



Rethinking Fossil Fuels

**THE NECESSARY STEP TOWARD PRACTICAL
CLIMATE POLICY**

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If we are to stabilize global greenhouse gas (GHG) emissions, the world's largest current emitter – the United States – along with other industrialized countries must radically curtail the emission of GHGs, most notably carbon dioxide (CO₂). This means that our current primary energy sources – which drive both the electricity and transport sectors in the United States, and are responsible for carbon dioxide emissions – must change. But change to what and how?

These two questions, what and how, are at the core of the domestic and, to a large extent, international policy debate about climate policy. What changes to the electricity and transport sectors are practical, technically feasible, and economically and politically viable over the next several decades? Given we can answer the first question, how do we formulate a constellation of domestic and international policies that will provide the proper incentives to undertake the desired changes?

These questions are quite a bit different from the issues surrounding international discussions of the Kyoto Protocol or domestic debates over tailpipe standards in California and federal greenhouse gas legislation like that introduced by Senators John McCain and Joseph Lieberman. While these other discussions concern near-term reductions in greenhouse gas emissions, the questions posed here relate to the fundamental problem of providing the incentives and resources necessary to transform the global energy system over the next half-century.

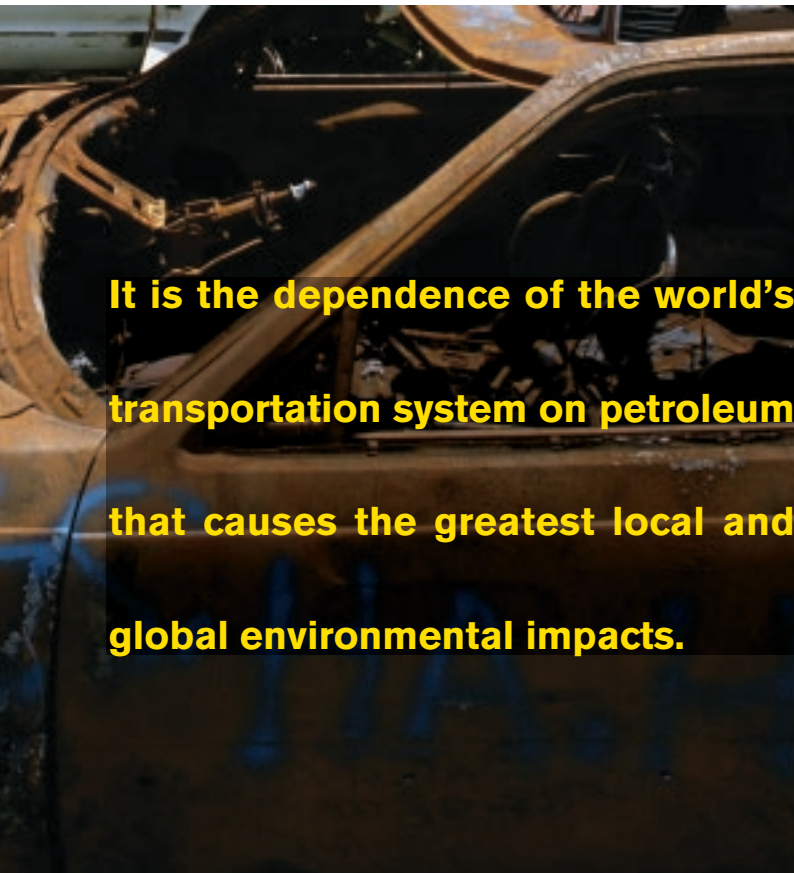
Rethinking Coal

For many the answer to the “what” question is obvious. We must dramatically reduce reliance on fossil fuels, especially coal and petroleum, and expend the resources necessary to develop and deploy noncarbon energy technologies, namely renewables. As the old saying goes, “easier said than done.” Current reliance on coal and oil is the result of past and present economics and technology, and the answer to the “what” question requires us to rethink our approach to these fuels.

Rethinking fossil fuels begins with coal and recognition of these facts: there is a lot of coal, it is spread widely around the globe, and it’s cheap. Add to this the political clout that coal interests have in the United States—and a perception that the Chinese are anxious to use their coal reserves and fear growing dependence on foreign oil—and you have a picture of two very important CO₂ emitters that are wedded strongly to coal. While renewables such as wind, solar, and biomass will likely be a part of the energy future, the coal reality—its abundance, price, and political power—suggests that it is naïve to think of a world where coal is not a large part of the energy system.

The problem with coal is the harmful by-products released into the atmosphere when it is burned. Of these, CO₂ is the most significant global pollutant, but mercury, sulfur dioxide, nitrogen oxides, and particulates cause serious problems as well. A sensible solution exists: avoid burning coal directly and convert it to natural gas instead, using oxygen and steam, then clean it of impurities such as mercury and sulfur. The natural gas can be further processed to increase its hydrogen content and convert carbon monoxide to carbon dioxide. This CO₂ can then be separated and stored underground while the remaining hydrogen is used for carbon-free electricity generation.

At present, there are no actual demonstrations of this process, and it sounds a bit like science fiction. But we do know how to make this work. What we don’t know is how to



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do this on a grand scale and do it cheaply. If the technology—everything from the gasification, to the CO₂ separation and storage, to hydrogen production—could be commercialized and available at a competitive cost, coal can be an environmentally benign and important part of the world's energy future. Of course, simultaneous research would have to be done to improve the environmental impact and safety of coal mining itself.

Rethinking Petroleum


Transportation and petroleum use poses a number of important public policy questions ranging from local issues such as traffic congestion, land use, and highway safety to international ones such as foreign policy and of course global climate change. When rethinking petroleum, three facts must be kept front and center.

First, from the perspective of climate policy, all issues concerning transportation revolve around fuels, and, at present, that fuel is petroleum. It is the dependence of the world's transportation system on petroleum that causes the greatest local and global environmental impacts.

Second, the transportation sector is growing in virtually every corner of the world and with it, the combustion of petroleum and resultant emissions. Without a doubt, the greatest growth is in the developing world, with China leading the way. In the decade of the 1990s, China doubled its petroleum consumption. Even in the developed countries of the European Union, where gasoline is highly taxed, aggressive programs to increase fuel efficiency and subsidize public transportation are, at best, flat with respect to petroleum consumption during the same decade. In some countries, like France and Germany, consumption has in fact increased.

Third, one does not simply switch quickly to another more environmentally friendly transportation fuel. Both vehicles and the necessary infrastructures are designed solely around petroleum and internal combustion engines using gasoline and diesel. From a technical point of view, there is no alternative fuel ready for prime time. The hope that battery-powered electric vehicles would be the wave of the future seems to have faded, along with the visions of a vehicle fleet powered by compressed natural gas. The jury is still out with respect to the feasibility of large-scale transformation of waste products and crops other than corn into fuels, also called second-generation biomass. Even if vehicles can be created that use an alternative fuel in a reasonable amount of time, the petroleum infrastructure (oil fields, pipelines, refineries, and retail outlets) represents an enormous amount of very long-lived capital.

What is on the table are alternatives, like hydrogen, fuel cells, and electric motors. Existing electric motor technology is sufficient for our needs. If we have hydrogen, the missing piece of technology is the fuel cell that turns hydrogen into electricity to drive the motors, along with a cost-effective way to store hydrogen on vehicles. Fortunately, fuel cell research is on an upswing. To be sure, there are difficult technical issues to master, but the future seems bright. It appears the truly difficult technical part will be the development of safe and low-cost on-board hydrogen storage.



If stabilizing greenhouse gas emissions is our goal – and it is a worthy goal to strive for – we had better be prepared for the long haul.

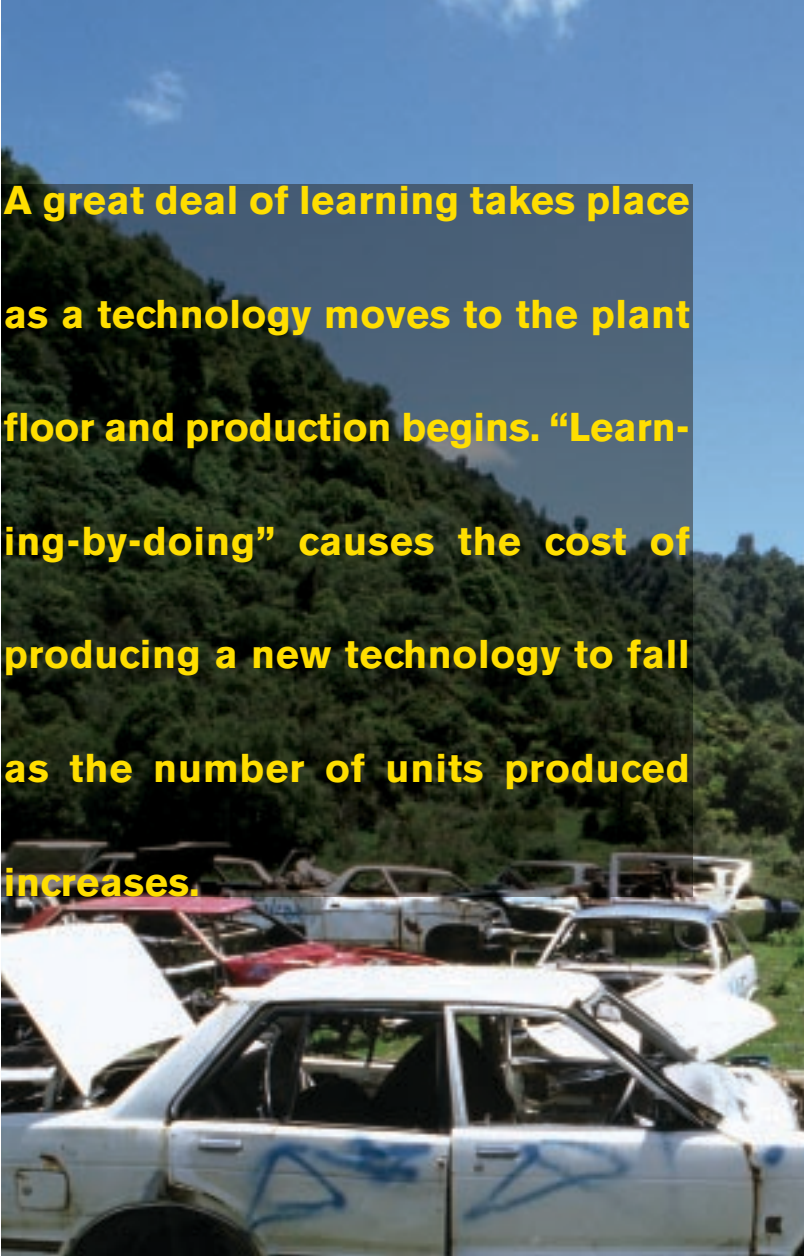
The next technological challenge will be bringing hydrogen to the marketplace. Moving and storing hydrogen is not as easy as petroleum. We may need entirely new pipeline systems (although some portions of the existing natural gas transmission system may work), distribution networks, and of course hydrogen stations. To complicate matters, hydrogen will displace petroleum as a transport fuel slowly as the internal combustion engine stock (namely, billions of cars and trucks) rolls over to fuel cell electric motors and as the hydrogen transportation system develops. So, at the same time we will have petroleum competing with hydrogen in the marketplace.

There may be as many answers to the “what” question as there are technologists. For example, there is much talk about production of hydrogen by electrolysis using nuclear power as the ultimate hydrogen production method. Similarly, second generation biomass liquid fuels hold real potential. There are those who argue that conservation combined with enhanced end-use efficiency will reduce energy needs enough that they can be met by wind and solar. All of these areas deserve further investigation. But the facts surrounding two of the three dominant fossil fuels remain. Coal’s low market cost and abundance make it difficult if not impossible to ignore, and petroleum’s current preeminent position as the only viable transport fuel suggests its environmental problems will remain with us (and perhaps get worse) unless we find a suitable alternative.

The Obstacles Ahead

Moving the U.S. energy system (that is, the electric power and transport sectors) to a coal-driven hydrogen future faces a series of obstacles. The country has a sizable investment in carbon-based energy technologies. Scrapping that capital precipitously and replacing it with something else will cost a significant amount of money. And, with a few exceptions, a good portion of the hydrogen technology needed is still on the drawing board. Thus, the dilemma is twofold: how to not only bring down the price of delivered hydrogen to a point where it is competitive with natural gas in electricity generation and with petroleum in transport, but also how to bring the cost so low that it will cause a rapid turnover in the existing energy-related capital stock.

To accomplish this feat, a new, integrated energy policy must do the following: hasten the development and commercialization of the necessary technologies, reduce their cost, and provide incentives to the private sector to replace the current carbon-based capital with the new hydrogen capital before the existing stock is fully depreciated. Funds will



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have to be directed to research and development (R&D) and spread across a number of different technologies ranging from coal gasification to hydrogen generation, among others. Each technology will have a different pace of development, so funding policies should be targeted differently to each technology or class of technologies.

Spurring R&D

While government may in fact undertake some of this research (perhaps through the system of National Laboratories run by the Department of Energy), the bulk of the R&D must be accomplished by the private sector. One might then ask why government policies are necessary for the private sector to undertake this work. The answer is quite straightforward. Absent any government policy, there are simply no incentives for the private sector to make the large investments needed to transform the energy system. Environmental problems

aside, from a business perspective the current carbon-based energy system functions fairly well, and few firms would make massive investments to change it without external pressure.

Some would argue that all that is needed is for the government to “get the prices right,” that is, set a price on carbon emissions either through a carbon tax or a cap-and-trade permit system and let the private sector react to the price signal. This view makes sense and should be part of a portfolio, but if a single, price-based policy had to do all the “heavy lifting” the resulting high price would be politically unacceptable.

It is common knowledge that commercial firms underinvest in R&D because they are never able to appropriate all the benefits for themselves. This “market failure” is the primary justification for government policy to stimulate R&D in private markets through such things as tax incentives, grants, and private–public partnerships, as well as government support of research at universities and other public institutions. While firms would no doubt increase their R&D expenditures in carbon-free technologies in response, say, to a \$100/ton carbon tax, they would be investing less than the socially optimal amount. Rather than raise the tax to, say, \$200 to bring forth more R&D, it is more efficient from a policy perspective to augment the tax with other policies that induce firms to invest more in R&D.

Learning by Doing

Once nearly commercialized technologies are available, a second set of policies is needed to buy down their cost. History has revealed that a great deal of learning takes place as a technology moves to the plant floor and production begins, and this learning lowers cost. This phenomenon, called learning-by-doing, causes the cost of producing a new technology (say a fuel cell) or the cost of production from a new technology (for example, tons of hydrogen from coal gasification) to fall as the number of units produced increases. A variety of these buy-down policies can be put in place to expand the production rates for new technologies, thereby lowering their cost and hastening the time when they can compete in the marketplace. These policies usually take the form of government purchase commitments or a subsidy, where the subsidy is used to lower the cost of production in the future.

Perhaps the most important part of this three-policy trilogy in getting the “prices right” is a carbon cap and tradable permit system. This policy acts to alter the economic playing field by disadvantaging carbon-emitting energy sources, causing their cost to rise, and thereby promoting carbon-free

sources. Lowering the cost of the latter will help “pull” the nascent coal-to-hydrogen technology and all its other components (carbon separation and storage, fuel cells, and hydrogen-based transportation infrastructure) into the commercial marketplace.

Also, a system in which carbon permits are auctioned by the government provides the crucial revenues to fund the likely expensive and long-lived R&D and cost buy-down policies discussed above. The importance of a dedicated revenue stream to the funding of long-term basic research cannot be understated.

The pull policy alluded to above can act like an accelerator pedal in a car. If new climate science suggests that we must move to a noncarbon energy system more quickly than anticipated, the number of permits is reduced (causing auction revenues to rise). The rising permit price further advantages the commercial adoption of the noncarbon technology while at the same time generating more revenue that can be used to hasten technology development.

If stabilizing greenhouse gas emissions is our goal—and it is a worthy one to strive for—we had better be prepared for the long haul. New technologies such as electric- and hydrogen-powered motors will eventually be readily available. New techniques for deriving energy from coal and other fossil fuels will eventually be standardized and in greater use. Since the transformation of the global energy system to one that emits zero greenhouse gases can be expected to take half a century or more, the sooner the transformation begins, the lower the accumulated greenhouse gases in the atmosphere will be. ■

Raymond J. Kopp, a senior fellow, is an expert in techniques of assigning value to environmental and natural resources that do not have market prices, which he uses in cost-benefit analysis and to assess damage to natural resources.

Further Reading

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