

Works Cited

ASES. 2009. Defining, Estimating and Forecasting the Renewable Energy and Energy Efficiency Industries in the U.S. And in Colorado. Boulder, CO: American Solar Energy Society, and Washington D.C.: Management Information Services Inc.

Badenhausen, Kurt. 2010. "The Best States for Business and Careers." Forbes. October 13. http://www.forbes.com/2010/10/13/best-states-for-business-business-beltway-best-states_2.html

Baker, Matt. 2011. Interview with Nina Kelsey. Telephone with notes. May 10, 2011.

Bezdek, Roger D. 2009. "Green Collar Jobs in the U.S. and Colorado, Economic Drivers for the 21st Century." Report for the American Solar Energy Society, Boulder, CO.

Broehl, Jesse. 2004. "Colorado Voters Pass Renewable Energy Standard; Amendment Creates First Ever Voters-Approved Renewable Energy Standard." RenewableEnergyAcess.Com. November 3.

Burnell, James R., Christopher Carroll, and Genevieve Young. 2007. "Colorado Mineral and Energy Industry Activities, 2007." Information series 77, Colorado Geological Survey and Colorado Department of Natural Resources, Denver, CO.

Clean Air Clean Jobs Act, State of Colorado House Bill 10-1035 (2010).

Davis, Charles and Katherine Hoffer. 2010. "Energy Development in the US Rockies: A Role for Counties?" The Journal of Federalism 40, no. 2: 296-311.

Espinoza, Annette. 2010. "5 arrested in Boulder anti-coal protest." The Denver Post. April 27. http://www.denverpost.com/commented/ci_14969890?source=commented-

EIA. 2010. "Colorado Electricity Profile 2008 edition." U.S. Energy Information Agency, Department of Energy, Washington D.C. 2010. Last accessed July 28, 2011. http://www.eia.doe.gov/cneaf/electricity/st_profiles/colorado.html

Finley, Bruce. 2009. "Protestors want Colorado to stop 'clowning around' on Clean Air." The Denver Post. November 19. http://www.denverpost.com/ci_13819745

Frates, Chris and Erin Cox. 2004. "Voters like tobacco tax Poll says per-pack hike, renewable energy backed MANY REMAIN UNDECIDED Other amendments to split the state's electoral and remove construction liability limits "look pretty weak."" The Denver Post, October 11.

Laird, Frank N. 2008. "Learning Contested Lessons: Participation Equity and Electric Utility Regulation." Review of Policy Research 25, no. 5: 429-228.

MacDonald, Lisa A. et al. 2007. "Oil and Gas Economic Impact Analysis." Report for Colorado Energy Research Institute, Denver, CO.

Minard, Anne. 2010. "Colorado Seeks a Renewable Energy Peak: But can Rocky Mountain power success be repeated in other terrain?" National Geographics. May 5. http://news.nationalgeographic.com/news/2010/05/100505-energy- colorado- renewable-power/

Net Metering Act, State of Colorado House Bill 08-1160 (2008).

Olinger, David. 2004. "STATEWIDE BALLOT ISSUES AMENDMENT 37 10% by 2015: Energy initiative would force Colo. to reap renewables." The Denver Post, October 17.

Paulson, Steven K. 2004. "List of initiatives certified for the November ballot." The Associated Press State & Local Wire, August 17.

Plant, Tom. 2011. Interview by Nina Kelsey. Telephone with notes. May 12, 2011.

Purdy, Penelope. 2004. "Amendment 37 Voters get their say on energy Ballot measure sets renewables standard." The Denver Post, October 10.

Renewable Energy Financing Act, State of Colorado Senate Bill 09-051 (2009).

Ritter, Bill. 2010. "Colorado's New Energy Economy." Forbes. May 27. http://www.forbes.com/2010/05/26/clean-energy-wind-technology-colorado.html

KOREA
A COUNTRY CASE ANALYSIS

June 15, 2011

Prepared by Irene Choi

1 Introduction

Today, "green" tops the agenda for the Korean government. The Lee Myung-bak administration has set impressive goals: according to its plans, Korea will reduce carbon emissions, improve energy security, and create new economic growth engines, and improve the quality of people's lives based on green technologies. Meeting these goals will also improve Korea's energy security, shielding it from fuel price and supply shocks that could hurt its economy.

The concept of green growth, and with it the development of renewable and/or fossil-free energy, is naturally attractive to a country that imports 96.7% of its energy from overseas and has the fastest growing emissions among OECD countries. The need to create a new engine for economic growth is also an important element of the Korean government's exceptional commitment to green growth. The Korean government sees the push for green growth as an opportunity to open a new era of national development that not only incorporates sustainability into the conventional economic growth framework by reducing carbon emissions, but also further improves corporate competitiveness by greening and upgrading the existing industries and nurturing green industries.

"This strategy is envisioned as an economic and social paradigm shift that revolutionizes the daily lives of Koreans, by reorganizing energy systems, industry, and urban management systems including buildings and transportation"

The potential for a transformed society in which economic growth comes from green energy could tie together key industrial players in Korea with other societal and international interests. President Lee Myung-bak's strategy effectively creates a partnership between the advocates of "green" and the advocates of "growth," in order to promote more balanced and sustainable future growth. This strategy is envisioned as an economic and social *paradigm shift* that revolutionizes the daily lives of Koreans, by reorganizing energy systems, industry, and urban management systems including buildings and transportation.

This definition of green growth goes beyond what was proposed in the green literature review (Green Growth Leaders 2011c) undertaken as a companion piece for our country studies. That review discusses three possible definitions of green growth, all of which are used in contemporary debates:

1) **Growth *compatible with* emissions reductions,** such as growth that continues while efficiency measures are used to decouple growth from emissions.
2) **Growth *driven by* emissions reductions,** which comes in two flavors:
   a. **Jobs** created by green growth policy
   b. **GDP** growth created by green growth policy

The Korean green growth vision encompasses all of these benefits and goes a step beyond, toward a multi-level transformation that, if realized, will be more than a simple growth strategy and affect many more aspects of Korean lives than just the economy.[1] A full exploration of the Korean vision for green growth and the multi-level transformation it entails is therefore beyond the scope of this report. Here, we focus on what we see as some of the key parts of the economic story. We seek to understand the goals Korea has set for itself in the spheres of energy and economy, what basic drivers underlie these goals, and what obstacles Korea may face in achieving them.

This report will first examine the overall green growth objectives Korea has chosen. Major green growth projects include developing green energy, building a smart grid, promoting smart work[2], and laying rapid-transit rails. While all of these objectives are aimed at constructing a green infrastructure, this report focuses particularly on green energy (energy security, generation, and efficiency), as well as green industry and energy markets. Specific plans regarding each green growth objective, as well as the structural challenges that deter the implementation of these plans, will be discussed.

2 Korean green growth objectives

In 2008, Korea faced two problems. First, concerned voices had been raised about whether Korea, as a non-annex country to the Kyoto Protocol, was ready to start

1 In this respect the Korean vision reaches intentionally for a transformation that is conceptually similar to that which has occurred de facto in the Danish economy. See our Danish Country Case Analysis report (Green Growth Leaders 2011b) for further discussion. However, Korea's specific goals, specific tools chosen, and particular obstacles differ because Korea begins from the basis of a different political configuration and resource base than Denmark. One example is the way in which Denmark's copious wind resources and particular political configuration combine to create a critical mass of popular and business support for commitment to wind energy; Korea, with a different set of resources and a different political economic configuration, arrives at its visions for transformation in a different way and is aimed in different directions. Both represent potentially viable experiments in green growth.

2 "Smart Work" is a term coined by the Korean government that is synonymous to telecommuting, in other words, allowing for all types of working conditions that are not confined by time or place by employing Information and Communication Technologies.

bearing global emissions reduction requirements under post-Kyoto systems (Kim, Kim, and Park, 2). Meanwhile, after the global financial crisis in 2008, Korea was also searching for stimulus policies that would get the Korean economy back on track. The Green New Deal announced in January of 2009 was the Korean government's effort to solve both problems. It was followed by the creation of the Presidential Committee on Green Growth; the Green Growth Development Strategy, a longer-term effort extending through 2050; and the Five Year Plan for Green Growth.

As seen from the progress report between 2008 and 2009, issued by the Presidential Committee on Green Growth, the Green New Deal is an investment plan of 50 trillion Korean won (45.4 billion USD) during the years from 2009 to 2012 on nine key green projects that include four major river restorations, green transportation, green cars and clean energy, waste resource catchment and reuse projects (PCGG 2010a, 9). The Green New Deal predated, but did not include, the establishment of the Presidential Committee on Green Growth, preparation and publication of Green Growth Development Strategy (for period up to 2050) and the 5YP for GG (2009~2013). The government has also promised an investment of 2% of GDP to initiate developments in the green sector as part of the five-year plan for Green Growth (PCGG 2010b, 22). By now, the Lee Myung-bak administration has made the message clear: the government is serious about its commitment to its vision of green growth, and an over-arching plan for the near, middle, and long term is in place.

The Korean goals for green growth, as outlined in the national strategy for green growth, are as follows: 1) reducing greenhouse gas emissions and improving energy security, 2) creating new engines for economic growth, and 3) greening the country and Korean lifestyles, with the objective of becoming a model green growth country internationally. Together, these three objectives constitute (and require) a transformation of Korean economy and society. The objectives are closely intertwined, with business opportunity and improvement in quality of life springing from the need to reduce emissions and increase energy security. As noted above, the Korean green vision goes beyond the focus and scope of this project, particularly in the realm of the third objective (greening the country and Korean lifestyles, which includes greening the land space and transportation). As mentioned above, green economic growth as defined for this project is growth that is compatible with, and driven by emissions reductions. Our discussion below therefore focuses on the first two Korean objectives, which are most closely related to our central focus on green economic growth.

2.1 First objective: reduce green house gas emissions and improve energy security

The first objective set by the Korean government involves two major goals that are intertwined, in the sense that achievements in one tend to imply (but do not guarantee) achievements in the other: reducing carbon emissions and enhancing the nation's energy security. Three strategic approaches contribute, to varying extents, to accomplishing these two goals:

The first strategic approach is ***increasing energy efficiency,*** thereby reducing fossil fuel consumption. According to the Ministry of Knowledge Economy (MKE), the Korea Electric Power Corporation (KEPCO) plans to invest 4.7 trillion Korean won (4.2 billion USD) on smart transmission and distribution to decrease energy loss (MKEEID 2010, 4), while the introduction of the smart grid and demand side management will bring further improvements in energy efficiency. The strengthening of energy efficiency standards, introduction of energy management systems as well as smart grid techniques, deployment of high efficiency appliances, and the rationalization of the energy pricing system are all expected to boost energy efficiency. With better energy efficiency leading to lowered consumption of fossil fuels, both green house gas emissions and import dependency are expected to be reduced.

The second method is ***deployment of clean energy:*** generating more energy from greener sources. The law on renewable energy development, usage, and dissemination has been amended in 2010 as part of the effort. As described in a report issued by the Korean Institute for Industrial Economics and Trade (KIET), the government has been using feed-in tariffs (FIT) to subsidize medium and small sized renewable energy producers in the past. It is now shifting from FIT to a Renewable Portfolio Standard (RPS) system beginning 2012 (Choi 2009, 35). RPS targets are 2% by 2012, and 8% by 2020, with quotas concentrated on solar energy during the initial five years

Korea's current and projected energy mixes

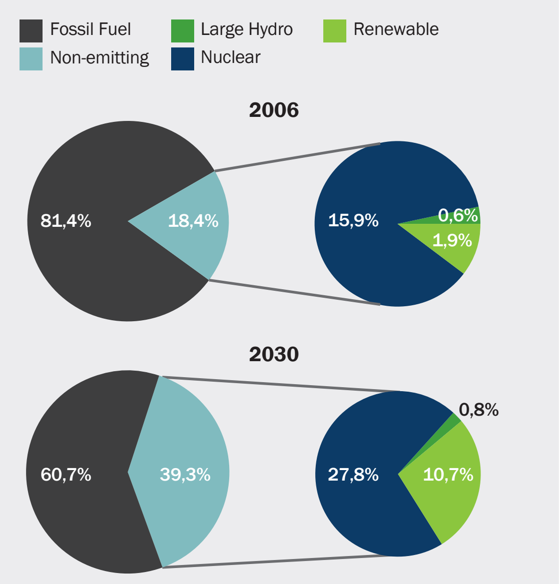


Figure 1: Planned Shift in Korean Energy Mix, 2008 to 2030 (PCGG 2010a, 8)

Source: Presidential Committee on Green Growth 2010. "Progress Report 2008-2009." Government report, Seoul.

from 2012 to 2016 (MKE, 2010b). The current goal is to increase renewable energy usage to 11% of total energy consumption by 2030 (PCGG 2010a, 8) (See Figure 1).

In absolute terms, Korea's renewables goal appears modest compared to those of renewables powerhouses like Denmark. This apparent modesty reflects in part the low installed base from which Korea must start (Korea's goal of 10.7% is a 4-fold increase from 2009's 2.7%). It is also a reflection of the relative dearth of strong renewable resources (Korea's renewable plans are constrained by the fact that Korea's wind and solar potential is limited compared to many nations.) Korea believes that, given these limitations, it has set quite challenging goals.

The third method is to ***produce more energy from nuclear power plants,*** a carbon-free but not renewable source. Korea is already the fifth largest nuclear energy producer (151TWh), generating 5.5% of the world's total nuclear energy (International Energy Agency 2010, 17). By 2030, Korea aims to produce 59% of its domestic electricity from nuclear energy, according to the *Korea Herald* (Cho 2010) The Basic Energy Plan of 2008 further shows that nuclear energy will take up to 27.8% in the country's overall energy mix. In addition to the potential to reduce carbon emissions, Korea hopes to emerge as a major exporter of nuclear power technologies and plants in the global market.

2.1.1 Challenges - nuclear development

There are some significant questions surrounding the development of nuclear power in Korea. Whether nuclear power constitutes green energy has been as controversial an issue in Korea as it has been elsewhere. The Presidential Committee had attempted to include provisions for development of nuclear power in the Framework Act on Low Carbon Green Growth enacted at the end of 2009, but had to abandon this because of objections regarding the safety and cleanliness of nuclear power. Still, nuclear power is included in Korea's blueprint for future energies as a major alternative energy to fossil fuels.[3]

However, nuclear energy's safety concerns have gained further saliency recently. When Korea won the bid in 2010 to construct nuclear power plants in the United Arab Emirates, with expected profits of four million dollars, the country was excited about becoming the next major nuclear power exporter. Yet, despite such major accomplishments, safety issues regarding nuclear energy generation, including proper disposal methods of the nuclear wastes, continue to be debated. The fear of nuclear explosion and radiation exposure in Fukushima, Japan, has raised new nuclear safety issues, prompting the Korean government to undertake the "Domestic Nuclear Energy Security Check Plan" to ease safety concerns, and it expects continuing discussion about this issue in Korea.

Finally, it is worth noting that the effect of nuclear power on energy security is unclear. Despite KEPCO's recent discovery of uranium in Waterbury Lake, Canada, Korea would have to import a major portion of its uranium from Russia, Kazakhstan, and/or Australia. While it is potentially simply trading one dependency for another, expanding nuclear power in the country's energy portfolio will reduce its high dependency on oil coming from the Middle East. At the moment, Korea is more concentrated on tackling the potential safety issues of nuclear power plants; potential dependency issues related to uranium are not considered a major concern

2.2 Second objective: provide an engine for economic growth

The second major objective of Korea's National Green Growth Strategy and Five Year Plan for Green Growth is to create new growth engines from green technologies, promoting green industries.

"The Korean government's choice of the next generation's growth-driving green industries such solar panels, fuel cells, LED, and green cars industries, reflect well on the strengths of its current industrial sector"

Korea has the market clout and technical skills to capitalize on green markets like those Objective One (with its goals of increasing national efficiency, renewables, and nuclear power) would create domestically. The Korean government's choice of the next generation's growth-driving green industries such solar panels, fuel cells, LED, and green cars industries, reflect well on the strengths of its current industrial sector. The country is home to some of the top global corporations in many high-tech industries such as the electronics, semi-conductor, IT, automobile, and ship-building industries. Korea also owns some of the most advanced technologies in related areas, and since 2005, the government has been spending 253.2 billion won (230 million USD) on research and development in heavy electric equipment and semiconductors (MKE 2010d, 14). Technological capabilities, experience, and knowledge on market trends and consumer taste in those industries could help the Korean firms make a fast start in some of the new green industries.

"Korean companies are in fact making major moves in target industries"

Korean companies are in fact making major moves in target industries. Hyundai Heavy Industries is building a 175MW (7 trillion USD) generator in what is to become America's largest solar energy generation project (total of 900MW) in California and Arizona (Park and Lee 2010). Samsung will invest 23 trillion won (20.9 billion USD) on solar panels, fuel cells, LED, and medical devices by 2020. It will also start building a green industrial complex by 2021 with 7 trillion won (6.3 billion USD) initial investments (Ryu 2011). Hyundai-Kia Automobile has developed the Sonata Hybrid and K5 Hybrid using its own independent technologies, acquiring 1000 new patents. Hyundai will also release a new plug-in hybrid electric

3 Private communication with Korean government official, 2011.

vehicle (PHEV) model next year and a fuel cell car model in 2013, strengthening its environmentally friendly automobiles line up (Cho 2011).

The electricity and smart grid businesses also represent a major business opportunity for Korea. According to the International Energy Agency (IEA), 13.6 trillion dollars are expected to be spent worldwide on the electricity industry by the year 2020. In addition to leveraging a significant domestic market, Korea can also hope to export to developed countries, as well as to China and Asia, where the markets for smart grid are expected to grow exponentially in the near future (qtd. in MKE 2010a, 96). In the best-case scenario, Korea would see an annual increase of 50,000 jobs, 74 trillion won (67 billion USD) increase in domestic demand, and 49 trillion won (44.5 billion USD) in exports of smart grid related products by the year 2030 (MKE 2010c, 33).

With an industrial sector that is prepared and eager to take advantage of the market opportunities inherent in capturing this new industry, Korea appears to have the commercial drive necessary to achieve the major transformations in energy systems, industrial structure, and life-style changes that the government has promised.

With an industrial sector that is prepared and eager to take advantage of the market opportunities inherent in capturing this new industry, Korea appears to have the commercial drive necessary to achieve the major transformations in energy systems, industrial structure, and life-style changes that the government has promised.

2.2.1 Challenges – restructuring the market

However, significant challenges must be overcome to realize Korea's vision of a green economic engine. Some of these center around providing the right set of incentives in the domestic market and energy system. One major challenge is introducing the carbon pricing system such as the ETS and carbon taxes. In 2009, the government announced its plans to implement cap and trade policies starting 2013. Last year, the Federation of Korean Industries (FKI), representing Korea's top conglomerate firms, strongly advised the government against the implementation, and implementation was delayed until 2015. This April, the bill was submitted to the National Assembly. The government hopes to see its passage before the end of the year. Carbon tax is currently under study.

Delays in implementation have to do with concerns about the potential economic effects. According to the FKI, the proposed carbon trading schemes will raise production costs for Korean firms and erode their price competitiveness in global markets, especially because Korea's major trading partners like America, China, and Japan are also delaying the implementation of similar carbon pricing systems. Also, the FKI argued that Korean firms, except for a few conglomerate ones, are lacking the appropriate tools to measure their own greenhouse gas emissions, and the government should first construct a national carbon measurement, report, and management system. It acknowledged that introducing the *greenhouse gas target management system* (starting 2012) which allowed the collection of data on carbon emissions was the right step towards national carbon emissions management, and a sufficient one. On the other hand, the proposed ETS bill visualizes the parallel running of the systems, with graduation clauses for the emitters in the target management system with emission above a certain amount required to move into ETS while to the others this would be optional.

Yet another change that the government must supervise is the restructuring of the electricity market. While the restructuring of electricity markets is a complex and often controversial challenge in most settings (see for instance our discussion of the deeply troubled and largely failed deregulation attempt in the California system in our California State Case report (Green Growth Leaders 2011a), some rearrangement of the market dynamics may be necessary for two reasons. First, better price incentives could drive domestic efficiency, reducing consumption and emissions. Second, it would make Korea a more suitable nursery for refining and commercializing effective new products in these areas, by providing the appropriate structure and market incentives for the development and use of energy efficiency and smart grid products. Responsiveness within the energy system is likely necessary to support the kind of green transformation of the economy and society that Korea seeks.

In 1999, the government recognized the need for a more open and competitive market for electricity. Consequently, KEPCO's generation has been divided into five separate power generation firms (excluding nuclear). However, while the government guarantees certain amounts of profits to independent power with Power Purchase Agreements (PPA), generation capacity of the private sector has not been increasing since 2001 (Kim and Kim 2010, 13). Also, further restructuring of the market has stopped since 2004, and significant improvements in efficiency have not been observed. According to Kyung Hoon Kim and Hye Soon Kim, the Korean electricity market is currently structured so that KEPCO monopolizes transmission and distribution of electricity, while 93.3% of generation is also produced by KEPCO and its six subsidiary firms. Transactions of electricity over 20MW are required to go through the Korea Power Exchange (KPX), where wholesale price is determined by the actual variable costs of the generators and not by a market mechanism (Kim and Kim 2010, 13).

"In Korea, electricity usage is classified into six types—residential, general, educational, agricultural, industrial, and streetlight—and each type pays different rates."

Current subsidies for electricity create distorted incentives for electricity usage and efficiency. In Korea, electricity usage is classified into six types—residential, general, educational, agricultural, industrial, and streetlight—and each type pays different rates. Electricity rates for consumers are determined by the government, based on consideration of KEPCO proposals and inflationary pressure. For residential and general usages, the government imposes six levels of progressive utility rates to induce energy conservation. However, the industrial sector, which consumes more than 50% of the total electricity generated in Korea (qtd. in MKE 2010c, 50) uses electricity at a price which is only 86.59% of the production cost (MKE 2010c, 11). This cost recovery rate varies over time and year, and is said to be between 89.4% and 90% in 2010.[4] While cheap utility prices have helped Korean industries to be price-competitive in the global market, distortions in the pricing structure of the electricity market fail to induce industries to reduce electricity usage. They further limit the introduction of real time pricing of electricity that is critical to the effective utilization of the smart grid, and generally weaken natural incentives to develop and use efficiency and smart grid products in the domestic market. These factors in combination make creating a pricing system that effectively conveys market incentives, a key feature of the smart grid, very difficult.

Currently, the PCGG is trying to reform the retail electricity market by introducing a variable pricing system for electricity. The Ministry of Knowledge Economy thus has announced that it will release the Electricity Price Roadmap in June. The roadmap contains plans for introducing more realistic pricing mechanisms that reflect the actual costs of power generation. Though specifics have not been revealed yet, it is expected to call for increases in the prices of electricity, while also including measures to support the more vulnerable parts of society that might be hurt due to a possible increase in electricity prices (Lee 2011). As prior attempts at deregulation and privatization have shown – both in Korea and in other cases – the task of introducing responsiveness into the market is complex, and the solutions that will ultimately work to support the type of transformation Korea seeks may need to be the product of experimentation.

2.2.2 Challenges – playing the global standards game

Finally, Korea will face increasing incentives to meet, or in many cases set, global standards – that is, the technical standards that govern interoperability, and hence usability, of products. Standards are critical in some of the emerging industries Korea wants to play in, particularly smart grid and related products. With a relatively small domestic market, Korea's ability to satisfy scale economies without exports has limits. This means it will do best if it can sway international decisions on use of standards, ultimately acting as a leader in the international development of newly emerging standards and hence ensuring a broad market for its own producers. If Korea can lead the international development of newly emerging standards, this will place it at the center of global innovation and position it to reap a strong share of the benefits from a global green transformation.

Korea intends to expand its influence on global standards by actively participating in international discussions and consortia. Taking the smart grid business as an example, Korea and Italy's selection as leading countries for the smart grid project during the expanded G8 summit in 2009 presented one early opportunity. Korea plans to lead international discussions of global standards for smart grid, by holding the World Smart Grid Forum and other conferences.

"Korea intends to expand its influence on global standards by actively participating in international discussions and consortia"

Already, there have been successful results in this regard. Xeline's Broadband Power Line, developed together with the US and Spain, was selected as the global standard by the International Standard Organization (ISO) in 2009. In terms of exports, Korea has secured major sales of solar energy generation and advanced metering infrastructure hardware to countries such as Japan, Australia, Mexico, Norway, Italy, and Sweden (MKE 2010a, 127-128).

2.2.3 The role of emerging firms

Interestingly, much progress is being made by smaller firms like Xeline and Nuri Telecom, which are not the traditional conglomerate industrial leaders in Korea. This suggests that Korea's green growth is not entirely led by the familiar *chaebol* organizations, but offers new opportunities to smaller businesses as well. In order to further improve these small and medium sized firms' brand recognition and facilitate international cooperation, the government has introduced various measures such as Green Certification and Green Financing. The success of efforts to encourage the growth of small and medium-sized firms in Korea has been controversial in the past, but the early participation of SMEs in the growth of green industry is encouraging.

The government has launched several programs aiming to provide effective policy tools and support specifically for SMEs. *Green Certification* is one example. It will reduce the uncertainty for investors by presenting government-selected green technologies and businesses to the private sector investors. Investors who choose to invest in these green-certified businesses can enjoy tax benefits, and selected businesses also receive credit benefits, get additional points when applying for foreign conventions, export incubator projects, and R&D investment projects, and finally, enjoy priority treatment in patenting. While firms can apply for Green Certification regardless of their size, local governments such as the Gyeonggi are working with smaller firms so that the costs of preparing the necessary paperwork do not deter them from applying (Chung 2011).

4 Private communication with Korean government official, 2011.

3 Government role in green growth

The government has historically played a major role in developing globally competitive domestic industries in Korea. Yet meeting Korea's green growth goals require the development of new tools for economic guidance. The three objectives of green growth—reducing greenhouse gas emissions and promoting energy security, achieving accelerated levels of economic growth, and improving the quality of life while also contributing to the international community—implies a paradigm shift that requires participation from all parts of the country and all levels of the economy – not just the top-level decision makers and Korea's leading conglomerates. The government has started progress in this regard, by setting up channels for public-private collaboration. The Presidential Committee for Green Growth (PCGG) is one such institution: it includes the President, Prime Minister, 14 Ministers and 36 private experts, and it also actively seeks input.

The Korean government historically had a tight relationship with conglomerate firms, which facilitated steps aimed at driving economic growth. Today, the government is concentrated on maintaining such relationships, amid the growing influences and sometimes diverging interests of conglomerate firms. Challenges to changing the pricing structures of the electricity market or introducing carbon pricing systems come in part from a need to earn the cooperation of the industrial sector, which has a critical part in the government plans for green growth.

4 Conclusion

The Korean case is unusual in the extent to which its multiple objectives – energy security, economic growth, and emissions reduction – intertwine to create a common purpose. As its goals are currently formulated, there is little conflict between these three objectives. According to the plan, green growth will lower emission reductions, improve energy security, create significant employment, and drive economic growth, all in a "greener" way. This unity of purpose could translate to an unusually unified coalition of interests supporting these goals, assuming the different actors involved (government, business, consumers) can reach comparable unity on the tools to use to get to the desired outcomes.

"Yet conglomerate businesses have picked up green technology because it is a product that will sell"

Of course the pleasant rhetoric of "green," "environment-friendly," and "emissions reductions" is not always warmly welcomed by businessmen – Korea is no different in this from many other countries. Yet conglomerate businesses have picked up green technology because it is a product that will sell. In the end, their green technologies will reduce emissions and support better energy security. A strong perception of a purely economic rationale strengthens the overall rationale for Korea's package of energy objectives and helps build a coalition of interested parties. The fact that the country has a uniting economic incentive pushing for green growth is a strength.

Korea does face meaningful challenges in achieving many of its goals. Yet considering that green growth is still at a very early stage of development, the government has definitely taken significant steps, such as laying out the institutional framework necessary for green growth. It is prepared to take active roles in delivering many of its promises to emerge as a role model for later developing countries in realizing the green growth paradigm for sustainable and balanced growth.

"Korea may also be somewhat unique in the scope and timeline of its ambitions"

Korea may also be somewhat unique in the scope and timeline of its ambitions. In this discussion we have, directly or implicitly, discussed a variety of transformations that are being undertaken or must be undertaken as part of Korea's desired paradigm shift: a shift in power sources and use; a restructuring of the energy market and its pricing structure; a possible shift in industrial structure toward more incorporation of small and medium-sized firms that are natural fits for emerging niches in new industries; a shift in international role toward a more assertive leadership in standard-making. And these are just a subset of the range of changes Korea wants to make; shifts beyond our scope of discussion here range from changes in ecological approach to mass transit to building and urban planning to citizen lifestyle.

Individually, these shifts are important. But taken together, the whole may be greater than the sum of its parts, if Korea succeeds in restructuring the expectations, logic, and behavior of Korea's society and economy into a new, self-sustaining "green" whole with a momentum of its own – what President Lee Myung-bak termed "a new national development paradigm" (Lee 2008). We have argued that we have seen such self-reinforcing transformations occur, to greatly varying degrees, in the companion cases of Denmark and California. However, if Korea succeeds in a similar paradigm shift, its transformation will be somewhat unique in being the result less of the kind of path-dependent, evolutionary process seen in those cases, and more of a conscious effort undertaken at a historic moment. It remains to be seen how fully Korea will succeed with its goals – individually and as a coherent whole – but the process commands attention from scholars of green growth policy.

Works Cited

Cho, Chungun. 2010. "KHNP foremost in nuclear plant operation." Korea Herald, Mar. 29. http://www.koreaherald.com/specialreport/Detail.jsp?newsMLId=20100325000817. Accessed April 5.

Choi, Hyun Kyung. 2009. "Comparison and Implications on Renewable Portfolio Standard (RPS) and Feed-In-Tariffs for Renewable Energy." Report, Korea Institute for Industrial Economies and Trade (KIET), 26-38.

Cho, Chungun. 2011. "Hyundai develops an Independent Plug-in Hybrid Car, Avoiding the Dense Toyota Patents." HangookKyungjae Daily, Apr. 22. http://www.hankyung.com/news/app/newsview.php?aid=2011042260731&intype=1. Accessed May 5.

Chung, Hyung-suk. 2011. "Green Certification for the Growth of Green Industries." JungiShinmoon, Apr. 14.

Green Growth Leaders. 2011a. "California State Case Analysis." White paper prepared for the Green Growth Leaders Project in collaboration with CRESTS. May 17, 2011.

Green Growth Leaders. 2011b. "Denmark Country Case Analysis." White paper prepared for the Green Growth Leaders Project in collaboration with CRESTS. May 17, 2001.

Green Growth Leaders. 2011c. "Shaping the Green Growth Economy." White paper prepared for the Green Growth Leaders Project in collaboration with CRESTS. May 17, 2011.

International Energy Agency. 2010. "2010 Key World Energy Statistics." Statistics Book, OECD/IEA.
Kim, Kyung Hoon and Hye Soon Kim. 2010. "Private Generation and Credit Rating System." Korea Ratings Weekly, 450 (2010): 2 - 19.

Kim, Yong-gun, Ee-jin Kim, and Shi-won Park. 2009. "Study on the Negotiation Trends and Response on Commitments to Greenhouse Gas Emission Reduction." Report, Korea Environment Institute (KEI).

Lee, Jonghyun. 2011. "Choi Joon Kyung 'Progress towards Realizing Electricity Price Will Continue'." ChosunIlbo, May. 5.http://biz.chosun.com/site/data/html_dir/2011/05/05/2011050500581.html. Accessed May 5.

Lee, Myung-bak. 2008. "A Great People with New Dreams." August 15, 2008. http://eng.me.go.kr/file.do?method=fileDownloader&attachSeq=2094. Accessed May 16, 2011.

Ministry of Knowledge Economy, Electricity Industry Division (MKEEID). 2010. "Development Status of the Smart Grid." Government report, Seoul.
Ministry of Knowledge Economy (MKE). 2010a. "Foreign Smart Grid Policy and Market Research." Government report, Seoul.

.2010b. "Amendments to the law on renewable energy development, usage, and dissemination on enforcement ordinance and enforcement regulation of RPS."Government press release, Seoul.

. 2010c. "Smart Grid Fact Book." Government report, Seoul.

. 2010d. "Smart Grid National Roadmap." Government report, Seoul.

Park, Jong-sae and Gil-sung Lee. 2010. "Hyundai Heavy Industries builds America's largest solar energy plant." ChosunIlbo, Aug. 11. http://biz.chosun.com/site/data/html_dir/2010/07/20/2010072001958.html. Accessed May 5.

Presidential Committee on Green Growth (PCGG). 2010a. "Progress Report 2008~2009." Government report, Seoul.

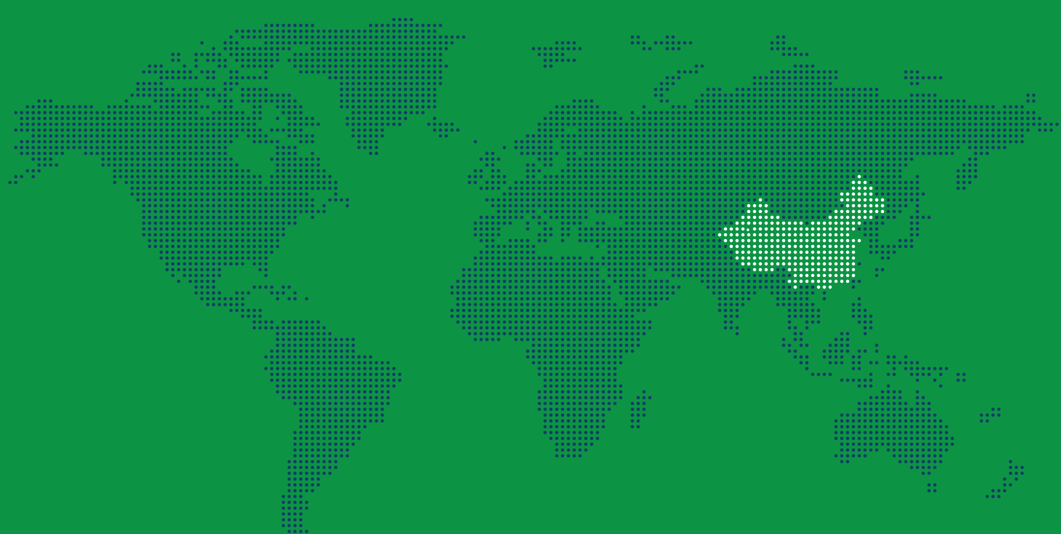
. 2010b. "Road to Green Growth." Government report, Seoul.

Ryu, Hyun-jung. 2011. "Samsung builds Green Industrial Complex in Saemangum… 7 trillion won investment." ChosunIlbo, Apr. 27. http://biz.chosun.com/site/data/html_dir/2011/04/27/2011042701470.html.Accessed May 5.

CHINA
A COUNTRY CASE ANALYSIS

June 15, 2011

Prepared by Crystal Chang and Jany Gao



I. Introduction

As international concern over climate change grows, many countries including China are pursuing "green growth" strategies that aim to both stimulate economic growth and reduce carbon emissions.[1] The recently announced 12th Five-Year Guideline (FYG) dedicates an entire section to "green development". China's green initiatives, such as conserving scarce resources and investing in renewable energy, are important and necessary steps toward creating a more environmentally sustainable economy. Yet in order to assess the impact these initiatives are likely to have on China's carbon emissions, it is imperative to place China's green policies in the broader context of its manufacturing-driven economy and national energy system. The analysis presented here suggests that, given the rapid rate at which China's overall energy demand is growing, the government's green initiatives will not displace the country's heavy reliance on coal, and hence will have limited effects on its total carbon emissions in the near term. China's carbon emissions are not likely to plateau until 2030 when urbanization and population growth begin to slow, and when China makes more progress in its transition from an energy-intensive industrial economy to a service economy.

At the highest level, the primary concern of the Chinese leadership is to secure enough energy to fuel the country's hungry economic growth engine, and thereby keep a lid on social and political unrest.

At the highest level, the primary concern of the Chinese leadership is to secure enough energy to fuel the country's hungry economic growth engine, and thereby keep a lid on social and political unrest. In China, "energy security" – ensuring continued *and* expanding access to energy at relatively low prices – is a matter of political survival. The legitimacy of the party and government comes through the ability to create tens of millions of jobs each year and raise the living standards of more than a billion people. From 1990 to 2007, 380 million people moved to Chinese cities; between 2007 and 2030, another 380 million are expected to move to urban areas (Zhou et al. 2011, 4). As it turns out, this task requires an enormous amount of energy. To that end, the government is investing heavily not only in energy efficiency programs and non-fossil fuel energy sources, but also in new coal-fired power plants and high voltage transmission lines to connect both new coal and new renewable sources to the state grid. Despite this massive investment, China is still rationing electricity and dealing with power outages in 2011. The core challenge the government faces, therefore, is not how to *supplant* coal with renewables, but rather how to supplement existing energy sources with new sources and generate enough electricity to keep the lights on and the factories running.

The core challenge the government faces, therefore, is not how to supplant coal with renewables, but rather how to supplement existing energy sources with new sources and generate enough electricity to keep the lights on and the factories running.

The purpose of this report is to illuminate the opportunities and implications of China's current green initiatives for both energy security and carbon emissions. Our key findings are as follows: First, because of China's need for a cheap and abundant energy source, coal will remain the dominant energy source in the foreseeable future, even under the most optimistic scenarios. As such, carbon emissions as a policy issue will continue to take a backseat to energy security. Second, although renewable energy will barely make a dent in China's overall energy needs, the country's burgeoning green industries are likely to significantly impact global energy markets through learning and scale effects. Third and finally, the greatest contribution the international community can make toward reducing global carbon emissions is to help China devise methods to burn coal more efficiently and cleanly. Foreign criticism of – and energy proposals which ignore – China's reliance on coal is unproductive.

The rest of this report is organized as follows. First, we investigate the broader political and economic context of China's energy strategy. The legitimacy of China's authoritarian, single-party government is contingent on its ability to create jobs for and improve the living standards of average Chinese citizens. Therefore, the government's priority is on securing enough energy to feed the country's economic growth engine. Second, we examine China's current energy-related initiatives – including energy efficiency, economic restructuring, expansion of renewable sources, and electricity transmission – and assess the implications for both energy security and carbon emissions. Third, we reiterate China's continued reliance on coal as its primary energy source. China's present en-

1 Given the limited scope of this cross-country report, we confine our analysis to a narrower area of interest, defining green growth as job creation or economic growth compatible with or driven by actions to reduce greenhouse gas emissions. These summarize the types of growth that must be achieved in order to successfully support growth while simultaneously avoiding climate catastrophe. As such, we focus our attention on those Chinese policies that affect carbon

ergy goals represent an optimization of the current coal-based energy system, with non-fossil fuel energy sources largely acting as supplements, not substitutes, for coal.

2. Political and economic context of energy policy in China

"Green development" is an important theme in China's 12th Five Year Guidelines (FYG) for 2011-2015, the policy document which reveals the government's top economic and social objectives for the coming years. Responding to global climate change via mitigation and adaptation measures is a clearly stated goal in the green development plan. Yet China's targets for energy consumption reduction and carbon emission reduction are per unit of GDP, rather than absolute caps. Thus as the Chinese economy expands, the country's total energy consumption and carbon emissions will also grow, though the rate of that growth will be modestly slower.

Understanding the particular configuration of the China's political and economic system can help explain why there is little political will to either reduce China's reliance on fossil fuels such as coal or cap total emissions. During the reign of Mao Zedong, the Chinese Communist Party (CCP) derived its legitimacy through the banner of communism. With the winding down of communist ideology in China's reform period (1978-present), many argue that the ability to create jobs and continuously improve living standards has become the new source of legitimacy for the CCP. [2]

In recent years, public awareness and concern over environmental degradation and poor natural resource management have increased. But carbon emissions are a unique breed of environmental problem. Unlike deforestation, air pollution, and water pollution, carbon emissions have had little immediate and tangible effect on economic productivity or people's daily lives. In addition, while many scientists would argue that China's endemic problems of water shortage or desertification are the results of climate change, such claims are hard to "prove" to ordinary citizens. As a result, climate change has little obvious, immediate impact on Chinese living standards, and there has been little if any domestic pressure on the Chinese government to reduce carbon.

Energy security, however, has been a top government priority, because it is critical to driving the economy and creating jobs. The Chinese economic model has relied heavily on manufacturing-intensive industries which require an enormous amount of energy. The industrial sector is estimated to contribute to 46.8% of China's economy in 2010 (CIA 2011b), much higher than in other prominent industrializing and developing economies, such as 28.6% in India or 26.4% in Brazil (CIA 2011a; CIA 2011c). The dominance of steel, cement, electronics and other energy-intensive industries, coupled with double-digit GDP growth, has led to soaring energy demand in China.[3] China is currently the world's largest energy consumer.

Meanwhile, due to rising incomes and increasing urbanization, the Chinese are buying more homes, cars, and home appliances, all of which require energy to produce as well as to use. In its *World Energy Outlook 2010*, the International Energy Agency predicts that between 2010 and 2035, China's energy demand will increase by 75% (2010, 5). Equally alarming is the US Energy Information Administration's prediction that China's electricity generation alone will triple between 2009 and 2035, producing 10,555 billion kWh of electricity in 2035 (2010, 16). Though China has had a remarkable track record when it comes to improving energy efficiency, the 12th FYG's stated goal of reducing the energy intensity of GDP by 16% over the next five years is simply not enough to level off energy consumption.

China's Primary Energy Consumption, 2008

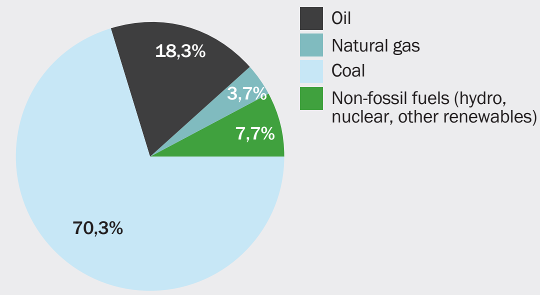


Figure 1: China's reliance on coal

MM **Source:** National Bureau of Statistics (2010, 2-7)

As figure 1 below shows, China's energy consumption relies heavily on low-cost and domestically abundant coal. According to the latest official data from its National Bureau of Statistics, China's total primary energy consumption measured 2.91 billion tons of standard coal equivalent in 2008, of which 70.3% came from coal.[4] Similarly, China's electricity production is also overwhelmingly reliant on coal. In 2008, 83.3% of China's electricity was generated by thermal power plants, which are mostly coal-fired with only a few natural-gas power plants. Hydroelectric power generated 13.8% of electricity. Nuclear power contributed 2.0% to the total generation, wind 0.8%, and all others such garbage incineration plants, solar energy, and geothermal power contributed 0.1% (State Electricity Regulatory Commission 2009, 10).

Despite massive infrastructure investments in recent years, renewable sources not including hydroelectric currently comprise only a tiny fraction of China's total energy consumption. Even if the Chinese government continues to commit billions of dollars of investment to the development of renewables and other non-fossil fuel energy sources, such installations are unlikely to significantly shift the composition of China's overwhelmingly coal-based energy system. In Section IV, we will further explain why, from the Chinese government's perspective, coal remains the only plausible candidate to satisfy China's energy demand.

To sum up, the legitimacy of China's single-party government rests largely on its ability to sustain economic

2 In his investigation of the Chinese political system, Guo (2003) suggests that this form of 'utilitarian legitimacy' is a powerful legacy from China's imperial era. Perry (2010) argues that this concept of utilitarian legitimacy justifies anti-government sentiments stemming from food, housing and other material necessities, which may in part explain why the CCP is more tolerant of protests over land and energy prices than those over religious and political freedoms. Utilitarian legitimacy also explains why the CCP places so much emphasis on sustaining high levels of economic growth, enhancing energy security, creating jobs, and controlling inflation.

3 Export industries and investment were largely responsible for the trend-breaking increase in energy intensity during the few years after China first entered WTO. According to Kharl and Roland-Hoslt's research, export and investment accounted for more than 70% of the growth of energy consumption between 2002 and 2004 (2009, 9).

4 These statistics only account for commercial fuel consumption; rural residents in China still rely heavily on biomass and waste fuels, which account for roughly 10% of total energy consumption according to the IEA (2010c).

growth and improve living standards. Environmental protection has become an increasingly salient social issue in the past few years, but the public's attention has mostly focused on those issues which directly affect economic productivity and living conditions. The issue of carbon emissions has not yet hit the radar of the average citizen, and thus little public pressure has been put on the government to reduce emissions. On the other hand, providing enough energy to sustain China's energy and manufacturing intensive economy is both a social and political priority. Indeed, meeting energy demand is the single most important objective of China's green development. In next section, we will show how Chinese government plans to meet the challenge of satisfying China' growing energy demand, and the opportunities and challenges for global climate change with China's green development plan.

3. Overview of China's energy policies: opportunities and challenges

It is our view that the key objective in the government's green development plan is to enhance China's energy security by moderating the growth of energy demand and at the same time increasing energy supply. Compared to a business-as-usual scenario, China's carbon emissions will grow at a slower rate as a result of these initiatives. Yet these initiatives alone are highly unlikely to lead to a reduction in China's *total* carbon emissions or even a full decoupling of emissions from growth in the next two decades.[5] The findings presented in this section suggest that:

- Energy efficiency programs will lower the energy intensity of GDP, but are not likely to reduce China's total energy demand or total carbon emissions.
- The government's economic restructuring efforts may eventually bear fruit, but are not likely to reduce energy demand or carbon emissions in the near term.
- China's burgeoning green industries will influence global energy markets through learning and scale effects, even though they will have little impact on China's primary energy mix.
- China's new and improved electricity transmission and distribution system will not only integrate new renewable sources into the state grid, but also incorporate new coal developments and other fossil fuel sources; thus, its effect on emissions is likely mixed.
- Electricity pricing reforms are required to rationalize energy usage, but such reforms have stalled due to the government's concern over inflation and social unrest.

We now turn to examine in greater detail each of these five aspects of China's current energy policy framework to explain how we arrived at the above conclusions. To reiterate, these five initiatives are energy efficiency, economic restructuring, expansion of renewables, electricity transmission, and electricity pricing reform.

3.1 Improving energy efficiency

The Chinese economy is very energy-intensive. In 2006, per unit of GDP, China consumed 48% more energy than the US and nearly twice as much compared to Japan or France (EIA 2008). The high energy intensity of the Chinese GDP is the result of a combination of factors, including but not limited to: inefficient technology, a manufacturing-driven export-led economy, and price controls that distort energy usage by industrial and residential consumers.

From the late 1970s to the late 1990s, China actually had a rather strong track record of reducing the energy intensity of its economic growth. But after China's accession to the World Trade Organization, manufactured exports began to soar, as did the energy intensity per unit of GDP. In order to curb this unwelcome trend, the Chinese government in 2004 began to adopt a number of policies to promote energy efficiency. Those policy measures included fiscal incentives such as tax breaks for purchasing energy conserving equipment, stricter standards for new buildings and appliance, mandated closures of inefficient coal-fired power plants and manufacturing plants, and information-driven programs like appliance labeling and media advertising (Zhou, Levine and Price 2010). Despite the blip in the early 2000s, the Chinese government has been remarkably successful with its energy efficiency programs.

The government has been particularly aggressive in closing small and inefficient power plants and producers of energy-intensive products. In 2007, the NDRC launched a "build big, close small" campaign to consolidate the number of coal-fired power plants. The following types of generators had to be shut down: those under 50,000kWh, those under 100,000kWh and in operation for more than 20 years, and those that do not satisfy existing environmental or efficiency standards. Between 2006 and 2010, China closed down 72.1GW of small coal-fired generators (Wen 2011). Many inefficient producers of coal, steel, concrete and coke were also closed down. This type of industrial upgrading has, and will continue to, improve energy efficiency in China.

Perhaps more importantly, the central government has signaled that it will begin to evaluate the performance of local officials based on their ability to meet not only economic growth targets, but also national energy intensity reduction targets. The 12th FYG states that the central government will strengthen evaluation of energy conservation goals and improve the reward and punishment system to ensure that local governments have the proper incentives to carry out energy efficiency policies (NDRC 2011, chapter 22 section 1).

From 2006 to 2010, the implementation of energy efficiency policies has helped China to reduce energy intensity by 19.1% from 2005 levels. This achievement was a little shy of the stated target of 20%, but nonetheless significant. However, there were severe unintended consequences of energy efficiency programs, particularly at the local level. Some local officials, struggling to meet the energy intensity reduction targets, scheduled brownouts

5 According to the latest forecasts by the China Energy Group at Lawrence Berkeley National Laboratory, China's emissions are likely to peak between 2030 and 2035. However, this result is based on the crucial assumption that China's average GDP growth rate between 2010 and 2020 will be 7.7%, considerably lower than the previous 10 years and in line with China's stated target, and even slower growth rates of 5.9% between 2020 and 2030 and 3.4% between 2030 and 2050 (Zhou et al. 2011, 3). This again demonstrates that compatibility between emissions reduction and economic growth not only requires aggressive policies, but also a much slower growth rate than what China is accustomed to.

which caused temporary shutdown of factories, schools, and hospitals. When the lights were turned off, manufacturers fired up diesel generators to compensate for the loss of electricity from the grid. Such actions had the perverse effect of driving up diesel prices and ultimately food prices (Xinhua 2010), not to mention promoting an uncontrolled source of energy and emissions in the form of off-grid diesel generation. The use of ad hoc measures – brownouts, shutdowns, off-grid generation, etc. – suggests that China was pushing close to its practical limit of energy intensity reduction under the current policy framework.

Though the central government gave no specific reason for lowering the energy intensity reduction target in the 12th FYG to 16% from the 20% target in the 11th FYG, it likely did so to limit these types of unintended consequences at the local level. A lower target will hopefully preclude local officials and manufacturers from taking drastic and disruptive measures to reduce energy consumption. And given China's proven track record on energy efficiency, a 16% reduction in energy intensity appears achievable under the current policy framework.

3.2 Restructuring the economy

One of the goals of economic restructuring is to decrease the relative importance of the industrial sector in the economy while increasing the share of the service sector, and thereby slow the growth of energy demand. The Chinese government has often discussed the need for economic restructuring in order to achieve a more balanced and sustainable economic development and mitigate the depletion of China's limited natural resources. Nonetheless, at present, the Chinese economy is still heavily reliant on manufacturing and energy intensive industries.

The 12th FYG lays out various policies to promote less energy-intensive industries. The document states that the government should severely control the export of energy-intensive, pollution-intensive goods and natural resources and promote the export of services and service-related products such as cultural products, Chinese medicine, software, and information technology (NDRC 2011, Chapter 51 Section 1). The 12th FYG also calls for a 4% increase in the share of services in the economy (NDRC 2011, chapter 3), which was about 43.6% in 2010 (Central Intelligence Agency 2011). In part to meet this goal, the government is offering firms in the service sector the same rates for water, electricity and natural gas currently enjoyed by firms in the industrial sector (NDRC 2011, chapter 17 section 2).

How quickly the large Chinese economy can shift away from energy-intensive, export-oriented manufacturing and large infrastructure investments and toward increased services and domestic consumption is open for debate. Though the government's intentions are clear, it has yet to put forth a detailed and actionable plan to facilitate the restructuring of the Chinese economy, beyond the shift in resource pricing noted above. In our view, a significant transition away from energy-intensive industries such as steel and cement, not to mention downstream sectors like building and rail construction, to more services could take decades.

3.3 Growing renewable energy

In the past few years, renewable energy, especially wind, has witnessed explosive growth in China. As of 2010, the country had a total of 25.8GW of installed wind capacity, second only to the United States in absolute terms. More than half of that capacity, 13.8GW, was added in 2009 alone (GWEC 2011, 4). China has become a huge market for renewable technology deployments, which has enticed the participation of the world's leading energy companies. At the same time, China's own green industries – particularly solar panel production – have themselves become globally competitive players.

The two national grid companies are required by law to purchase energy from wind and solar farms at higher rates, which will ensure that renewable power plants can cover their cost and maintain a profit margin.

The current build out of renewable energy infrastructure in China will likely continue on the back of stronger policy support. The two national grid companies are required by law to purchase energy from wind and solar farms at higher rates, which will ensure that renewable power plants can cover their cost and maintain a profit margin. This pricing policy allows the nascent wind and solar industries to expand despite being more expensive than conventional energy. China's major power producers, especially the five firms known domestically as the "Big Five," have been in negotiations with local governments to secure rights on land and at sea to develop new renewable resources. Ocean front investment agreements from the Big Five can exceed RMB 100 billion (USD $15 billion) in committed funds (Zhang 2010a). This shows the scale of some of the investment in renewable energy. Similarly, there has been a wave of land deals in western China's vast deserts with high solar potential (Dong 2009). Numerous hydroelectric projects are also on the drawing board. China's grid companies are also investing in a new transmission system that will help overcome current transmission bottlenecks and facilitate the integration of renewable sources into the grid.

Renewables have the benefit of being zero emission, but that is not the primary reason for the government's massive investments. Rather, investing in alternative energy resources is desirable because such investments allow China to both diversify its energy portfolio and expand its domestic energy supply. The reality is that the expansion of renewables along with other non-fossil fuel sources like nuclear will not have a large impact on China's energy landscape or emissions. Not only is the government's target of 15% non-fossil fuels in the primary energy consumption by 2020 rather modest, but a majority of that 15% will come from hydroelectric power (Zhou 2010).

Despite the limited impact renewables will have on China's domestic energy mix, China's domestic green industries are booming. China's green firms enjoy many advantages: a large domestic market with potential for scale, cheap labor, an extensive electronics supply chain; as well as price supports, state-subsidized loans, and cooperation from local governments. China's wind turbine and solar cell producers are already some of the most competitive in the world. China's solar industry has enjoyed an annual growth rate of more than 100% for the past five years, and produced more than half of the world's photovoltaic cells in 2010 (SEMI, PV Group and CPIA 2011, 6). Several of the world's leading solar equipment companies, such as Suntech Power, Yingli Green Energy and JA Solar, are headquartered in China. Similarly, China was the world's largest producer of wind turbines in 2009 (Bradsher 2010), led by the state-owned Sinovel, the second largest wind turbine manufacturer in the world in 2011 (Xinhua 2011). Industry experts are finding that Chinese solar firms are contributing to the falling prices of photovoltaic cells (SEMI, PV Group and CPIA 2011). The manufacturing scale advantage of Chinese green industries has the potential to lower global equipment prices and hence reduce the costs of renewable energy installations around the world.

Yet China's green industries are not the only ones benefitting from China's investment in renewable energy. Many foreign technology firms are also winning contracts to provide equipment and services in China. In 2009, American firm First Solar signed a memorandum of understanding with the Chinese government to build a sprawling, 2GW solar power field in Inner Mongolia (Daily 2009). In 2010, General Electric signed contracts to supply 88 wind turbines to HECIC New Energy Co., Ltd, one of China's leading wind energy developers, for three new projects in Hebei and Shanxi Provinces (General Electrics 2010). These are only two of many examples of the many foreign firms participating in Chinese domestic market for clean energy. Experience, learning, and scale gained from playing in the large Chinese market could also help these firms grow and bring costs down.

Given the Chinese government's long-term commitment to renewables, it should be able to reach its 15% non-fossil fuel target by 2020, but the impact on total carbon emissions will likely be marginal.

3.4 Ultra-high voltage transmission grid

One of the most important enablers of the continual growth of non-fossil fuel energy will be the ultra-high voltage (UHV) transmission grid currently under construction. Grid connectivity and long-distance transmission have been two of the greatest obstacles to expanding renewable energy in China. The majority of China's hydroelectric, wind and solar energy resources are located in western and northern regions, far away from the regions where energy demand is the greatest (State Grid 2010). As might be expected, the regions where renewable opportunities are the greatest are also those in which grid networks are the weakest (GWEC 2011).[6] Lack of transmission capacity in part explains why a shocking 30% of China's wind generation capacity is not connected to a power grid of any kind (Xinhua 2010b).

To overcome the transmission bottleneck, the State Grid, China's largest transmission and distribution company, is building a new UHV transmission grid that is scheduled to be completed by 2020. By 2015, there will be seven long distance, alternate current UHV transmission lines, as well as eleven 800kV direct current UHV transmission lines. Together these lines are capable of transmitting electricity across a distance of more than two thousand kilometers, linking renewable energy resources in northern and western China to load centers in the east (State Grid 2010, 28; Zhang 2010b). The new UHV transmission grid will enhance the expansion of renewable energy by providing access to new markets and strengthening the grid's capacity to accept intermittent renewable power. State Grid predicts that in 2015 the grid will be able to accommodate three times more clean energy sources compared to 2005 (2010, 53). Less talked about, however, is the fact that this same UHV transmission grid will also expand the transmission capacity and reach of coal-fired electricity plants.

3.5 Electricity pricing reform

Unlike the market liberalization that occurred in other areas of the Chinese economy, much of the energy sector remains under heavy state control. While prices for petroleum and natural gas have been allowed to move more or less with global prices, the government continues to tightly control electricity prices for residential and some industrial users. Electricity subsidies distort the market and may prove to be one of the greatest obstacles to reducing energy use and overall energy intensity in China.

The price of energy inputs and retail energy prices are set by China's National Development and Reform Commission (NDRC), the main agency in charge of national economic policy. The NDRC has always been reluctant to raise utility rates, despite the fact that market-based coal prices have climbed precipitously due to China's exploding energy demand. The average price of coal at Qinhuangdao port, a major coal terminal in China, increased from roughly US$60 per metric ton in early 2005 to US$160 per metric ton at the height of energy prices in 2008 (Morse and He 2010, 7). During the same period, there were only one or two modest electricity rate hikes per year, and not a single adjustment exceeded 5%. Chinese power producers and grid companies have been squeezed between rising coal prices and state-controlled retail prices, often suffering huge losses. Rather than allowing electricity prices to rise, the NDRC and other government agencies have supported state-owned utilities and grid companies by helping them negotiate for lower coal prices, or in some cases, by offering government hand-outs to compensate for losses.

Another problem with subsidized electricity prices is that they may encourage residential and industrial users to consume more energy than they otherwise would under market-driven prices. This makes lowering emis-

6 For example, the province of Inner Mongolia, where the majority of China's wind resources is located, has an independent regional power grid and is not connected to the rest of China. Consumers in Inner Mongolia alone do not provide sufficient demand to digest all the wind energy, and distant demand from other parts of China cannot be satisfied with this supply due to the lack of transmission infrastructure. Thus despite that wind energy from Inner Mongolia is already cheaper than thermal electricity produced in eastern and southern China, this cheap, clean energy cannot reach consumers and generation capacity is often forced to remain idle (Xin 2010).

sions or per-capita/per-unit GDP energy use more difficult. Price supports may also make China a less effective "nursery" market for new efficiency products that Chinese firms could eventually export to the rest of the world. If such distortions cannot be removed, then efforts to reduce energy intensity may be limited. The NDRC has expressed its intent to adjust electricity prices. For example, the NDRC is planning to introduce tiered rates for residential users in order to promote conservation (Liu and Huang 2010). But as a new round of inflationary fears grip China, increasing energy prices may continue to be socially and politically unpalatable.

4. China's continued reliance on coal

Though China's renewable energy sources are expanding, one cannot ignore the stark reality that China's energy system will continue to rely on coal as its primary energy input for the foreseeable future. As discussed in Section II, the Chinese government's top priorities are to maintain the economic growth engine and to improve living standards, both of which require a cheap and secure supply of abundant energy. Coal is not only relatively inexpensive compared to other energy sources, it is also plentiful in China. In countries that lack large domestic sources of fossil fuels (especially coal), such as Denmark and Korea, the need for energy security naturally overlaps with the need to develop non-fossil fuel energy sources. However, in countries where fossil fuels like coal are abundant, such as the US and China, the need for energy security often means exploiting available domestic sources first.

As such, the government is not likely to reduce the use of coal, despite its contribution to atmospheric greenhouse gases. Indeed, it may not be possible to do so without creating major economic disruption.

According to several estimates, China has 114.5 billion tons of proven coal reserves, or 14% of the world's total reserve (EIA 2008; Morse and He 2010).[7] China is capable of satisfying most of its own coal demand, though some provinces do import coal when international coal prices are more competitive than domestic prices. Not only does China have domestic coal sources, it is also situated near a number of other large coal-rich countries, including Mongolia, Russia, and Australia. From the Chinese government's perspective, coal's abundance and relatively low costs make it the best option to satisfy China's rapidly expanding energy demand. As such, the government is not likely to reduce the use of coal, despite its contribution to atmospheric greenhouse gases. Indeed, it may not be possible to do so without creating major economic disruption.

The government is actively seeking ways to mine and burn coal more efficiently, safely, and cleanly. These measures address economic efficiency as well as energy efficiency and local pollution. As mentioned earlier, China is overhauling its fragmented coal mining industry via closure of small mines as well as merger and acquisition.[8] The 12th FYG emphasizes consolidation in coal mining industry to create large, efficient mining conglomerates (NDRC 2011, chapter 11 section 1). More efficient mines can better enforce safety and environment standards for local pollution, but they also produce cheaper coal, which may lead to increased use of coalThe Chinese government is also actively closing down small coal-fired power plants and installing larger, 600MW and higher power plants that produce less pollution, including CO-2 emission, per unit of energy produced (Yang, Guo and Wang 2010).

Improving the efficiency of coal is also intimately tied to the UHV transmission grid mentioned earlier. The use of coal has been somewhat constrained by the transportation capacity between coal producing areas and eastern regions where energy demand is greatest. Currently, coal is transported from mines in northwestern China to coal-fired power plants in the eastern seaboard via railroads, or first via rail to a northern seaport, then via boats to southern cities. In 2008, 49% of the freight cargo by weight traveling on national railroads and 21% of China's total port throughput were coal, most of which was destined for power plants (NBS 2009, 15-20; State Grid 2010).[9] Thus the transportation of coal is one of the greatest bottlenecks for meeting energy need in China. The new UHV grid will allow more coal-fired power plants to be built where the coal is mined, and electricity can be sent to load centers on a new long-distance transmission network. This can also reduce the energy used and emissions resulting from the transport of coal. Producing electricity where coal is mined will also allow the exploitation of lignite. Nearly 55% of China's coal deposit is lignite, but because lignite loses too much heat content during long transportation, these resources have not been used in every coal-fired power plant. With the new ability to place power plants where the mines are, this low grade coal can be fully exploited (State Grid 2010, 34).

Vertical integration of mining, transport, power generation and chemical industries is also being promoted to by the government to optimize China's energy industry and other related industries. Such vertical integration will allow firms to operate more efficiently. Coal mines are encouraged to own and operate railroads and ports to facilitate the transportation of their products, as well as have on-site power plants. A policy document from the NDRC and approved by State Council calls for local governments to give priority approval to coal mines planning to build on-site power plants (State Council 2010). According to a newspaper published by the NDRC, there are fourteen coal production bases planned for the next five years, all of which will have on-site power plants (Diao 2010).

Alongside these measures to expand coal-fired power plants in coal-producing regions, China is also expanding transport capacity between coal producing regions and southern and eastern China, where the demand is the greatest. Rail transport in eastern China will be ex-

7 Recent explorations show that China has 1,275 trillion cubic feet of shale gas reserve, 12 times the size of its natural gas reserve (EIA 2011, 4). As of 2009, only 3.9% of China's primary energy consumption comes from natural gas (National Bureau of Statistics 2011, 7-2). If exploitation of shale gas can prove to be economical, then share of gas in China's energy portfolio may increase given the abundance of the resource. While natural gas is still a fossil fuel and produces greenhouse gases, its carbon content is 45% less than that of coal (EIA 2010, 7) and increased use of natural gas will help China lower its carbon intensity.

8 For example, in the major coal producing province of Shanxi, restructuring has slashed the number of operating mines from 2600 to 1053; all mines with annual production less than 300,000 tons were closed, and 70% of the remaining mines produced more than 900,000 tons every year (Nie 2010).

9 China's highway systems are also overburdened by the transportation of coal, as well known episodes of monster traffic congestions can attest. The 60 miles long monster traffic jam on the Beijing-Tibet highway in the summer of 2010 was due mostly to trucks carrying coal from Inner Mongolia to the capital, and the truckers say they are used to such congestion (Ni and Chua 2010; Watts 2010).

panded (Diao 2010), and new railroads connecting Inner Mongolia, Shanxi and central China will also be developed. In addition, coastal ports are being constructed to facilitate more north-south coal transport via sea lanes (Zhen and An 2011).

The wild card in China's carbon story is carbon capture and sequestration (CCS). In order to reduce the carbon intensity of coal, the government is actively exploring CCS. In the mid-2000s, the government did not consider CCS a serious option. Yet by mid-2009, China's first near-zero-emission coal plant had won state approval. Other pilots are in the works, including one in Inner Mongolia that could be the largest sequestration project in the world (Friedman 2009). However, it is yet unclear how much CCS projects will cost to build and operate, what the environmental consequences might be of putting tons of CO2 into the ground, or what the ultimate impact will be on China's total carbon emissions.

These large infrastructure investments throughout the domestic coal supply chain indicate that the Chinese government considers coal a vital part of the country's energy future. Indeed, if the Chinese government continues to be compelled to supply the growing domestic economy with cheap energy inputs, coal appears the only viable option. The continued reliance on coal has detrimental consequences for global greenhouse gas emissions.

5. Conclusion

China's version of "green growth" is drastically different from much of the advanced industrialized world. The government's prioritization of energy security over carbon emissions is driven in part by China's stage of development – it is still a developing country – and in part by the nature of its political system. China's single-party government maintains its legitimacy and political power by improving living standards, which in turn requires sustaining high rates of economic growth, creating tens of millions of new jobs every year, and controlling inflation. Coal, a relatively inexpensive and domestically abundant energy source, has been –and will continue to be—an important enabler of China's prosperity. The looming question for China is not how to reduce its consumption of coal but rather how to use it more efficiently and cleanly. Because of the rapid pace at which China's overall energy demand is growing, renewables are viewed as desirable supplements to – but not viable substitutes for—coal.

The magnitude of the energy and environmental challenges facing China is unprecedented. On the one hand, the government is attacking the country's mounting energy problems on multiple fronts: energy efficiency, economic restructuring, investment in non-fossil fuels, and expansion of transmission capacity. All of these measures are designed to slow the growth rate of energy demand and increase the supply of energy. As a result, the growth rate of carbon emissions will also slow. To its credit, China appears to be on a path that will enable it to meet its target of reducing the carbon intensity of its economy by 40 to 45% by 2020 from 2005 levels.

On the other hand, significant obstacles remain, the most serious of which are distorted incentives at the local level, the difficulty of retail pricing reform, and the energy intensity of the manufacturing-driven economy. Without a solution to these issues, the improvements in energy efficiency and carbon intensity resulting from the 12th FYG's green initiatives alone can do little to prevent China's overall carbon emissions from growing. Rather, China's green initiatives will only slow the pace of emission growth. We calculate that even if China meets its goal of reducing carbon intensity by 40% to 45% and economic growth slows down to an average rate of 7% per year for the next ten years, its total emissions would still increase 83.7% by 2020 from 2005 levels. If China meets its carbon intensity reduction targets but grows at an average of 10% per year, which has been its average growth rate during the past two decades, then its total emissions would increase 142.2% by 2020 from 2005 levels. Despite its genuine efforts to curb the energy and carbon intensity of its economy, China's carbon emissions are unlikely to plateau until 2030 (Zhou et al. 2011).

The fate of China's greenhouse gas emissions may rest with a yet elusive technological solution to de-carbonize coal. There is ample opportunity for international cooperation in the advancement of emerging technologies like carbon capture and sequestration. The European Union, for example, pledged up to €50 million (US$70 million) in mid-2009 to help China build the near-zero-emission coal plant mentioned earlier. Partnerships like this will be crucial in the global effort to combat climate change. If China in collaboration with concerned members of the international community cannot figure out how to safely and cheaply de-carbonize coal, then the planet may have no choice but learn how to adapt to a warmer world.

Works Cited

A Anderson, Jonathan. "Solving China's Rebalancing Puzzle: Market forces will do the trick 'naturally'." Finance and Development 44, no. 3 (2007): 32-35.

Arrow, Kenneth et al. "Economic growth, carrying capacity, and the environment." Environment and Development Economics 1, no. 1 (1996): 104-110. DOI: 10.1017/S1355770X00000413.

Barboza, David. "China Passes Japan as Second Largest Economy." New York Times, August 15, 2010. http://www.nytimes.com/2010/08/16/business/global/16yuan.html

Beijing Electric Power Company. "Beijing shi dianwang xiaoshou dianjia biao [Beijing City Utilities Rates Chart]." Zhongguo Dianli Xinxi Gongkai Wang [China Power Industry Information Network], July 28, 2010. Accessed April 22, 2011, http://www.12398.gov.cn/html/information/201008011/201008011201000005.shtml

Bradsher, Keith. "China is Leading the Race to Make Renewable Energy." New York Times, January 30, 2010. http://www.nytimes.com/2010/01/31/business/energy-environment/31renew.html.

Broder, John M. "Countries Submit Emission Goals." New York Times, February 1, 2010. http://www.nytimes.com/2010/02/02/science/earth/02copenhagen.html?_r=1.

Central Intelligence Agency. The World Factbook, Brazil. Washington D.C.: CIA, 2011a. https://www.cia.gov/library/publications/the-world-factbook/geos/br.html.

Central Intelligence Agency. The World Factbook, China. Washington D.C.: CIA, 2011b. https://www.cia.gov/library/publications/the-world-factbook/geos/ch.html.

Central Intelligence Agency. The World Factbook, India. Washington D.C.: CIA, 2011c. https://www.cia.gov/library/publications/the-world-factbook/geos/in.html.

Daily, Matt. "First Solar to build huge Chinese solar plant." Reuters, September 8, 2009. http://www.reuters.com/article/2009/09/08/us-firstsolar-idUSTRE5874XC20090908.

Diao, Cui. "Shierwu meidian buju moubian, yunshu pingjing youjie [Coal and power industries seek change in the twelfth five-year guidelines; potential solution for transport bottleneck]." Zhongguo Jingji Daobao [China Economic Herald], November 6, 2010. http://www.ceh.com.cn/ceh/jryw/2010/11/6/70997.shtml

Dong, Lilin. "Guangfu fengkuang quandi duojinggui guosheng jinbao zhouxiang [PV industry enclosure fervor; alarm of polycrystalline silicon overcapacity is sounded]. " Jingji Guancha Bao [The Economic Observer], August 30, 2009. http://business.sohu.com/20090830/n266321956.shtml

Energy Information Administration. "International Energy Annual 2006." EIA database, Department of Energy, Washington D.C., 2008. http://www.eia.gov/emeu/iea/contents.html.

Energy Information Administration. "U.S. Carbon Dioxide Emissions in 2009: A Retrospective Review." Review, EIA, Department of Energy, Washington D.C., 2010. http://www.eia.doe.gov/oiaf/environment/emissions/carbon/.

Energy Information Administration. "World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States." Independent Statistics & Analysis from EIA, Department of Energy, Washington D.C., 2011. http://www.eia.gov/analysis/studies/worldshalegas/.

Fan, Sili. "1000 qianqu tegaoya gongcheng zhuanzheng [1000kV ultra-high voltage project becomes official]." Zhongguo Jingji Shibao [China Economic Times], August 13, 2010. http://www.sgcc.com.cn/ztzl/tgyzl/mtbb/229870.shtml.

Fang, Jiaxi. "Xin nengyuan qiche chanye luxiantu qiaoding [Roadmap for new energy vehicles confirmed]." Jingji Cankao Bao [Economic Consultation], April 7, 2011. http://gd.people.com.cn/GB/123946/14334482.html

Friedman, Lisa. "A Sea Change in China's Attitude Toward Carbon Capture." New York Times, June 22, 2009. http://www.nytimes.com/cwire/2009/06/22/22climatewire-a-sea-change-in-chinas-attitude-toward-carbo-94519.html.

General Electrics. "China Selects GE Technology Again to Support Rapid Growth in Wind Energy Sector." Press release, January 12, 2010. http://www.gepower.com/about/press/en/2010_press/011210.htm.

Guo, Baogang. "Political legitimacy and China's Transition." Journal of Chinese Political Science 8, no. 1-2 (2003): 1-25.

Han, Zhang. "Trees fell subway." Global Times, April 11, 2011. http://special.globaltimes.cn/2011-04/643196.html.

International Energy Agency. World Energy Outlook 2009. Paris, France: IEA, 2009. http://www.worldenergyoutlook.org/2009.asp.

International Energy Agency. World Energy Outlook 2010 Executive Summary. Paris, France: IEA, 2010. http://www.worldenergyoutlook.org/docs/weo2010/WEO2010_es_english.pdf.

International Energy Agency. "Share of total primary energy supply in 2008, People's Republic of China." IEA Energy Statistics, IEA, Paris, France, 2010c. http://www.iea.org/country/n_country.asp?COUNTRY_CODE=CN

Li, Junfeng, Pengfei Shi, and Hu Gao. "China Wind Power Outlook 2010." report for Global Wind Energy Council, Brussels, Belgium, 2010. http://www.gwec.net/index.php?id=169&L=0.

Liu, Yang and Hua Huang. "Jieti dianjia lunwei zhangjia fangan [Has tiered-pricing turned to a rate hike]?" Guoji Jinrong Bao [International Finance News], October 26, 2010. http://finance.people.com.cn/GB/13046646.html.

Kharl, Fredrich and David Roland-Holst. "Growth and structural change in China's energy economy." Energy 34, no. 7 (2009): 894-903.

Morse, Richard K., and Gang He. "The World's Greatest Coal Arbitrage: China's Coal Import Behavior and Implications for the Global Coal Market." Working Paper #94, Freeman Spogli Institute for International Studies, Stanford University, Pala Alto, CA, 2010. Accessed April 2, 2011, http://pesd.stanford.edu/publications/the_worlds_greatest_coal_arbitrage_chinas_coal_import_behavior_and_implications_for_the_global_coal_market/

National Bureau of Statistics of China. China Statistical Yearbook 2009. Beijing: China Statistics Press, 2009. http://www.stats.gov.cn/tjsj/ndsj/2009/indexeh.htm

National Bureau of Statistics of China. China Statistical Yearbook 2010 Beijing: China Statistics Press, 2010. http://www.stats.gov.cn/tjsj/ndsj/2010/indexeh.htm

National Development and Reform Commission of China. Guojia fazhangaigewei guanyu zuohao 2007 kuashengqu meitan chanyunxu xianjie gongzuo de tongzhi [Announcement from the NDRC on management of inter-provincial coal production and transportation for 2007]. Fagai Yunxing[2006]2867. Beijing, China: NDRC, 2006. Accessed March 21, 2011, http://law.baidu.com/pages/chinalawinfo/8/26/5c4f97b003e8d4f84b592f91d315bc5f_0.html

National Development and Reform Commission of China. Guojia fazhangaigewei guanyu wanshan fengli fadian shangwang dianjia zhengce de tongzhi [Announcement from the NDRC on improving pricing policies for wind power]. Fagai jiage[2009]1906. Beijing, China: NDRC, 2009. Accessed Mach 21, 2011, http://www.sdpc.gov.cn/zcfb/zcfbtz/2009tz/t20090727_292827.htm.

National Development and Reform Commission of China. Zhonghuarenmingongheguo guomin jingji he shehui fazhan di shierge wunian guihua gaoyao [The Twelfth Five-Year Guidelines of Economic and Social Development in People's Republic of China]. Beijing, China: NDRC, 2011. Accessed April 16, 2011, http://politics.people.com.cn/GB/1026/14159537.html

National People's Congress of China. Zhonghuarenmingongheguo kezaisheng nengyuan fa xiuzhen [Revision of Renewable Energy Act of People's Republic of China] . Beijing, China: NPC, 2009. Accessed April 16, 2011, http://www.npc.gov.cn/huiyi/cwh/1112/2009-12/26/content_1533216.htm

Ni, Vincent, and Baizhen Chua. "Chinese demand for coal spurs 9-day traffic jam on expressway." Business Week, August 24, 2010. http://www.businessweek.com/news/2010-08-24/chinese-demand-for-coal-spurs-9-day-traffic-jam-on-expressway.html.

People's Daily Online. "Number of pure electric vehicles in Beijing to reach 100,000 by 2015." People's Daily Online Reports, April 8, 2010. Accessed May 6, 2011, http://english.peopledaily.com.cn/90001/98649/7344880.html

Perry, Elizabeth J. "Challenging the Mandate of Heaven: popular protests in modern China." Critical Asian Studies 33, no. 2 (2001): 163-180.

SEMI, PV Group, and CPIA. "2011 Zhongguo guangfu chanye fazhan baogao [2011 Report of China's photovoltaic industry]." China PV Industry Association, Changzhou, China, 2011.

State Council. Guowuyuan pizhuan fazhangagei, nengyuanban guanyu jiakuai guanting xiaohuodian jizu ruogan yijian de tongzhi [State Council's approval of suggestions from National Development and Reform Committee and Energy Department on accelerating the closure of small thermal power-generating units]. Guofa[2007]2 . Beijing, China: State Council, 2007. Accessed March 21, 2011, http://www.gov.cn/zwgk/2007-01/26/content_509911.htm

State Council. Guowuyuan bangongting zhuanfa fazhangaigeiwei guanyu jiakuai tuijin meikuang qiye jianbing chongzu ruogan yijian de tongzhi [State Council Office's forwarding of suggestions from National Development and Reform Committee on accelerating the merger and reorganization of coal mining corporations]. Guobanfa[2010]46. Beijing, China: State Council, 2010. Accessed March 21, 2011, http://www.gov.cn/zwgk/2010-10/21/content_1727160.htm

State Electricity Regulatory Commission of China. Dianli Jianguan Niandu Baogao 2009 [Annual Report of Power Industry 2009]. Beijing, China: SERC, 2010.

State Grid Corporation of China. Guojia Dianwang Lüse Fazhan Baipishu [State Grid White Paper on Green Development]. Beijing, China: State Grid, 2010.

Stern, D. "Economic growth and environmental degradation: The environmental Kuznets curve and sustainable development." World Development 24, no. 7 (1996): 1151-1160. DOI: 10.1016/0305-750X(96)00032-0.

United Nations Statistics Division. "Environmental Indicators, Greenhouse Gas Emissions." UNSD database, United Nations, New York, 2010. Accessed April 17, 2011, http://unstats.un.org/unsd/environment/air_co2_emissions.htm.

United States Geological Survey. Mineral Commodities Summary 2008. Washington D.C.: USGS, Department of the Interior. 2008. http://minerals.usgs.gov/minerals/pubs/mcs/2008/mcs2008.pdf.

Wang, Zhaokun. "Zhongguo meitanye jianci jinru quyu jiegou tiaozheng shidai [China's coal industry gradually moves into era of regional structural adjustment]." Xinhua, March 25, 2010. Accessed March 21, 2011, http://finance.people.com.cn/GB/11219660.html.

Watts, Jonathan. "China's mega-jams show the true cost of coal." Guardian Environment Blog, August 25, 2010. Accessed March 22, 2011, http://www.guardian.co.uk/environment/blog/2010/aug/25/china-mega-jams-coal.

Wen, Jiabao. "Zhengfu gongzuo baogao [Report on government's work]. " Presentation at the 4th plenary session of the 11th National People's Congress, Beijing, China, 2011. Accessed April 5, 2011, http://2011lianghui.people.com.cn/GB/214393/14152063.html

World Bank. World Development Indicators. Washington D.C.: World Bank, 2011. Accessed April 10, 2011, http://data.worldbank.org/country/china.

World Nuclear Association. "World Nuclear Power Reactors & Uranium Requirement." April 1, 2011. Accessed May 16, 2011, http://www.world-nuclear.org/info/reactors.html.

World Steel Association. Steel Statistical Yearbook 2009. Brussels, Belgium: World Steel Association. 2010. Accessed May 16, 2011, http://www.worldsteel.org/index.php?action=stats_search.

Xin, Yang. "Fengdian weihe 'songbuchu' [Why can't wind power be sent out]?" China Daily, April 6, 2010. http://www.chinadaily.com.cn/hqcj/2010-04/06/content_9688874.htm?navigation=1.

Xinhua. "Energy reduction policies cause unexpected Diesel shortage in China." Global Times, November 7, 2010. http://business.globaltimes.cn/industries/2010-11/590017.html.

Xinhua. "Sinovel becomes world's No. 2 wind turbine maker." China Daily, April 7, 2011a. http://www.chinadaily.com.cn/bizchina/2011-04/07/content_12285567.htm.

Xinhua. "China drafting new rules for small wind farm projects." China Daily, April 11, 2011b. http://www.chinadaily.com.cn/bizchina/greenchina/2011-04/11/content_12304788.htm.

Yan, Fang, and Ken Wills. "China car sales set to grow after record 2010." Reuters UK, January 10, 2011. http://uk.reuters.com/article/2011/01/10/retire-us-china-autos-idUKTRE70926X20110110.

Yan, Pengfei. "Waizi cheli zhongguo dianli shichagn [Foreign investors leave China's utilities market]." Zhongguo Jingji Caifu [China Economics and Fortune], March 2005, 24-31.

Yang, Yongping, Xiyan Guo, and Ningling Wang. "Power generation from pulverized coal in China." Energy 35, no 11(2010): 4336-4338.

Zhang, Chao. "Fengdian quanhai: touzi huanyan zhong de xinyilun channeng guosheng [Wind power's ocean enclosure: another round of over capacity in an investment feast]? " Caijing Guojia Zhoukan [Economy & Nation Weekly], April 23, 2010a. http://www.chinapower.com.cn/newsarticle/1117/new1117864.asp.

Zhang, Yi. "Xibu zuida tegaoya dianli tieta jidi luohu liangjiang xinqu [Largest ultra-high voltage transmission tower construction facility comes to the new zone of Chongqing]." Renminwang Chongqing Shichuang [People's Daily Network Chongqing], December 1, 2010b. Accessed April 5, 2011, http://cq.people.com.cn/news/2010121/201012192546.htm.

Zhen, Xiaoyi, and Pei An. "Rang nengyuan dongmai gengjia changtong----shierwu nengyuan yunshu tongdao jianshe xin kandian [Let energy flow more freely: what to look for in energy transport routes in the twelfth five-year guidelines]." Xinhua, March 25, 2011. Accessed April 17, 2011, http://news.xinhuanet.com/politics/2011-03/25/c1212324772.htm.

Zhou, Nan. "Wen Jiabao: baozhang nengyuan gongji anquan, zhichi jingji shehui fazhan[Wen Jiabao: ensure energy supply, support social and economic development]. " Xinhua, April 22, 2010. http://news.xinhuanet.com/politics/2010-04/22/c_1250122.htm.

Zhou, Nan. "Wen Jiabao: baozhang nengyuan gongji anquan, zhichi jingji shehui fazhan[Wen Jiabao: ensure energy supply, support social and economic development]. " Xinhua, April 22, 2010. Accessed May 5, 2011, http://news.xinhuanet.com/politics/2010-04/22/c_1250122.htm.

Zhou, Nan et al. "China's Energy and Carbon Emissions outlook to 2050." LBNL-4472E, Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, CA, 2011. http://china.lbl.gov/publications/Energy-and-Carbon-Emissions-Outlook-of-China-in-2050

BRAZIL
A COUNTRY CASE ANALYSIS

June 15, 2011

Prepared by Benjamin Allen

Deforestation's challenge to green growth in Brazil

1 Introduction

Understanding Brazil's green growth and emissions story requires a second look. Brazil's energy matrix is approximately 46% renewable, so when one compares the share of greenhouse gas (GHG) emissions from energy in Brazil to that of most OECD countries, Brazil is doing relatively well (IPEA 2010, 133). However, looking at energy alone misses the core GHG story in Brazil: The principal drivers of GHG emissions in the country are not energy production or heavy industry, but rather deforestation and agriculture. Deforestation is responsible for about 55% of Brazil's GHG emissions, and agriculture for another 25% (McKinsey & Company 2009, 7). In fact, the two areas of emissions are intimately linked: deforestation is principally a problem of agriculture. Cattle ranching and soybean and sugar cane farming are the major industries contributing to Brazil's emergence today as an agricultural and agroenergy superpower – and are directly and indirectly responsible for deforestation in Brazil's largest forests, the Amazon and Atlantic (Banco Mundial 2010, Barros 2009, Margulis 2004, McAllister 2008b, Nassar 2009, Nepstad et al. 2008, Sennes and Narciso 2009). By extension, because Brazil's large and growing renewable energy sector is principally based on agriculture, it has ties to deforestation and may not be as green as it first appears.

In short, the problem of deforestation cuts across several of Brazil's fastest growing economic sectors, including renewables.

Brazil therefore faces contradictory imperatives on the road to green growth: First, cattle ranching and soybean farming revenues – which contributed 25% to Brazil's gross domestic product (GDP) in 2008 – risk being squeezed by enforcement of legal restrictions on cultivation and grazing in the Amazon forest.[1] Second, Brazil's energy grid has a comparatively high proportion of renewables in it, but each major renewable – sugar cane-based ethanol, biodiesel, and hydropower – comes at some cost to forests and biodiversity because of its extensive land use. In short, the problem of deforestation cuts across several of Brazil's fastest growing economic sectors, including renewables. As a result, the potential for divergence between "greenness" and "growth" in the Brazilian case is particularly great. The analysis below explores this problem in greater depth.

This study examines the problems of deforestation-related GHG emissions and green growth in Brazil in cattle ranching and agriculture; sugar cane-derived ethanol and other biofuels; and in hydropower. Section 2 begins this analysis by discussing Brazil's GHG emissions profile in greater depth, detailing the contributions made by deforestation, agriculture, and energy. Section 3 shows how ranching and agriculture contribute to Amazon deforestation, the leading cause of GHG emissions in Brazil; and profiles the strengths and limitations of Brazil's current policy responses. Finally, Section 4 argues that, despite its potential to reduce energy-related GHG emissions, renewable energy production in Brazil in the forms of ethanol, biodiesel, and hydropower threaten to increase GHG emissions from deforestation in the medium run if strict zoning and environmental laws are not effectively enforced.

2 Overview of GHG emissions in Brazil

Brazil is a federal democracy of almost 200 million people, has a diversified economy (Baer 2008, 1-3),[2] and is the fourth largest greenhouse gas emitter in the world – responsible for 5% of world emissions, or 2.2 GtCO2e in 2008 (World Resources Institute, cited in McKinsey & Company 2009, 2).[3] However, unlike the United States of America and other OECD countries, the majority of GHG emissions in Brazil stem from deforestation – the logging and burning of large tracts of forest to clear land for cattle pasture or agriculture in the Amazon rainforest – not from energy and industry.[4] Thus, GHG emissions in Brazil are primarily an *agricultural*, not an *industrial*, problem.[5]

While annual GHG emissions data from deforestation in the Amazon are not available, it is clear from Brazilian satellite data that high deforestation rates there since 1988 have caused the release of massive amounts of CO2 and other GHGs into the atmosphere. Deforestation does appear to be declining: the Brazilian National Institute for Spatial Research (INPE 2011) uses satellite images to calculate annual deforestation rates in the Amazon, and finds that after spikes in 1995 and 2004, the annual deforestation rate dropped to an estimated 6,451 km2 in

1 This study defines green growth as "job creation or GDP growth compatible with or driven by actions to reduce greenhouse gases" (see Huberty et al. 2011, 3).

2 In 2005, Brazil's GDP per capita was US$3,326. That year, services accounted for 56.09%, industry for 34.86%, and agriculture for 9.05% of total GDP (Baer 2008, 405). However, agribusiness straddles the divide between agriculture and industry: Counting production, industry, commerce, and inputs, agribusiness is estimated to have contributed to 31% of Brazil's GDP in 2003, and to 26% of Brazil's total employment in 2002 (*ibid*., 303).

3 GtCO2e refers to *gigatons of carbon dioxide equivalent.*

4 The Brazilian Legal Amazon consists of nine states (Acre, Amapá, Amazonas, Maranhão, Mato Grosso, Pará, Rondônia, Roraima, and Tocantins), and originally had approximately 4.3 million km2 of forest (Baer 2008, 336). According to Baer (ibid., 332), the Amazon "stores about 60 billion tons of carbon, or 8 percent of the total carbon present in the atmosphere in the form of carbon dioxide."

5 McKinsey & Company (2009, 5) estimates Brazilian per capita GHG emissions at 12 CO2e, comparable to industrialized countries. However, "if we exclude the forestry sector, Brazilian per capita emissions drop to 5 tCO2e, which would bring this country down to the level of low/moderate emitters" (ibid.).

2010 (IPEA 2010, 82; INPE 2011) – largely due to less competitive commodity (beef and soybean) prices resulting from the appreciation of Brazil's currency (the real) against the U.S. dollar, but also partly to conservation policies and stronger environmental law enforcement efforts (Banco Mundial 2010, 40).[6]

But despite the recent decline in deforestation, forest loss in the Amazon and elsewhere has been severe: The World Bank estimates that the Amazon lost 18% of its forest cover from 1970 to 2007. During the same period, the neighboring Center-West savannah, the Cerrado, lost 20% of its forest cover, and the coastal Atlantic Forest – of which only 7% of its historical expanse remains today, according to São Paulo-based NGO S.O.S. Mata Atlântica (2011) – lost 8% (Banco Mundial 2010, 39-40). Cattle ranching and soybean cultivation contributed to forest loss in the Amazon and Cerrado, while sugar cane farming, coffee plantations, logging, urbanization and other population pressures have over centuries decimated the Atlantic forest (McAllister 2008b, S.O.S. Mata Atlântica 2011).

Agriculture, including cattle ranching, is Brazil's second-largest greenhouse gas emitter, at 25% of Brazil's total GHG emissions – and much of the sector's growth involves deforestation on the Amazon frontier.[7] Cattle ranching and soybean farming contribute directly and indirectly to particularly high deforestation rates in the Amazonian states of Mato Grosso, Rondônia, and Pará (Greenpeace 2009; INPE 2011; Margulis 2004). In addition, deforestation rates are exacerbated by the fact that the productivity of cattle ranching is generally lower in the Amazon than elsewhere, due to the widespread and increasing availability of land.[8] Section 3 will study the relationship between ranching, agriculture, and deforestation in greater depth.

Finally, in contrast to OECD countries, Brazil's energy sector contributes very little to Brazil's GHG emissions. Depending on how energy-related GHG emissions are calculated, estimates vary from 13% (McKinsey & Company 2009, 6) to 16% of Brazil's total GHG emissions (IPEA 2010, 128).[9] Whatever the true number, energy in Brazil contributes comparatively little to Brazil's GHG profile because the sector is relatively green, with 46% of energy generation stemming from renewable sources such as wood, biomass, ethanol and biodiesel, and hydroelectricity in 2008 (*ibid*., 133-134).[10] However, Brazil plans to double the supply of energy in the next twenty years, which will exacerbate two trends that threaten to increase the sector's GHG emissions: First, the share of fossil fuels (oil and gas) in Brazil's energy matrix will increase from the current 9% to 14% by 2030, which will triple energy sector emissions from 30MtCO2e in 2008 to 90 MtCO2e (McKinsey & Company 2009, 13). Second, investments in expanding the supply of energy from hydroelectric dams, sugar cane-derived ethanol, and other biofuels will place greater pressure on land, which could lead to higher emissions from deforestation.[11] Section 4 will examine the environmental risks of Brazil's renewable energy industries.

3 Ranching, agriculture, and Amazon deforestation

The story of green growth in Brazil must begin with a look at agriculture and the deforestation of the Amazon, since together these contribute the largest share of Brazil's GHG emissions and, in the case of agriculture, a growing share of Brazil's economy. Brazil's problem is that two of its most lucrative industries are agriculture and ranching, and both of these industries have a long

Deforestation rates in the Brazilian Amazon, Km2 deforested per year

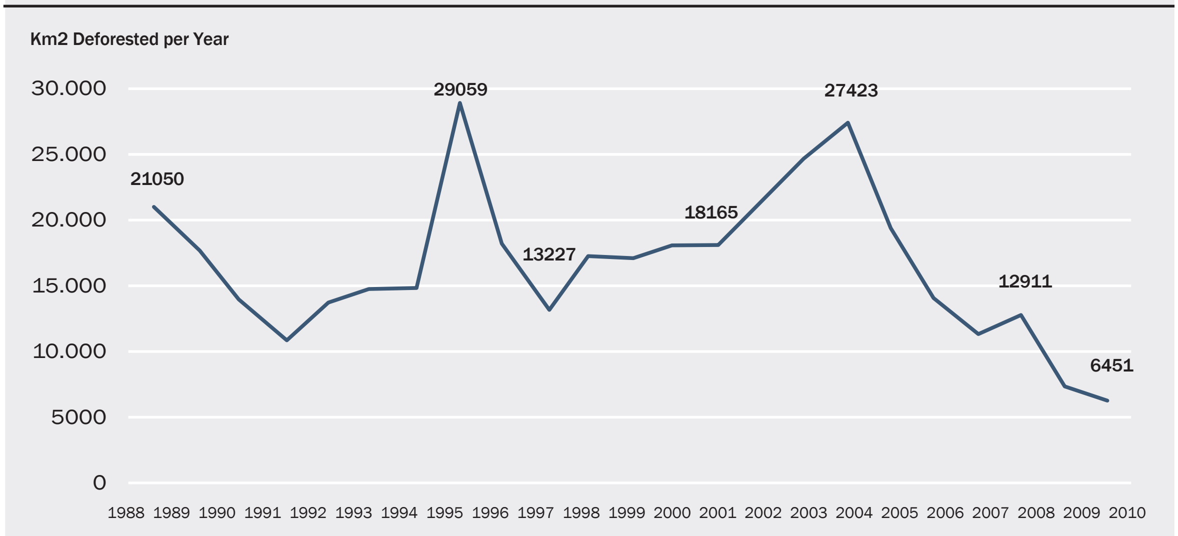


Figure 1: Deforestation Rates in the Brazilian Amazon, 1988-2010 (IPEA 2010, 82; INPE 2011)

Source: IPEA 2010, 82; for 2009, 2010: INPE 2011 PRODES website.

6 INPE counts Amazon deforestation rates in the nine states of the Brazilian Legal Amazon (see fn. 4).

7 Brazilian agriculture is responsible for 10% of world agricultural GHG emissions, second only to China (McKinsey & Company 2009, 24). McKinsey & Company (2009, 24-25) expects agriculture-related GHG emissions to grow by 40% from 2005 to 2030, of which cattle rearing will account for 37% of the growth (*ibid.*).

8 In the South, Southeast, and parts of the Center-West regions of Brazil, cattle ranching competes with sugar cane farming for land, so ranchers there are forced to adopt more efficient methods of production (Nassar 2009, 62). Margulis (2004, 35-36) finds that cattle ranching productivity also varies within the Amazon region, depending on factors such as climate, the productivity of grass, and the mortality rate of cattle.

9 The McKinsey & Company (2009, 6) estimate of 13% includes electric power generation and fuels for transportation. The 16% number, from IPEA (2010, 128), includes energy generation as well as consumption in the energy sector itself, which accounts for 10% of national energy consumption. Exact calculations used for each of these estimates are unavailable.

10 According to McKinsey & Company (2009, 13), "Brazil emits an average of 94 t[ons] of CO2e per gigawatt hour (GWh) produced. The global average is 580 tCO2e per GWh and, in countries that rely heavily on coal fired power plants, can be as high as 1,000 tCO2e per GWh."

11 In addition to the controversial Belo Monte mega-dam project in the Amazonian state of Pará, there are 311 hydroelectric plants of various sizes planned or being built, which will add over 15,000 MW to Brazil's energy grid (IPEA 2010b, 137).

history of expanding into the Amazon – facilitated by industry subsidies, poor property protection, and institutional weakness. Brazil has only recently begun to try to correct incentives and halt deforestation, but with mixed results. It is too early to say whether Brazil will be able to control deforestation successfully, especially if doing so requires slowing the growth of core industries. However, to do so it needs to make significant progress in imposing rule of law and creating market incentives to enhance the sustainability of these industries.

3.1 Background on ranching and agriculture in the Amazon

The rapid growth of ranching and agriculture in Brazil, due to growing domestic and international demand for beef and soybeans, is the leading driver of deforestation in Brazil.[12] To ensure that the recent decline in Amazon deforestation (see Figure 1 above) continues and to reduce GHG emissions in the long run, increases in ranching and agricultural productivity, payments for avoided deforestation, domestic and international consumer pressures, and more consistent environmental law enforcement are needed.

Much of the expansion of beef production (along with leather and other cattle-derived products) has been in the Amazon region, and it is estimated that 70% of area deforested there is converted to cattle pasture

Much of the expansion of beef production (along with leather and other cattle-derived products) has been in the Amazon region, and it is estimated that 70% of area deforested there is converted to cattle pasture (McAllister 2008b, 10,875).[13] From 1995 to 2006, Brazil's cattle herd grew by 10%, from 153 million to 169 million heads of cattle. However, "[w]hile outside the Amazon region total numbers decreased by 4 million head, inside numbers increased by almost 21 million, to 56 million head in 2006" (Greenpeace 2009, 13). During this period, the Amazonian states of Mato Grosso, Pará, and Rondônia increased their cattle stock by 36%, 111%, and 120%, respectively. Meanwhile, ranches in Amazonian states have increased in size by 90% (*ibid.*), a result both of the low price of available land and the opening up of new lands through illegal logging (Margulis 2004). Increases in cattle head and ranch area correspond to alarming deforestation numbers: By 2007, Mato Grosso had lost about 38% of its original forest area, Rondônia 39%, and Pará 20% (Greenpeace 2009, 14-15).[14]

3.2 Systemic problems create incentives for deforestation

The relationship between deforestation and the expansion of beef and agriculture in the Amazon involves a system of *perverse incentives* provided by the Brazilian federal and subnational governments, as well as domestic and international consumer behavior. These perverse incentives encourage expansion into the Amazon in spite of the problems expansion creates. They include weak property rights, subsidized credits and tax exemptions from the Brazilian government, weakness of federal and state agencies, and collusion between state agencies, cattle ranchers, and soy farmers. Together, these factors reduce the ability of the federal and subnational states to enforce environmental laws.

Like most policy areas in Brazil, environmental governance is decentralized: The federal Ministry of the Environment enacts norms and broad policy, but state environmental agencies have considerable policy and administrative autonomy. Combined with their relatively low capacity and periodic collusion with illegal deforestation activities, decentralization poses risks to the Amazon: Hochstetler and Keck (2007, 151) characterize Amazonian politics as one of "state absence," in which elites refuse to crack down on illegal logging because they benefit from the revenues from beef and agricultural exports.[15] Even where the state is present, it may be unable to enforce environmental laws. Indeed, there have been several cases of corruption in state agencies: In December 2008, the Federal Ministério Público (Public Procuracy) charged 33 people – including the former Secretary of the Environment for Pará – with trafficking in illegal wood in Pará ("Ex-secretário…" 2008). Other reports indicate that corruption is endemic in Amazonian state environmental agencies (Hochstetler and Keck 2007; Luíse 17 March 2011; McAllister 2008a).

Corruption and weak state capacity lead to high rates of impunity for environmental crimes in the Amazon. Although Brazil's *Ministério Público* has constitutional autonomy and both enforces environmental laws and roots out corruption in federal and state environmental agencies (McAllister 2008a), it cannot always ensure that punishments for environmental transgressions are carried out: A 2009 study by the Amazonian Institute for Man and the Environment (IMAZON) think tank in Belém, Pará, found low rates of punishment for illegal deforestation in the Amazon's extensive network of environmentally protected areas, due to the inefficiency of the police and court system (Barreto et al. 2009). In this context, ranchers and farmers often have incentives to increase production by expanding their landholdings, rather than investing in productivity increases.

Expansion of landholdings is also due to lack of effective land titling, which when combined with low levels of environmental law enforcement on the Amazonian deforestation frontier, worsens deforestation by depressing incentives to invest capital in productivity and raising incentives to expand horizontally – into neighboring fallow pastures or virgin forests (Barreto et al. 2008). This process exacerbates the problem of illegal and often violent land seizures on the Amazon frontier: Land grabbers invade and deforest public and unclaimed lands (*terras devolutas*) – as well as the lands of the small settlers, whom they expel – and falsify titles to them.[16] In 2009, the Brazilian federal government enacted a program of Amazonian land titling, part of a larger effort to reduce deforestation by identifying property owners who may be

12 In the 2000s, Brazil became the world's largest exporter of beef. Beef exports grew over 450% in volume and 385% in value from 1994 to 2005 (McAllister 2008b, 10,875). In 2008, agriculture and ranching (including both production and distribution) accounted for 25% of Brazil's GDP, and 36% of Brazil's total exports (Greenpeace 2009, 3). That same year, Brazil accounted for 31% of the global trade in beef, and 36% of the global trade in soybeans – and its share in each is expected to increase to 61% and 40%, respectively, by 2018 (ibid., 2).

13 Nepstad et al. (2006, 1599) estimate that "more than 80% of the Brazilian Amazon could sustain profitable cattle production."

14 Margulis (2004) traces the micro-processes by which cattle ranching drives illegal Amazon deforestation: Loggers enter virgin forest, build roads, and remove the valuable timber. They then sell the land to cattle ranchers. Without the possibility of selling the land on to cattle ranchers, loggers' incentives to deforest would be greatly reduced (Margulis 2004, XVIII).

15 "'[I]nstitutional weakness' and 'absence of the rule of law' often cited by studies of the 'failure' to enforce environmental standards or pursue miscreants is not an accident of recent settlement but rather a strategy deliberately pursued by powerful operators in the region for which a more robust state geared to maintaining law and order would be highly inconvenient" (Hochstetler and Keck 2007, 153).

16 Falsification of land titles is widespread in Brazil, especially in the Amazon, and known as *grilagem*, after *grilo*, the Portuguese word for cricket. Sometimes, land grabbers write a false title, and then place it in a jar with crickets. The crickets chew on the paper, and this makes the land title look old, so that land agency bureaucrats are less likely to suspect that the claim is false.

17 This program is controversial, as formalizing property rights implies forgiving the past transgressions of land grabbers. Some Brazilian environmentalists fear that this program may actually increase deforestation, as new land grabbers see the potential to occupy land illegally and then argue for legal title.

held accountable for illegal logging on their properties (*t*, 3 June 2009).[17] It is too soon to evaluate the effects of this program on deforestation rates.

Furthermore, the Brazilian state has only recently begun to embrace a sustainable development model in the Amazon. Indeed, from the late 1960s to the 1980s, Brazilian Amazon settlement policy promoted deforestation to ensure national security and to expand agricultural production, and settlers in the region were required to deforest their lands to lay claim to them and become eligible for subsidized credits. Mineral extraction and industrial development in the Amazon were key economic goals for Brazil's 1964-1985 military dictatorship, and from 1965 to 1974, subsistence farmers were expelled from the agricultural frontier "to make way for enormous cattle ranches, whose pastures required the burning of huge swaths of forest" (Hochstetler and Keck 2007, 145). In 1974, the current agribusiness and ranching model of development was consolidated, setting the trajectory of deforestation seen today. In addition to national Amazon settlement policy, subsidized credits and tax exemptions for agribusiness lowered production costs and stimulated deforestation for many years (Binswanger 1991).

This suggests that access to credit needs to be more strongly conditioned on environmental sustainability, but doing so will require more coordination between Brazil's developmental and environmental ministries.

Over the last decade, some of the perverse incentives driving Amazon deforestation detailed above have been removed. At the same time, cattle expansion has become profitable independently of state subsidies – thus, now market mechanisms are the principal drivers of cattle ranching expansion and consequent deforestation, rather than policy (Margulis 2004). However, the Brazilian federal government continues to be a major investor in Amazonian agribusiness, through institutions such as the Brazilian National Development Bank (BNDES) (Greenpeace 2009, 3), which gives the government conflicting incentives vis-à-vis tradeoffs between production and environmental sustainability. The Brazilian government has also indirectly subsidized the soy industry in the Cerrado and Amazon by investing in transportation infrastructure (Fearnside 2001). Finally, studies find that the more access farmers and ranchers have to rural credit, the more deforestation occurs (IPAM 2008). This suggests that access to credit needs to be more strongly conditioned on environmental sustainability, but doing so will require more coordination between Brazil's developmental and environmental ministries.

3.3 Mixed results: efforts to fix the system

In conjunction with the removal of some perverse incentives, federal and state government initiatives have helped to reduce Amazon deforestation. These initiatives, however, must be combined with productivity enhancements, stronger law enforcement, and domestic and international consumer pressures if they are to contribute to reducing deforestation in the long run.

At the federal level, the Action Plan to Prevent and Control Deforestation in the Legal Amazon (PPCDAM) and the Amazon Protected Areas Program (ARPA) have sought to increase law enforcement and land area designated as environmentally protected. In addition, the federal government enacted a National Climate Change Plan in 2008, which includes the ambitious goal of eliminating deforestation by 2040 (Governo Federal 2008). Fi-

Area of Soy planted by year and region

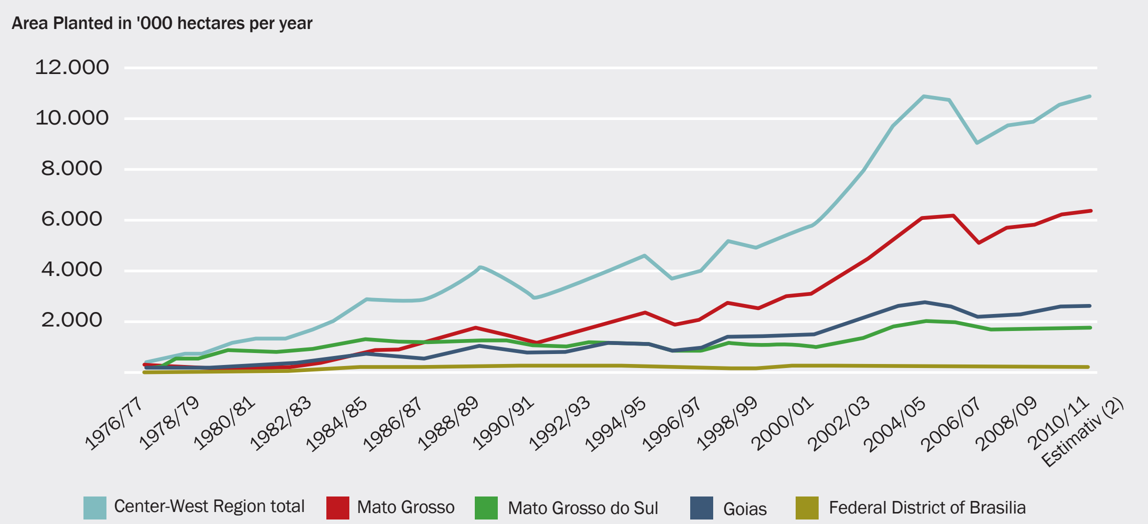


Figure 2: Area of Soy Planted in the Center-West

Source: CONAB 2011

nally, the Amazonian states of Acre and Amazonas have sought to create markets for sustainably produced forest products, and Amazonas has enacted a program to pay smallholders monthly stipends not to deforest (Viana 2009; 2010, 38-42).[18]

Conflicts between those who favor development at any cost and those who support conservation and sustainable development continue, but the programs described above (and in greater depth in Appendix 1) indicate that Brazil is becoming serious about reducing GHG emissions from deforestation, and about protecting biodiversity.

3.4 Enhancing ranching and agricultural productivity

The alternative to expanding agriculture into new areas is to do more with existing areas. Thus, while federal and state initiatives have helped to reduce deforestation, meeting Brazil's National Climate Change Plan target of zero deforestation by 2040 while maintaining the country's stature as an agro-industrial powerhouse will require further investments in enhancing the productivity of agriculture and ranching. Subsidized credit for inputs such as machinery and fertilizer have increased productivity in both industries: Some older ranches on the Amazon frontier have managed to increase their beef production per hectare (Margulis 2004), and, as figures 2 and 3 show, though the area in the Center-West Cerrado devoted to soybean production continues to grow, soybean productivity has also increased steadily from 1,452 kg/hectare in 1976 to 3,135 kg/hectare in 2010. A combination of advances in farming techniques that enabled soybean farming in the Cerrado in the 1980s, and the fertile virgin soil of that region and the Amazon have contributed to this (Luna and Klein 2006, 120).

Increasing cattle and soy productivity is to be celebrated for its potential to reduce ranchers' and farmers' dependence on deforestation for expansion, but it is not sufficient to render ranching and farming "green" in the medium run. Indeed, continued increases in productivity and profits in these industries may place stronger pressures on state and federal governments to loosen forest conservation laws.[19] Continued government investment in improving law enforcement in the Amazon region and the effective implementation of Brazil's policies to reduce deforestation are necessary to ensure that these sectors' productivity increases do, indeed, lead to reductions in GHG emissions from deforestation.

Finally, domestic and international consumers could help to ensure that environmental laws are enforced by demanding that beef and soybeans be produced sustainably. Some efforts have already begun: "A large Swedish grocery store chain" (Nepstad et al. 2006, 1600) has demanded that Brazilian soybeans meet environmental criteria, the U.K.'s National Beef Association called for a boycott of Brazilian beef (ibid.), and international NGOs, producers, and consumers imposed a "soy moratorium" for three years on Brazilian soybeans, from 2006 to 2009 (Greenpeace 17 June 2008). In addition, domestic beef retailers in Brazil, such as the supermarket chains Carrefour and Pão de Açúcar, and the meat processors Friboi and Bertim, are seeking to sell beef "produced on ranches that obey environmental legislation and use good land-management techniques" (Nepstad et al. 2006, 1600). More effort is needed on this front to promote environmental sustainability in the beef and soybean industries.

In their current states, the agriculture and ranching industries present Brazil with a real dilemma between "green" and "growth." Solving this problem – and achieving green growth – means finding a way to decouple growth in these industries from rising emissions. Without significant progress in increasing the productivity of cattle ranching and soybean farming, enforcing environmental laws, implementing anti-deforestation policies responsibly, and cultivating domestic and international consumer pressures, it is unlikely that Brazil will move

18 See Appendix 1 for details on federal and state environmental programs.

19 Pressures to loosen conservation laws are already being felt in the ongoing acrimonious debate in the Brazilian Congress over revising the 1965 Forest Code. The agribusiness sector would like the legal reserve requirement (the percentage of land on private property in different biomes that must be preserved in its natural state) in the Amazon to be significantly reduced from its current 80%. The environmental movement and environmental bureaucracy oppose this change (Noronha 2011). Revisions to the Forest Code to loosen conservation rules for small-scale farmers and ranchers passed in the lower house of Congress on 25 May 2011, but are expected to have a tough fight in the Senate. President Dilma Rousseff is also expected to veto certain provisions in the legislation, such as amnesty for illegal deforestation on private lands prior to July 2008 (Brooks 2011).

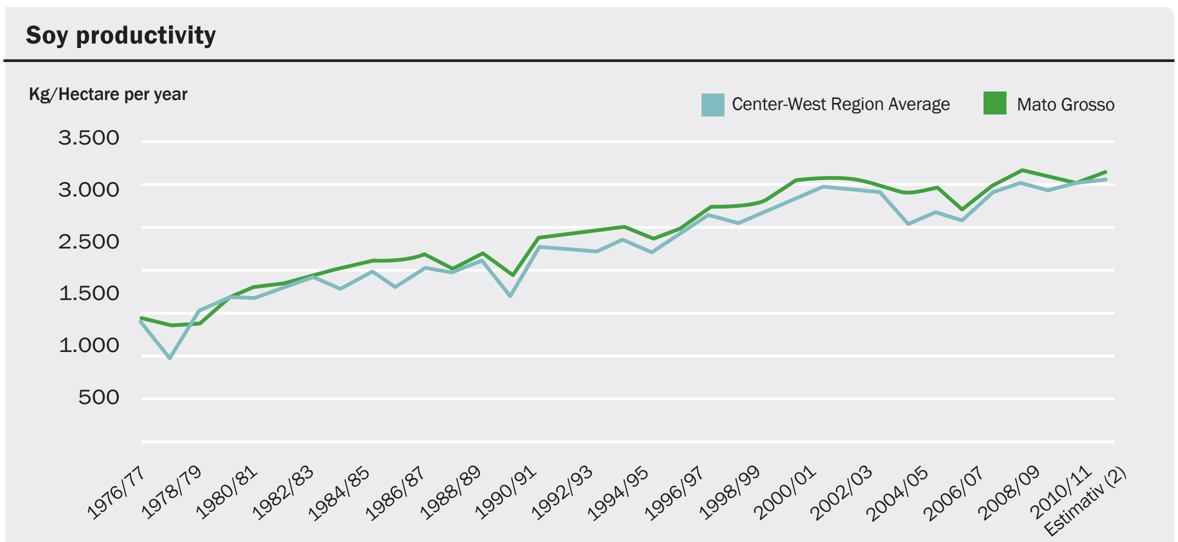


Figure 3: Soy Productivity in Center-West and Mato Grosso.

Source: CONAB 2011

off of its current track of deforestation-driven increasing GHG emissions.

This section has shown how cattle and agribusiness in the Amazon region drive deforestation, and how through deforestation and their own emissions they contribute to about 80% of Brazil's total GHG emissions. Brazil's energy sector, discussed in the next section, provides a contrasting perspective on the potential for green growth in Brazil, but there are environmental risks there as well: like cattle and soy, agroenergy production is land use-intensive, and risks increasing competition for land among different crops. This is especially true in the small but growing biodiesel sector, which currently extracts fuel largely from soybeans and bovine fat (IPEA 26 May 2010, 28). Meanwhile, large hydropower projects in the Amazon threaten to flood large tracts of forest and disrupt ecosystems.

4 Brazil's energy generation: A renewable powerhouse with a possible dark side

Brazil's energy matrix is remarkably green, with 45.9% of its domestic energy supply provided by renewables in 2008 – well above the world average of 12.9% (IPEA 2010, 133). As can be seen in Table 1 below, though petroleum and derivatives account for the largest source of energy in the country, the renewable energy sources of sugar cane products and hydroelectricity come second and third, respectively (EPE 2010, 31). This impressive performance results from policies enacted since the 1970s that have aimed to secure Brazil's energy independence, and growth is expected to continue due to recent technological breakthroughs (e.g. flex-fuel cars), global demand for ethanol, and government investments in ethanol, biodiesel, and hydroelectric dams.

Nevertheless, there is a possible dark side to renewable energy in Brazil: Growth in the production of ethanol requires increases in both crop productivity and the amount of land cultivated, which may displace food crops (raising the price of food), and force more farmers to move into the Center-West Cerrado by increasing the price of land in coastal regions, exacerbating deforestation on the Amazon frontier (IPEA 2010, 417). Expanding land area in the Southeast and Northeast of Brazil under sugar cane cultivation, meanwhile, is expected directly to worsen deforestation in the Atlantic Forest (IPEA 2010, 431-432). Meanwhile, because the major ingredients in biodiesel are soy and bovine fat, Brazil's current investments in biodiesel production may increase Amazon deforestation in the medium run. Finally, large hydroelectric dams, such as the proposed Belo Monte dam in Pará, require logging of surrounding lands and displacement of local residents, and may have deleterious downstream ecological effects from diverting river flows.

This section will examine the potential for green growth in Brazil's renewable energy sector. It will first profile the share of renewable energy sources in Brazil's energy matrix. Then, it will analyze growth and environmental risks in the ethanol and biodiesel sectors. Finally, it will discuss the environmental tradeoffs of hydroelectricity.

4.1 Profile of Brazil's energy matrix

Brazil has succeeded in providing a large share of its domestic energy supply from renewable sources such as ethanol, biomass, and hydropower – and in the com-

Brazilian energy supply by source

Source	1940	1950	1960	1970	1980	1990	2000	2005	2008	2009
Petroleum, Natural Gas, and Derivatives	1,522 (6.4)	4,280 (12.9)	12,668 (25.7)	25,420 (38.0)	56,485 (49.2)	62,085 (43.7)	96,999 (50.9)	105,079 (48.1)	111,344 (46.8)	113,567 (46.6)
Mineral Carbon and Derivatives	1,520 (6.4)	1,583 (4.8)	1,412 (2.9)	2,437 (3.6)	5,902 (5.1)	9,615 (6.8)	13,571 (7.1)	13,721 (6.3)	14,562 (5.8)	11,572 (4.7)
Hydropower	352 (1.5)	536 (1.6)	1,580 (3.2)	3,420 (5.1)	11,063 (9.6)	20,051 (14.1)	29,980 (15.7)	32,379 (14.8)	35,412 (14.0)	37,064 (25.2)
Wood and Vegetable Carbon	19,795 (83 3)	25,987 (78.1)	31,431 (63.9)	31,852 (47.6)	31,083 (27.1)	28,537 (20.1)	23,060 (12.1)	24,468 (13.0)	29,268 (11.6)	24,610 (10.1)
Sugar Cane Products	563 (2.4)	892 (2.7)	2,131 (4.3)	3,593 (5.4)	9,217 (8.0)	18,988 (13.4)	20,761 (10.9)	30,147 (13.8)	42,866 (17.0)	44,447 (18.2)
Other				223 (0.3)	1,010 (0.9)	2,724 (1.9)	6,245 (3.3)	8,869 (4.1)	12,185 (4.8)	12,670 (5.2)
Total	23,752 (100)	33,278 (100)	49,222 (100)	66,945 (100)	114,761 (100)	142,000 (100)	190,615 (100)	218,663 (100)	252,638 (100)	243,930 (100)

Table 1: Brazilian energy supply by source in 103 tons of oil equivalent (Percentage share of each source in total energy supply). Adapted from EPE (2010, 31-32).

Source: MSWord Tables, Brazil: A Country Case Analysis, prepared by Benjamin S. Allen ing years increasingly from biodiesel. Table 1 below shows the changes in Brazil's energy supply from 1940 to 2009 by source. Overall domestic energy supply rose from about 23 million toe in 1940 to 243 million toe in 2009. Concomitant with growth in the domestic supply of energy, production grew among all sources of energy. The use of petroleum in Brazil has steadily increased over time, but the substantial rise in production of sugar cane products (ethanol, biomass) and the generation of electricity from dams have reduced petroleum's overall share in the energy matrix. The growth of sugar cane and hydroelectric energy production was especially high between 1970 and 1980, when the 1973 OPEC oil shock induced Brazil's military dictatorship to reduce national dependence on imported oil.[20]

Table 1 also illustrates the changing shares of each source of energy in Brazil's energy matrix. The share of petroleum in total domestic supply peaked in 2000 at 50.9%, and has since fallen marginally to 46.6% in 2009.[21] Meanwhile the share of hydropower has risen substantially, from 1.5% in 1940, to 9.6% in 1980 and 25.2% in 2009. Much of this is consumed as electricity. At the same time, sugar cane products (ethanol and biomass from bagasse) have increased their share from 2.4% in 1940 to 8% in 1980 and 18.2% today. This changing balance between renewable and non-renewable sources of energy over time makes Brazil an impressive case of energy systems transition.

This section will focus its analysis on three important and growing renewable energy sectors: ethanol, biodiesel, and hydropower.

4.2 Ethanol

Ethanol is Brazil's signature biofuel, and its production and consumption both within Brazil and abroad are growing due to the advent in 2003 of flex-fuel cars in Brazil (which can run on any combination of petroleum-based gasoline and ethanol), and to world demand for renewable energy sources. Though Brazil's sugar cane-based variety of ethanol may reduce GHG emissions by up to 92% (from production to burning), sugar cane requires land on which to grow, and extension of farm land devoted to sugar cane may directly worsen deforestation rates in Brazil's Atlantic forest, as well as indirectly increase Amazon deforestation by displacing other crops and cattle ranching in coastal regions and the Cerrado toward the Amazon.

Ethanol is widely considered to be a carbon-efficient fuel when compared to petroleum because it burns more cleanly than oil and is extracted from crops, the next generation of which re-absorbs some of the carbon emitted from the burning of the previous generation. Studies indicate that Brazil's sugar cane-based ethanol is especially advantageous, reducing GHG emissions up to 92% per liter of ethanol when compared to one liter of petroleum-based gasoline (measuring life cycle emissions of each from production to burning). The U.S.'s corn based-ethanol, by contrast, only reduces carbon emissions by 19-47% (La Rovere et al. 2011, 1031). In addition, at about

Area of sugar cane

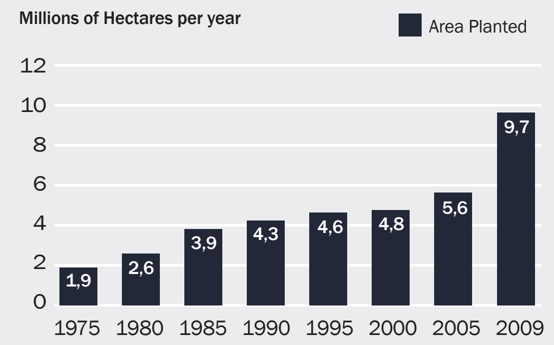


Figure 4: Area of sugar cane planted in Brazil, 1975-2009 (MAPA 2010)

Source: MAPA 2010. (Ministero de Agricultura, Pecuaria e Abastecimento, Anuario Estatistico de Agroenergia, http://www.agricultura.gov.br/arq_editor/file/Desenvolvimento_Sustentavel/Agroenergia/anuario_agroenergia/index.html#)

US$23/liter in 2005, Brazilian ethanol is more efficient to produce than sugar cane-based ethanol produced in other leading countries, such as Thailand and Australia (Nassar 2009, 70). Part of these advantages lies in climatic conditions, and part is due to the fact that all ethanol distilleries in Brazil power the production of ethanol by burning their own sugar cane bagasse, rather than fossil fuels – which reduces their own energy costs as well as net carbon emissions (Hofstrand 2008; Nassar 2009, 71).

State support (including subsidies and the creation of a domestic market through minimum ethanol-petroleum blending requirements in gasoline) since the implementation of the Pro-Álcool Program in 1975 has enabled the sugar cane-based ethanol industry to grow and thrive, and there are currently 434 ethanol distilleries in operation in Brazil (IPEA 26 May 2010, 14). Production is driven both by high domestic and global demand: In 2007, Brazil exported 185 million gallons of ethanol to the U.S. and produced just under 6 billion gallons for domestic consumption (Hofstrand 2008).[22]

Furthermore, if environmental laws in the coastal Atlantic Forest areas are not effectively enforced, ethanol production may lead to higher rates of deforestation there in the coming decades.

However, as land area in Brazil dedicated to sugar cane farming for ethanol grows to meet domestic and world demand for biofuels, other crops and cattle ranching may be displaced toward the Cerrado and Amazon, which may indirectly worsen GHG emissions from Amazon deforestation by increasing competition for land there (McAllister 2008b, 10,876). Furthermore, if environmental laws in the coastal Atlantic Forest areas are not effectively enforced, ethanol production may lead to higher rates of deforestation there in the coming decades. Figure 4 (below) shows the growth in the land area de-

20 Today, most of Brazil's petroleum is produced domestically, though some light petroleum is imported from elsewhere to mix with Brazil's heavy crude in the refining process (Sennes and Narciso 2009, 33-34).

21 Petroleum's share may rise in the coming decades as Brazil begins to explore its recently discovered pre-salt oil fields.

22 For an extended discussion of the development of Brazil's ethanol industry, see Appendix 2.

voted to sugar cane cultivation (to produce both sugar and ethanol) from 1975 to 2009.

Land area devoted to sugar cane cultivation grew especially rapidly in the 2005-2009 period, due to growing domestic and global demand for ethanol. To give a sense for ethanol's contribution to the trajectory shown in Figure 4, in the 1975/76 harvest, only 14% of sugar cane harvested on 1.9 million hectares was used to produce ethanol – the other 86% was converted to sugar. In contrast, in the 2009/10 harvest, 57% of the sugar cane harvested on 9.67 million hectares was used to produce ethanol, while only 43% was converted to sugar (MAPA 2010). Based on this pattern, we may conclude that a continuing rise in world demand for ethanol will lead to growth in the land area used to cultivate sugar cane in Brazil, which may exacerbate deforestation.

Indeed, econometric modeling by the Brazilian Institute for Advanced Economic Studies (IPEA) indicates that sugar cane cultivation will lead to more deforestation in the Atlantic forest over the next two decades. IPEA (2010, 431) estimates that sugar cane crop area will grow to 22-23 million hectares by 2035, with most growth concentrated in the Southeastern states of Minas Gerais, São Paulo, and Rio de Janeiro, and a lesser share in the more arid Northeast region. These two regions contain much of what remains of the Atlantic Forest, and if strict ecological zoning policies to protect forests are not implemented and enforced, sugar cane production may reduce the Southeast's remaining forest cover by 67%, and the Northeast's by 21% (*ibid*., 432).[23]

Some policy progress is being made to address the long-term environmental risks of ethanol growth, but more must be done to ensure that ethanol remains environmentally sustainable. A national law proposed in 2009 would prohibit sugar cane cultivation in the Pantanal and Amazon biomes (IPEA 2010, 144) – a measure that will have little effect, since sugar cane is expected only indirectly to affect the Amazon, as it does not grow well there (Nassar 2009, 68). More positively, in 2007 the state of São Paulo and the president of that state's sugarcane producers' union signed an Agroenvironmental Protocol, which sets deadlines to phase out and eventually eliminate sugarcane harvest burning – a major source of agricultural GHG emissions in the state – and commits sugar cane farmers to reforesting 400,000 hectares of degraded lands (Lucon and Goldemberg 2010, 343-344). São Paulo is also in the process of implementing an ecological-economic zoning program to minimize biodiversity loss in sugar cane expansion areas (Author's interviews with personnel of São Paulo's Forestry Foundation, July 2010). Finally, unlike in poorer states in Brazil, São Paulo's state environmental and forestry agencies are relatively competent, and the state's *Ministério Público* vigilantly enforces environmental laws (McAllister 2008a).

Finally, the productivity of sugar cane production has improved considerably since 1975. Tons of sugar cane produced per hectare has risen from 65 in the 1977-78 harvest to an average of 85 in the 1989-2004 period. Similarly, liters of ethanol produced per hectare of sugar cane planted increased from 4,550 to 6,800 over the same period (IPEA 26 May 2010, 13). Productivity is expected to continue to rise to about 7,160 liters of ethanol per hectare by 2020,[24] and if this is combined with effective ecological-economic zoning and environmental law enforcement, ethanol's potential to contribute to deforestation may decline from current estimates.

4.3 Biodiesel

Brazil has been investing in biodiesel production since 2005, and the country's 2008-2017 Decennial Plan aims to produce enough biodiesel not only to power vehicles, but also integrate into the electricity grid (IPEA 26 May 2010, 21). Though the industry remains small, growth in the coming decades may directly worsen deforestation rates: Despite Brazilian government efforts to diversify the agricultural ingredients in biodiesel, current inputs are largely soy and bovine fat, and soybean farmers and cattle ranchers in the Cerrado and Amazon regions – the principal economic drivers of Amazon deforestation – are beginning to invest in biodiesel production to take advantage of government supports for the sector.

Despite Brazilian government efforts to diversify the agricultural ingredients in biodiesel, current inputs are largely soy and bovine fat, and soybean farmers and cattle ranchers in the Cerrado and Amazon regions – the principal economic drivers of Amazon deforestation – are beginning to invest in biodiesel production to take advantage of government supports for the sector.

Soy and bovine fat account for 75.04% and 17.79% of raw materials used in biodiesel, respectively.[25] These raw materials are produced by the same industries that, as discussed in Section 2 above, are responsible for the majority of deforestation in the Amazon.[26] In regards to the international market for biofuels, McAllister (2008b, 10,876) notes that "…the production of biofuels elsewhere in the world may [increase]… the price of soybeans or cattle on the international market, thus stimulating further production of these commodities in the Amazon and the resultant deforestation." A mechanism by which this may happen is through the displacement of soybeans for corn cultivation for ethanol in the U.S., which may raise the price of Brazilian soybeans on the world market and induce Brazilian farmers to increase production (*ibid.*).

Although in 2008 biodiesel accounted for less than 1% of Brazil's domestic energy supply, it is being gradually integrated into the energy matrix: Currently, national standards require that all diesel gasoline sold in Brazil contain 3% biodiesel as of 2008 – and most diesel sold now contains 5% biodiesel (IPEA 26 May 2010, 20-22).[27] A 2005 law established state support for biodiesel, including research support and financing from BNDES and other public institutions.[28] These investments have begun to yield results: From 2006 to 2008, production of

23 Rosa et al. (2009, 16) are more optimistic: they calculate that there are 90 million hectares of land in Brazil still "available for the expansion of agriculture without deforestation."

24 See Table 3 in Appendix 2.

25 Cotton and other oils and fats account for only 7.17% of raw materials included in biofuels (IPEA 26 May 2010, 28).

26 On 18 March 2011, the Brazilian meatpacking company Minerva opened a bovine fat-based biodiesel plant in the Center-West state of Goiás (*Business News Americas* 16 March 2011). Together with four other large meatpacking companies – Bertim, Independência, JBS, and Marfrig – Minerva controlled over 50% of Brazil's beef export market in 2007 (Greenpeace 2009, 6).

27 Biodiesel has been integrated into diesel gradually since 2005: 2% in 2005-2007, 3% 2008-2012, 5% starting in 2013, per Law No. 11,097/2005.

28 Law 11,097/2005 introduced biodiesel into the Brazilian energy matrix, though BNDES Resolution No. 1,135/2004 established its Financial Assistance and Investment in Biodiesel Program (IPEA 26 May 2010, 23). From 2005 to 2009, through its Programa Biodiesel, BNDES provided R$9.156 billion to 47 programs or actions related to biodiesel, including energy generation (R$520 million), bioelectricity (R$580 million), marketing (R$627 million), agriculture and industry (R$2.406 million), and credit for industry, commerce and services (R$3.295 million) (*ibid.*, 32-33).

biodiesel in Brazil jumped from 69 million to 1.167 billion liters, placing Brazil fourth in world production, behind only Germany (3.193 billion liters), the U.S. (2.644 billion liters), and France (2.063 billion liters) (*ibid.*, 27).

Growth in biodiesel is good news for Brazil's energy-related GHG emissions profile, but its effects on land use and its consequent potential to contribute to GHG emissions from deforestation means that enthusiasm over biodiesel's overall greenness must be tempered. Indeed, if biodiesel production grows considerably in the long run, the potential for an increase in deforestation in the Amazon is alarming. Area devoted to the planting of soybeans in Brazil has increased from 6.9 million hectares in 1976 to an estimated 24.2 million hectares today, of which 6.4 million hectares are in Mato Grosso state, one of the two leading Amazon deforesters after Pará (to put this in perspective, in 1976 Mato Grosso had only 310,000 hectares under soybean cultivation) (CONAB 2011 data).

As the world market for ethanol grows, and as new technologies to extract biodiesel from soybeans and bovine fat are developed and implemented, agroenergy is likely to contribute more directly to deforestation than it currently does. This, in turn, will partially offset ethanol biodiesel's potential contribution to reducing Brazil's GHG emissions.

4.4 Hydropower

Finally, hydropower presents another paradox in Brazil's quest for green growth: Hydropower has the third largest share in Brazil's domestic energy supply (Table 1 above), and is essential if domestic electricity generation is to meet growing demand over the coming decades (OECD/IEA 2006, 9-10). However, large hydropower projects in the water-rich Amazon require that massive tracts of land be deforested – with the corresponding release of massive amounts of GHGs – and dams may damage ecosystems upstream and downstream by altering river flows.

Brazil's 852 hydroelectric plants produce 72.5% (79,182.3 MW) of Brazil's domestic electricity supply, and 311 new plants are under construction (potentially adding another 15,336.7 MW) (IPEA 2010, 137). The Bi-National Itaipú Dam, whose management is shared between Brazil and Paraguay, alone "accounts for 20 percent of the Brazilian energy supply, providing most of the energy consumed in the country's Southeastern region," Brazil's industrial hub (Sennes and Narciso 2009, 47-48).

Hydropower is key to the Brazilian government's renewable energy strategy, but it is one that in some cases generates opposition from the domestic and international environmental movements. This is the case of a proposed mega-dam on the Xingú River in eastern Pará. If constructed, the Belo Monte dam will be the world's third largest, and the Brazilian government estimates that it will produce 11,200 MW of electricity (Inter-American Dialogue 2011). However, to build the dam will require the displacing of local indigenous communities, and the logging and flooding of 400 km2 of currently standing forest – a process that is expected to generate "enormous quantities of methane" (Amazon Watch 2011). Finally, dam construction will attract an estimated 100,000 migrants to the region, which will exacerbate deforestation problems there, as dam construction is only expected to create 40,000 new jobs – the rest of the migrants will likely become loggers and cattle ranchers (Amazon Watch 2011). Worse, critics argue that the Belo Monte dam will only produce 10% of its expected annual mega-wattage during the 3-5 month long dry season – or only 39% of its nominal annual capacity (Amazon Watch 2011). Thus, Belo Monte's long-run clean energy generating potential may be canceled out by its up-front environmental impacts.

It is still unclear if the dam will be built, but what becomes clear in the debate over Belo Monte is that the green benefits of hydropower are contingent on the ecological vulnerability of surrounding areas.

5 Conclusion

This study has demonstrated that deforestation presents a challenge to prospects for truly green growth in Brazil. Cattle ranching and soybean farming contributed to 25% of Brazil's GDP in 2008, and must continue to grow if Brazil overall is to grow economically (absent major restructuring of its economy). However, agribusiness produces approximately 25% of Brazil's annual GHG emissions, and the industry is a direct driver of deforestation, which produces another 55% of annual GHG emissions. Finally, as stated in the introduction, each option for renewable energy in Brazil may directly or indirectly worsen deforestation rates in the Amazon and Atlantic forests: Soy- and bovine fat-derived biofuels directly affect deforestation rates in the Amazon by making cattle ranching and soybean farming more lucrative; sugar cane-derived ethanol may directly contribute to deforestation in the Atlantic, and indirectly to deforestation in the Amazon by displacing other farming and ranching activities; and the construction of large dams to produce electricity requires deforestation and the flooding of fragile ecosystems. Thus, Brazil faces contradictory imperatives with respect to green growth, and responsible governance by federal and subnational states is necessary to ensure that agro-industrial growth has a minimal impact on the environment.

This study has demonstrated that deforestation presents a challenge to prospects for truly green growth in Brazil.

Brazil will continue to invest in renewable energy and agricultural exports, but to reduce its overall emissions, it must do so in a way that minimizes GHG emissions from deforestation and forest degradation. More consistent environmental law enforcement on the Amazon frontier and other rural areas, and the effective application of punishments for transgressors are necessary to raise the

29 For a detailed historical discussion of the development of public environmental institutions in Brazil since the 1970s, see Hochstetler and Keck (2007) and McAllister (2008).

30 Nevertheless, challenges remain: many protected areas in Brazil lack effective management, most are under ecological pressure from nearby populations, and few states have implemented their ecological-economic zoning plans (IMAZON 2011).

31 At the time, Brazil imported over 80% of its crude petroleum, and the cost was causing economic growth to slow (Hofstrand 2008).

perceived costs of deforestation relative to investments in enhancing agricultural productivity. Compensation mechanisms for avoided deforestation must also be implemented – the federal government, and state governments, may look to Amazonas' *Bolsa Floresta* as a model. Finally, credits for farmers and ranchers must be strictly conditioned on environmental sustainability.

Appendix 1: details of Brazilian anti-deforestation policy

Brazil's environmental laws date back to the 1934 Forest Code. This was Brazil's first attempt to regulate logging and land occupation practices, and was revised in 1965 (Drummond and Barros 2006, 87-89). In 1981, Brazil enacted a National Environmental Policy (*ibid.,* 92), and environmental concerns were later codified in the 1988 Constitution (*ibid*., 96) and in the Environmental Crimes Act of 1998 (*ibid.,* 90). Nevertheless, these laws have often generally been only weakly enforced, and have not effectively prevented illegal deforestation.[29]

In recent years, progress has been made by both the federal and state governments to enhance conservation by gathering information about deforestation from satellite images, increasing the land area under legal environmental protection, and enforcing environmental laws. Federal programs such as Action Plan to Prevent and Control Deforestation in the Legal Amazon (PPCDAM) and the Amazon Protected Areas Program (ARPA) have been implemented in coordination with Amazonian states, and benefit from financial and technical support from federal and state agencies, as well as the World Bank, the Global Environment Facility (GEF), the German Cooperation Fund (KfW), the German Technical Cooperation Agency (GTZ), and others (Soares-Filho et al. 2009, 11 fn. 11). These initiatives involve collecting and analyzing satellite data, promoting environmentally sustainable economic activities, and undertaking institutional reforms and ecological-economic zoning (to determine what lands need to be protected, and what lands can be cultivated); and, in the case of ARPA, creating 340,000 km^2 of new environmentally protected areas in the Amazon from 2003 to 2009 (IMAZON 2011, 23).[30] Finally, in 2008 Brazil enacted a National Climate Change Plan, which includes the ambitious goal of eliminating deforestation by 2040. The plan is currently in the early stages of implementation (Governo Federal 2008).

In conjunction with the aforementioned federal programs, some states have implemented their own plans to promote green growth by reducing deforestation: Acre and Amazonas have both sought to create or expand markets for sustainably produced forest products, in an attempt to offset smallholders' incentives to deforest. Acre's program began in the 1990s, and has focused on implementing extractive reserves and creating markets for forest products (Kainer et al. 2003); Amazonas' began in 2003, and builds on the state's longstanding Free Trade Zone of Manaus to create a "Green Free Trade Zone," in which producers of sustainable forest products have greater market access and can fetch better prices than before. As of 2008, Amazonas has also enacted a program to pay poor families for not deforesting their lands – a program based on Reduction of Emissions from Deforestation and Forest Degradation (REDD) principles and called *Bolsa Floresta* (Forest Basket) (Viana 2009). *Bolsa Floresta* supports families with US$25/month direct payments via debit cards, and benefited 6,325 families in 2009 (Viana 2010, 38). *Bolsa Floresta* also provides funding for various social programs and sustainable income generating programs (Viana 2009; 2010, 38-42). In conjunction with green free trade and income support, since 2003 the government of Amazonas has greatly expanded the state's network of environmentally protected areas (CEPAL 2007, Viana 2010), which now covers 23.5% of the state's territory (IMAZON 2011, 21).

There are limitations, however, to the contributions to deforestation reduction in Acre and Amazonas: the worst deforestation rates occur in Mato Grosso, Pará, and Rondônia, while Acre and Amazonas already have relatively low rates of forest clearing – 2,636 km2 in Amazonas and Acre in 2003 (the year Amazonas began its sustainable development program), versus 21,147 km2 in Mato Gross, Pará, and Rondônia that same year (INPE 2011). In contrast to Acre and Amazonas, whose rural areas are largely populated by traditional populations (including rubber tappers, fishing communities, and indigenous tribes) and a comparatively small cattle ranching sector, Mato Grosso, Pará, and Rondônia have large, organized beef and soy industries in their countrysides, with an interest in expanding the territory available for production. These states have unsurprisingly been slower to enact policies to reduce deforestation, though recently Pará passed a state plan (Governo do Estado do Pará 2009), and the former governor of Mato Grosso, Blairo Maggi – a soy mogul and longtime enemy of conservation – recently embraced the environmental cause (Patury and Edward, 16 September 2009).

Appendix 2: A brief history of Brazil's ethanol industry

Brazil has been producing sugar cane-based ethanol since the 1920s (IPEA 26 May 2010, 3), but the development of the modern ethanol industry began with the Pro-Álcool program in 1975, as the Brazilian government sought to secure energy independence by creating alternatives to expensive petroleum imports to power Brazil's industrialization process (IPEA 26 May 2010; Sennes and Ubiraci 2009).[31] Pro-Álcool involved four policies to stimulate ethanol production: A minimum required ethanol purchase by the state-owned oil company, Petrobrás, to create demand; US$4.9 billion in low-interest loans to stimulate ethanol production; subsidies to ensure that ethanol's retail price was 41% lower than gasoline; and a requirement that all fuels be blended with a minimum 22% ethanol (Hofstrand 2008).

Evolution of sugar cane and ethanol productivity

Period		Productivity		
		Agricultural (tons/hectare)	Industrial (liters/ton)	Agro-industrial (liters/hectare)
1977-1978	Initial phase of Pro-Álcool: Low efficiency in the industrial process and in agricultural production	65	70	4,550
1978-1988	Consolidation of Pro-Álcool: Agricultural and Industrial Productivity Increase Significantly	75	76	5,700
1989-2004	Process of production operates with best available technology	85	80	6,800
2005-2010*	First Stage of Process Optimization	81	86.2	6,900
2010-2015*	Second Stage of Process Optimization	83	87.7	7,020
2015-2020*	Third Stage of Process Optimization	84	89.5	7,160

Table 2: Evolution of sugar cane and ethanol productivity in Brazil.

Source: IPEA (26 May 2010, 13)
Note: *Estimates

Pro-Álcool's policies stimulated both production and demand: ethanol production grew rapidly, and sales of domestically-produced automobiles that ran exclusively on ethanol reached 85% of total automobile sales in Brazil by 1985. Unfortunately, in that year oil prices dropped and in 1986, the newly democratic government removed ethanol subsidies, which reduced ethanol producers' profit margins. By 1989, consumers faced ethanol shortages at the pump, and sales of ethanol-only cars plummeted to only 11.4% of total car sales in 1990.

Over the course of the 1980s and 1990s, the Brazilian government deregulated the ethanol sector, and in 2001 state market controls were completely removed (IPEA 26 May 2010, 4). Nevertheless, during that time the government continued to require that all gasoline contain 20% ethanol, thus maintaining a market for the industry (Levi et al. 2010, 77). Demand and production began to rise again in 2003, with the advent of flex-fuel cars, whose engines can run on any combination of petroleum gasoline and ethanol (IPEA 26 May 2010, 3-4). By 2007, over 70% of new cars purchased in Brazil were flex-fuel cars, and ethanol-only cars have virtually disappeared from the market (Hofstrand 2008). Almost all gas stations in Brazil now sell both petroleum-based gasoline and ethanol, and demand for flex-fuel cars continues to grow, while demand for gas- or ethanol-only cars is declining in Brazil: from 2004 to 2008, sales of flex-fuel cars rose from 328,380 to 23.3 million, while sales of gas-only cars fell from over 1 million to 217,000 (IPEA 26 May 2010, 5). Since the advent of flex-fuel cars, the ethanol industry has grown, and there are now 434 ethanol distilleries in operation in Brazil (IPEA 26 May 2010, 14).

As countries around the world have become concerned about global warming and instability in the oil-producing countries of the Middle East, international demand for ethanol has grown. Although the U.S. has a domestic corn-based ethanol industry, and imposes tariffs on Brazilian ethanol, it imported 453 million gallons of Brazilian ethanol in 2006, and 185 million gallons in 2007 (out of total U.S. ethanol imports of 731 and 439 million gallons, respectively, in 2006 and 2007) (Hofstrand 2008). In fact, the United States is Brazil's largest ethanol export market, accounting for 47% of exports in the 2006/7 harvest year, while the next largest market, Holland, accounted for only 11% (Hofstrand 2008).[32] Production for the domestic market is also rising, from just over 5 billion gallons in 2006 to just under 6 billion gallons in 2007.[33]

Concurrent with the rise in demand for ethanol, technological changes have increased the sector's productivity, as shown in Table 2 below:

These productivity increases have been made possible in part by the growing profitability of the industry, but also by new government investments in ethanol: the Brazilian state currently provides price guarantees to maintain ethanol's competitiveness in the domestic market, and requires minimal blending of 25% with petroleum-based gasoline. The state also finances the ethanol sector through BNDES – indeed, the sugar-alcohol sector is one of the largest borrowers from BNDES in Brazil. The bank provided R$6 billion in loans to the sector in 2009 (up from R$1.97 billion in 2006). Meanwhile, Petrobrás Biocombustíveis – a subsidiary of the national oil company, Petrobrás – seeks to control 15% of the ethanol market, and to invest R$500 million in the sector through 2013. Finally, Brazil's Decennial Energy Expansion Plan estimates that by 2017 R$147 billion will be invested in biomass energy from sugar cane bagasse and *capim elefante*

32 In 2009 and 2010, the trade relationship was reversed: Brazil imported ethanol from the U.S. because adverse weather conditions reduced the size of Brazil's sugar cane crop in those years (Crooks and Meyer 2011).

33 The potential to use ethanol as a base for a new generation of biofuels known as "drop-in fuels" is also driving partnerships between Brazilian ethanol firms and international investors, including oil companies and other investors. For instance, Brazil's third-largest sugar producer, Cosan, has established a joint venture with Anglo-Dutch oil company Shell and the California-based alternative-fuels firm Codexis to explore the possibility of using sugar cane as a base for drop-in fuel, a hydrocarbon derived from plants that may someday replace fossil fuel-based hydrocarbons (*Economist* 28 October 2010).

34 Capim elefante is a type of grass used in biomass, introduced into Brazil from Africa in the 1920s (Carbonovo do Brasil 2009).

35 Optimism is not universal: Hira and Oliveira (2009, 2455) counter that the mechanization of sugar cane harvesting to reduce emissions from burning the sugar cane at harvest time has "…created massive unemployment among labourers in the industry of up to 100,000 of a total of 1.2 million workers…."

(IPEA 26 May 2010, 16).[34] In terms of socio-economic development, UNICA (the Brazilian National Sugar Cane Industrial Association) estimates that the sugar cane and ethanol sector generates from 588,000 to 1.4 million jobs, accounting for seasonal variation (though salaries are on average lower than in the petroleum sector) (*ibid.*, 16-17).[35]

State support is related not only to growing demands for renewable fuel sources, but also to the Brazilian government's continued concern for energy independence and its growing role as a leader in Latin American energy integration efforts (IPEA 25 May 2010, 7; Ubiraci and Narciso 2009). The Brazilian government has also actively advocated for global standards for ethanol and biofuels in international forums, to ensure continued international market space for ethanol and the country's small, but growing, biodiesel industry (IPEA 26 May 2010, 7; Levi et al. 2010, 79).

Works Cited

Amazon Watch. 2011. "Amazon Watch >> Stop the Belo Monte Monster Dam." Accessed April 5. http://amazonwatch.org/work/belo-monte-dam.

Baer, Werner. 2008. The Brazilian Economy: Growth and Development. Boulder: Lynne Rienner Publishers.

Banco Mundial (World Bank). 2010. Estudo de Baixo Carbono para o Brasil – Relatório de Síntese Técnica - Energia. Washington, D.C.: World Bank.

Banco Mundial (World Bank). 2010. Estudo de Baixo Carbono para o Brasil – Relatório de Síntese Técnica – Uso da Terra, Mudanças do Uso da Terra e Florestas. Washington, D.C.: World Bank.

Barreto, Paulo, Andréia Pinto, Brenda Brito, and Sanae Hayashi. 2008. Quem é dono da Amazônia? Uma análise do recadastramento de imóveis rurais. Belém, Pará: Instituto do Homem e Meio Ambiente da Amazônia (IMAZON).

Barreto, Paulo, Marília Mesquita, Elis Araújo, and Brenda Brito. August 2009. "Impunity for Environmental Violations in Protected Areas of the Amazon." IMAZON State of the Amazon 13: 1-6.

Barros, Geraldo. 2009. "Brazil: The Challenges in Becoming an Agricultural Superpower." Chapter 4 in Brazil as an Economic Superpower? edited by Lael Brainard and Leonardo Martínez-Díaz. Washington, D.C.: The Brookings Institution Press, pp. 81-109.

"BB vai negar crédito para soja de áreas desmatadas." 2 December 2010. Valor Econômico Online. Accessed 2 December 2010. http://www.valoronline.com.br/impresso/agronegocios/105/345893/bb-vai-negar-credito-para-soja-de-areas-desmatadas.

Binswanger, Hans. 1991. "Brazilian Policies that Encourage Deforestation in the Amazon." World Development 19(7): 821-829.

Brooks, Bradley. 2011 (25 May). "Brazil's lower house approves looser forest protections." The Washington Post. Accessed 26 May 2011. http://www.washingtonpost.com/world/brazils-lower-house-approves-looser-forest-protections/2011/05/25/AGgXnaBH_story.html.

Business News Americas. 16 March 2011. "Minerva to launch fat-based biodiesel production plant." Accessed: 19 May 2011. BNamericas.com.

Carbonovo do Brasil. 2009. "Capim Elefante." Accessed 23 May 2011. http://www.carbonovo.com/capim-elefante/.

CEPAL (U.N. Economic Commission for Latin America and the Caribbean). 2007 (June). Análise Ambiental e de Sustentabilidade do Estado do Amazonas. Santiago, Chile: Nações Unidas.

CONAB [Companhia Nacional de Abastecimento]. 2011. National Data on Soybean Production. Accessed 13 May 2011. http://www.conab.gov.br/.

Crooks, Ed, and Gregory Meyer. 5 May 2011. "Brazilian Imports of U.S. Ethanol Soar." Financial Times. Accessed May 7, 2011. http://www.ft.com/cms/s/0/f1486874-775d-11e0-824c-00144feabdc0.html#axzz1LigC9tjf.

Drummond, José Augusto, and Ana Flávia Barros-Platiau. 2006. "Brazilian Environmental Laws and Policies, 1934-2002: A Critical Overview." Law & Policy 28(1): 83-108.

Economist, The. 28 October 2010. "The Future of Biofuels: The Post-Alcohol World." Accessed May 7, 2011. http://www.economist.com/node/17358802?story_id=17358802.

EPE [Empresa de Pesquisa Energética, Ministério de Minas e Energia]. 2010. Balanço Energético Nacional 2010. Brasília, D.F.: Ministério de Minas e Energia.

"Ex-secretário de meio ambiente do Pará e mais 32 pessoas são denunciados por corrupção." 19 December 2008. Press release of the Procuradoria da República no Pará. Accessed 18 May 2009. http://www.prpa.mpf.gov.br/noticias/ex-secretario-de-meio-ambiente-do-para-e-mais-32-pessoas-sao-denunciads-por-corrupcao.html

Fearnside, Philip M. 2001. "Soybean Cultivation as a Threat to the Environment in Brazil." Environmental Conservation 28(1): 23-38.

Garma, Florencio. 9 October 2009. "Brasil: Principales frigoríficos comprometen con la 'deforestación cero' en el Amazonas." TuVerde.Com. Accessed 13 May 2011. http://www.tuverde.com/2009/10/brasil-principales-frigorificos-se-comprometen-con-la-%E2%80%9Cdeforestacion-cero%E2%80%9D-en-el-amazonas/.

Governo Federal do Brasil. 2008. Plano Nacional sobre Mudança do Clima. Brasília, D.F.: Governo Federal, Comitê Interministerial sobre Mudança do Clima.

Greenpeace. 17 June 2008. "Landmark Amazon soy moratorium extended." Accessed 15 May 2011. http://www.greenpeace.org/usa/en/news-and-blogs/news/landmark-amazon-soya-moratoriu/.

Greenpeace. July 2009. Slaughtering the Amazon. Amsterdam: Greenpeace International.

Governo do Estado do Pará. 2009 (March). Plano de Prevenção, Controle, e Alternatives ao Desmatamento. Belém, Pará: Governo do Estado do Pará.

Hira, Anil, and Luize Guilherme de Oliveira. 2009. "No Substitute for Oil? How Brazil Developed its Ethanol Industry." Energy Policy 37: 2450-2456.

Hofstrand, Don. 2008. Brazil's Ethanol Industry. Agricultural Marketing Resource Center. Accessed: 10 May 2011. http://www.agmrc.org/renewable_energy/ethanol/brazils_ethanol_industry.cfm.

Hochstetler, Kathryn and Margaret E. Keck. 2007. Greening Brazil: Environmental Activism in State and Society. Durham: Duke University Press.

Huberty, Mark, Huan Gao, Juliana Mandell, and John Zysman. 2011. Shaping the Green Growth Economy – Executive Summary. Prepared for The Pathways Project, U.C. Berkeley, 31 March.

IMAZON [Instituto do Homem e Meio Ambiente da Amazônia]. 2011. Áreas Protegidas na Amazônia Brasileira: Avanços e Desafios. Belém, Pará: Instituto do Homem e Meio Ambiente da Amazônia.

INPE (Instituto Nacional de Pesquisas Espaciais). 2011. Prodes Taxas Anuais (Annual Amazon Deforestation Data). Accessed 8 May 2011. http://www.obt.inpe.br/prodes/prodes_1988_2010.htm.

Inter-American Dialogue. 2011. "Will the Belo Monte Dam's Benefits Outweigh the Costs?" Latin America Advisor, March 10.

IPEA (Instituto de Pesquisas Econômicas Aplicadas). 2010. Sustentabilidade Ambiental no Brasil: Biodiversidade, Economia e Bem-Estar Humano. Brasília: IPEA.

IPEA. 26 May 2010. "Biocombustíveis no Brasil: Etanol e Biodiesel." Comunicados do IPEA No. 53. Brasília: IPEA.

La Rovere, Emilio Lèbre, André Santos Pereira, and André Felipe Simões. 2011. "Biofuels and Sustainable Energy Development in Brazil." World Development 39(6): 1026-1036.

Levi, Michael A., Elizabeth C. Economy, Shannon K. O'Neil, and Adam Segal. 2010. Energy Innovation: Driving Technology Competition and Cooperation Among the U.S., China, India, and Brazil. New York: Council on Foreign Relations.

Lucon, Oswaldo, and José Goldemberg. 2010. "São Paulo – The 'Other' Brazil: Different Pathways on Climate Change for State and Federal Governments." The Journal of Environment & Development 19(3): 335-357.

Luíse, Desiree. 17 March 2011. "Carta Verde: Corrupção é algo crônico em Secretarias do Meio Ambiente na Amazônia, diz ex-secretário." Carta Capital. Accessed 15 May 2011. http://www.cartacapital.com.br/carta-verde/corrupcao-e-algo-cronico-em-secretarias-de-meio-ambiente-na-amazonia-diz-ex-secretario.

Luna, Francisco Vidal, and Herbert S. Klein. 2006. Brazil Since 1980. New York: Cambridge University Press.

MAPA (Ministério da Agricultura, Pecuária e Abastecimento). 2010. Anuário Estatístico de Agroenergia 2010. Brasília: MAPA. Accessed 8 May 2011. http://www.agricultura.gov.br/arq_editor/file/Desenvolvimento_Sustentavel/Agroenergia/anuario_agroenergia/index.html#.

Margulis, Sergio. 2004. Causes of Deforestation in the Brazilian Amazon. Washington, D.C.: World Bank Working Paper No. 22.

McAllister, Lesley K. 2008a. Making Law Matter: Environmental Protection and Legal Institutions in Brazil. Stanford, CA: Stanford Law Books.

McAllister, Lesley K. 2008b. "Sustainable Consumption Governance in the Amazon." ELR 38: 10873-10881.

McKinsey & Company. March 2009. Pathways to a Low-Carbon Economy for Brazil. São Paulo, Brazil: McKinsey & Company.

MME (Ministério de Minas e Energia, Brasil). 2009. Balanço Energético Nacional 2009: Análise Energética e Dados Agregados. Brasília: MME, pp. 10-16.

Nassar, André Meloni. 2009. "Brazil as an Agricultural and Agroenergy Superpower." Chapter 3 in Brazil as an Economic Superpower?, edited by Lael Brainard and Leonardo Martínez-Díaz. Washington, D.C.: The Brookings Institution, pp. 55-80.

Nepstad, Daniel, Claudia M. Stickler, and Oriana T. Almeida. 2006. "Globalization of the Amazon Soy and Beef Industries: Opportunities for Conservation." Conservation Biology 20(6): 1595-1603.

Nepstad, Daniel C., Claudia M. Stickler, Britaldo Soares-Filho, and Frank Merry. 2008. "Interaction Among Amazon Land Use, Forests and Climate: Prospects for a Near-Term Forest Tipping Point." Philosophical Transactions of the Royal Society B 363: 1737-1746.

Noronha, Gustavo Souto de. 2011 (24 May). "O repúdio dos ex-ministros ao novo código florestal." Luis Nassif Online. Accessed 24 May 2011. http://www.advivo.com.br/blog/luisnassif/o-repudio-dos-ex-ministros-ao-novo-codigo-florestal

O Estado de São Paulo. 3 June 2009. "Aprovado projeto de regularização fundiária da Amazônia." Accessed 10 May 2011. http://www.estadao.com.br/noticias/nacional,aprovado-projeto-de-regularizacao-fundiaria-da-amazonia,381895,0.htm.

OECD (Oraganization for Economic Cooperation and Development)/IEA (International Energy Agency). 2006. The Energy Situation in Brazil: An Overview. Paper prepared for the Standing Group on the Global Energy Dialogue. OECD/IEA (May).

Patury, Felipe and José Edward. 16 September 2009. "A Metamorfose de Blairo." Veja.com. Accessed 14 May 2011. http://veja.abril.com.br/160909/metamorfose-blairo-p-88.shtml.

Roett, Riordan. 2010. The New Brazil. Washington, D.C.: The Brookings Institution.

Rosa, Luiz Pinguelli, Christiano Pires de Campos, and Maria Silvia Muylaert de Araujo. 2009. "Biofuel Contribution to Mitigate Fossil Fuel CO2 Emissions: Comparing Sugar Cane Ethanol in Brazil with Corn Ethanol and Discussing Land Use for Food Production and Deforestation." Journal of Renewable and Sustainable Energy 1(033111): 1-21.

Sennes, Ricardo Ubiraci and Thais Narciso. 2009. "Brazil as an International Energy Player." Chapter 2 in Brazil as an Economic Superpower?, edited by Lael Brainard and Leonardo Martínez-Díaz. Washington, D.C.: The Brookings Institution, pp. 17-54.

Soares-Filho, Britaldo Silveira, Laura Dietzsh, Paulo Moutinho, Alerson Falieri, Hermann Rodrigues, Erika Pinto, Cláudio C. Maretti, Karen Suassuna, Carlos Alberto de Mattos Scaramuzza, and Fernando Vasconcelos de Araújo. 2009(?). Reduction of Carbon Emissions Associated with Deforestation in Brazil: The Role of the Amazon Region Protected Areas Program (ARPA). WWF-Brasil, WWF-U.S., IPAM, Universidade Federal de Minas Gerais, The Woods Hole Research Center.

Viana, Virgílio. 2009 (November). "The Costs of REDD: Lessons from Amazonas." IIED Briefing. London: International Institute for Environment and Development.

Viana, Virgílio M. 2010. Sustainable Development in Practice: Lessons Learned from Amazonas. London: International Institute for Environment and Development.

World Bank. 2008. Environmental Licensing for Hydropower Projects in Brazil: A Contribution to the Debate – Summary Report. Washington, D.C.: World Bank.

TAKE LEAD, OCTOBER 12-13TH, 2011 COPENHAGEN

The arguments for green growth go beyond climate, the environment and energy security. Green growth has the potential to fundamentally transform the economy. Remembering the effect American railroads had on European grain prices and the effect the Internet had on e.g. the book-, travel-, and media industries is the first step towards understanding the green growth economy. Ahead of us lie entirely new ways of creating prosperity, employment and quality of life with the cleantech sector having provided us with the tracks towards a sustainable economy. This is where we will Take Lead

At Take Lead you will:

- Gain an exclusive overview of what is shaping the green economy
- Discover new green growth opportunities for cities and businesses.
- Meet the architects of the green economy
- Learn more about the benefits of green growth.
- Share your visions with key decision makers in the world

A series of reports will secure the latest knowledge in the field of green growth and act as a platform for the discussions.

The results of the discussions – along with your input – are gathered in the report “State of the Green Economy” and will feed into global decision making forums such as EU, C40, Rio+20 and UN Global Compact.

To apply for an invitation please contact Ms Solvej Karlshøj Christiansen **skc@mm.dk**
Find out more about Green Growth Leaders and Take Lead visit **www.greengrowthleaders.org**

Green Growth Leaders is founded by