WILLIAM B. BONVILLIAN

Time for Climate Plan B

With the recent political rejection of cap-and-trade carbon policies, the nation needs a new approach that pushes the development of energy technologies and fosters markets for them.

Policymakers in the United States and elsewhere have assumed for 15 years that putting a price on carbon would be an effective strategy for addressing climate change. Nations would price carbon emissions, cap carbon production levels, ratchet down the cap over time, allow carbon emitters to pay for their continued use of carbon but at an ever-increasing cost, and use this market mechanism to price carbon emissions into a steep decline. This market-forcing would spur the introduction of innovative new technologies into energy markets, displacing fossil fuel technologies.

The approach derived from the successful use in the United States of cap-and-trade against acid rain under the Clean Air Act Amendments of 1990. At the Kyoto Framework Convention in 1997, the United States persuaded participating nations that the approach would work worldwide against carbon emissions. The subsequent Kyoto Protocol eventually obtained enough signatures to, in theory, go into effect, and Europe has enacted a cap-and-trade program. However, the biggest carbon emitters—the United States and China—have been AWOL. Concerned policymakers have continued to assume that the United States would adopt carbon cap-and-trade over time and then lure in China and other emerging economies. During the most recent session of Congress, they came close. The House passed cap-and-trade legislation in 2009, but the Senate in 2010 came up short of the votes needed to break a filibuster. In one of those periodic tidal shifts in congressional politics, cap-and-trade worried coal and manufacturing states suffering job losses from the recession and became anathema to many conservatives, indefinitely postponing the legislation.

Remarkably, U.S. policymakers never assembled a backup Plan B for carbon pricing. Although late, now is the time to develop such a plan, because the nation cannot afford to suspend climate efforts for years more in hopes of a congressional consensus.

A new Plan B will need to be more politically viable than the approach recently rejected. Aside from its political vulnerability, cap-and-trade as a stand-alone policy had a structural problem. The acid rain cap-and-trade program in the 1990s was possible because technological solutions were readily available. But few of the technological solutions for climate change are near maturity or ready for deployment on a large scale. The cap-and-trade solution for climate, if prices are set at sound levels, is strong on creating potential markets for innovations (demand pull) but weak on developing needed innovations (technology push) to feed the new markets. The United States will need a program that en-

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compasses technology push as well as new means for demand pull, supporting all the technology stages in between, from research through deployment.

Problems in innovation

To understand why needed technologies have been neglected, it is useful to consider the pattern of innovation in the United States more broadly. Take computers. There was nothing quite like computing before the advent of the computer, which opened up an entirely new economic sector. This is the U.S. way: A comparative advantage in innovation, painstakingly built since World War II, has operated largely at the frontier of innovation, fostering new sectors and new markets. The United States has not been good at incorporating innovation into complex, established sectors. The nation does biotech rather than health care services; it does not go back and innovate in entrenched sectors.

Energy is the poster child for this problem. It is a complex, established sector, reinforced by technological, economic, and political barriers that limit new entry. The first generation of new energy technologies will largely be secondary technologies: components in existing energy systems or platforms. For example, advanced batteries will be built for cars; enhanced geothermal energy will be part of utility systems. This means they will have to be cost-competitive at the moment they attempt to launch into established energy technology markets—a hard task for new technologies. In addition, they must scale up rapidly if they are to make a difference in an energy sector that constitutes more than 10% of the world economy. This profound price/scale problem is why "the moment of market launch" is as important as the traditional "valley of death" problem for new technologies entering established sectors such as energy.

The nation therefore must design a different kind of innovation system for new technologies entering the established energy sector. The system built for information technology assumed that new entrant technologies would be able to command a premium price because they offered a new functionality, then would drive down the production cost curve over time. But because this will not work for largely component-based energy technologies, the nation's innovation system, which historically has been organized to focus on the "front end" of R&D, will also have to focus on the "back end" of demonstrations, test beds, and the creation of initial commercial markets for new energy technologies. Each will reinforce the other: A stronger back end will inform and improve front-end R&D and vice versa.

In moving ahead, building public and political support will be the key. Building such support may require casting some familiar ideas in new ways. For example, many people do not grasp the idea or importance of the changing climate; a Pew survey finds that only 35% of the public in 2009 viewed it as a "very serious problem," and 49% believed that either there is no global warming or it is created by natural causes. But the public does understand the global politics of oil and the economic and political damage it inflicts. The nation's 2008 oil trade deficit approached $400 billion. People know that the relationship between oil supply and the two wars in the Middle East is not a coincidence. Energy security carries political resonance. It offers a potential political driver on the petroleum side of the energy economy, but what about the rest of the energy economy?

As nations such as China build major economic sectors around new energy technologies, the U.S. public is increasingly aware that there are competitive stakes attached to leadership of these new markets. After Japan missed leadership of the information technology innovation wave in the 1990s, its economy never quite recovered. Because the U.S. economy is organized around a comparative advantage at the innovation frontier, if it misses an innovation wave the results will be problematic. Expert observers anticipate that energy will be the center of the next major wave, yet the United States is starting to fall behind. For example, the United States developed solar photovoltaic technology but has less than 10% of the world market. It also developed key advances behind the lithium ion battery but is only now struggling to enter this market. China attracted $34 billion in clean energy private investment in 2009, almost twice the

U.S. level. The public relies on U.S. economic leadership; it will understand the consequences of ceding it.

Energy security and economic competitiveness are viable political drivers for progress on energy if they can be articulated to the public. What are the program elements they can drive?

Strengthening the front end

Although many studies have called for major new investments in energy R&D, funding is still not at robust levels. In 2007, federal investment was only about half its peak level of 1980. Private-sector R&D has similarly declined, and studies indicate that the energy industry invests less than 1% of annual revenues in R&D for new technology. This is far below the U.S. industry average and far below the 15 to 20% levels in the most innovative sectors such as semiconductors and pharmaceuticals. Although venture capital funding has grown significantly in energy technology (reaching $3 billion before the recession), venture funding supports commercialization and is not a substitute for R&D. Low private-sector R&D dictates a larger initial public-sector R&D role. Seeing this, the Obama administration made a major investment in the 2010 federal budget in stimulus legislation in energy technologies. The Department of Energy (DOE) funded some $5 billion in energy R&D and $34 billion in technology implementation above baseline appropriation levels. However, that was a one-time spurt, and those levels have not continued in the 2011 budget. The additional funding was welcome, but it risks building up the energy technology enterprise and then pushing it off a funding cliff.

Although the R&D funding issues persist, there has been significant progress in the institutional organization of the federal energy R&D enterprise. The DOE has a history of developing and maintaining institutions in separated stovepipes of laboratories, basic research, and applied agencies. The technology handoffs between basic and applied agencies are few, and technologies transitioned into markets are fewer.

The DOE has been working to improve the connections among the stovepipes. Within the Office of Science's $5 billion basic research program, 46 Energy Frontier Research Centers (EFRCs) have been created, providing $3 million to $5 million a year to competitively selected university and laboratory teams working on basic research problems, tied to advances in energy technologies. The DOE also is creating energy innovation hubs in areas such as solar, advanced nuclear, batteries, and buildings. Whereas EFRCs are searching for new opportunities in the basic research space, the hubs will work in areas of promise to push related advances at a larger scale and move them toward commercialization. Reflecting their scaling role, the three hubs budgeted so far will receive around $20 million in annual funding. Both the EFRCs and the hubs will engage and build up new talent at universities and also connect lab and university teams to enhance lab productivity.

The third new DOE front-end innovation entity, the Advanced Research Projects Agency–Energy (ARPA-E), may prove the most interesting. The agency, which received $400 million in stimulus funds, is modeled on the Defense Advanced Research Projects Agency (DARPA). It has adopted DARPA's "right-left" model of seeking particular technology advances on the right side of the innovation pipeline and then looking on the left side for revolutionary breakthroughs to get there. Its projects will aim at accelerating innovation, cutting technology costs and speeding ideas to proof of concept or prototype in three to five years. ARPA-E also is instituting DARPA's hybrid model of building groups of smaller companies and university researchers to ease technology transition and working to connect its emerging technologies with private-sector development customers. It is working in what it calls "the white space" of technology opportunities: higher-risk projects that could be transformational where little work previously has been undertaken. In addition, ARPA-E is working as a technology connector within the DOE, drawing on basic ideas from the Office of Science that could be accelerated and building ties with the Office of Energy Efficiency and Renewable Energy and other applied agencies to hand off the prototype and demonstration stages. Energy Secretary Steven Chu has argued that if just a few of

ARPA-E's high-risk, high-reward projects are commercialized, the energy technology landscape could be transformed.

Although a recent President's Council of Advisors on Science and Technology (PCAST) report appropriately proposes further DOE stovepipe streamlining, efforts to date represent considerable progress in filling gaps on the federal side of the energy innovation system. After the 2010 stimulus funding runs out, however, DOE energy technology R&D will remain inadequately funded; current levels are about $5 billion a year. When the federal government embarks on a major technology thrust [the Manhattan and Apollo projects, the Carter/Reagan defense buildup, and the recent Department of Defense (DOD) ballistic missile defense program are examples], it spends far more. These examples were more single-focus technology projects undertaken on a government contractor model. They were organizationally simpler than spurring the development of a range of new technologies in one of the economy's largest and most technically complex sectors, but their investment levels inform us of the scale needed for energy.

The nation is not going to be able to achieve an energy technology revolution on the cheap. President Obama's 2010 budget request for a $15 billion–per–year energy technology program, premised on cap-and-trade auction revenues, which was dropped from his 2011 budget, appears to be on the right scale. But it would still be less than half of what the National Institutes of Health spends on R&D each year. Although the deficit-control focus of the new Congress may rule out a ramping up of funding in the immediate future, front-end energy R&D funding levels need to be revisited. Bundling smaller-scale steady revenue streams aligned to meet particular R&D sectoral needs (the PCAST report notes that a small 0.1 cent per kilowatt hour charge on utility bills yields $4 billion a year) could be a new way to look at this problem.

But advances in energy technology will not be achieved simply by throwing more money at the problem; investments must be allied to a sounder innovation system. The new government entities designed to fill innovation gaps should be strengthened and made major recipients of this funding. ARPA-E was authorized to be a $1 billion–per–year agency, but currently is far from that. Even if it reached that number, it would still be only a third the size of DARPA, and the nation's energy technology challenges are at least as daunting as those involving national security. The EFRCs and the research hubs should be at multiples of current funding levels, and other key DOE programs should be similarly increased.

The United States will also need to make a variety of adjustments in its R&D portfolio. For example, R&D agencies should seek and support technologies that may offer new functionality at the outset and so initially command a premium price. The goals of energy innovation have been societal not individual: An electric car is an improvement for energy security, not for the driver. If energy R&D included a focus on new functionality where possible, that might help turn the corner on consumer acceptance of energy technologies. Similarly, agencies should fast-forward their research agendas to develop technologies to a stage that can be cost-competitive at the outset of their market launch. For example, the DOE is now aiming its solar agenda at an installed cost of $1 per kilowatt hour. If carbon pricing will not be available to induce new innovations into energy technology markets, R&D strategies will have to be adjusted accordingly to include these features.

In addition, the nation must move toward a true energy technology strategy. The DOE periodically issues such a document, but it is usually a list of projects the agency already is doing. A real strategy would be future-oriented and involve the key government players engaged in energy procurement and regulation, including the Environmental Protection Agency (EPA), DOD, Department of Agriculture (USDA), and Department of Housing and Urban Development (HUD). This effort also will require private-sector leadership from established and new energy firms, because new technologies must be adopted by the private sector. The strategy should lead over time to a public/private technology roadmap for energy R&D and implementation, updated frequently because the technology opportunities will shift as advances occur and markets evolve.

Beefing up the back end

With improvements to the front end of the innovation system, new ways are needed to encourage the market entry of new energy technologies. To reemphasize, strengthening and ensuring better connections between front and back ends will bolster the performance of both. Areas for improving the back end of the system include:

Financing, incentives, and subsidies. The DOE has had a significant loan guarantee program since 2005 but did not issue loans until 2009. It has a mandate to "facilitate the introduction of new or significantly improved energy technologies with a high probability of commercial success in the marketplace." Although the program is aimed at helping move technologies past the initial commercialization barrier, the mandate's language builds in potential contradictions. It is limited to deployment-ready projects, so it excludes demonstrations, and the "high probability of commercial success" clause, perhaps due to the legacy of failed 1980s synfuels projects, significantly limits the risks that the program can take with innovative technologies. In addition, there is the complex definitional problem of determining what constitutes a "significantly improved" technology. By fall 2010, the loan program had committed to funding 19 projects worth some $25 billion, from nuclear power to electric vehicles to renewable energy. However, it has disbursed only about $9 billion across four of these commitments, and demand remains far higher than lending.

Problems have plagued the program in the past. The DOE's credit committee and the Office of Management and Budget have set stringent requirements that restrict the criteria for project approval to projects that are commercially creditworthy. The program's new leadership inherited a sizable task in reforming burdensome and time-consuming application forms, slow turnaround times, a shortage of personnel with expertise in project financing, and a lack of demonstrable, portfolio-wide lending goals and loan performance benchmarks. Loan guarantees with their requisite thresholds and cumbersome processes can be too costly for smaller firms and projects; additional, nimbler financing vehicles should also be available. Recognizing the problems, the energy committees in the House and Senate have proposed legislation for a Clean Energy Deployment Administration—a "green bank"—that would have authority to overcome some of these hurdles. Consideration should be given to making this institution a self-financing, separate government corporation with a range of tools, a wider risk portfolio, authority to support commercial-scale demonstration projects, and protection from congressional vagaries.

Arrays of tax incentives are available to consumers, businesses, builders, and manufacturers for efficient homes, appliances, vehicles, and power systems. Fossil fuels continue to receive the lion's share of energy tax subsidies, and corn ethanol receives tax benefits and exemption from fuel taxes. The efficiency of existing tax incentives should be examined and steps taken to rationalize them according to a hierarchy ranging from high-carbon to low-carbon technologies. The tax savings from the former could help support the latter. Layered incentives that offer additional benefits for the next stages of efficiency gains could speed new technology deployment.

Government procurement. The DOD has long played a central role in implementing new technology, funding the research, development, demonstrations, test beds, and initial markets for many of the most important innovation waves, including aviation, electronics, nuclear power, space, computing, and the Internet. DOD historically has supported technology development only if it fits its direct mission, but there are signals that energy fits within this restriction. Energy needs the DOD's historic innovation function.

The DOD increasingly sees its energy dependence as a strategic vulnerability; if a major oil-supply nation goes down, the military can suffer operational problems. The department also knows that the nation's oil dependence forces it to maintain highly vulnerable lines of communication to the Mideast; military leaders have estimated that from one-third to one-half of the DOD's expenditures are aimed at

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ensuring the nation's global oil supply. Aside from its strategic energy concerns, the DOD faces significant tactical problems as well. The widely seen images in September 2010 of burning Army oil trucks in Pakistan illustrate this vulnerability. The Army's dependence on oil forces it to maintain systems of convoys and fixed strong points for constant oil resupply, which expose its troops and counteract the tactical flexibly and mobility it needs to succeed in asymmetric conflicts. Moreover, the DOD has significant facilities cost problems. It controls the largest block of buildings in the nation, in every kind of geographic and climatic area. In a period of cost cutting, improving the military's energy efficiency at its 507 installations, in its 300,000 buildings, and for its 160,000 nontactical vehicles translates to cost savings. The DOD therefore set a very aggressive energy savings requirement—a 34% greenhouse gas reduction for its facilities by 2020—under Presidential Executive Order 13514.

Every year, the DOD receives approximately $20 billion in military construction appropriations for facilities construction and renovation. If the DOD would apply sound efficiency standards for buildings and equipment to its funding stream, it could leverage a major initial market for new technologies. Buildings represent some 40% of U.S. carbon emissions, yet the construction sector is highly diversified and fragmented, dominated by small firms that undertake little R&D and are slow to implement innovations until their reliability and cost are fully demonstrated. If the DOD used its military construction revenue stream to boost innovation in the building sector, it would be an early beneficiary, and this could provide a significant test bed and initial market for new energy technologies in general. Although the DOD has begun an interesting test bed for new building energy technologies, building demonstrations are a big innovation gap, and this program should be ramped up.

The DOD is not the only federal agency that could leverage existing funding streams to support an energy shift on the back end. USDA, which funds biofuels R&D, could expand its support system to assist farmers in raising new cellulosic biofuel crops, and its rural development role could aid the entry of energy-efficient technologies. The General Services Administration, which operates federal, nonmilitary buildings and facilities, and the Departments of HUD, Interior, and Transportation are other agencies with funding streams that could play a role in energy efficiency and introducing new energy technologies.

Regulatory authority and standards. Regulatory authorities already have powers to drive significant energy savings and carbon reductions. They represent traditional command-and-control regulation, less economically efficient than a carbon pricing system, but their effect could be significant.

As a result of the U.S. Supreme Court decision in *Massachusetts v. EPA*, the EPA found that greenhouse gas emissions endanger public health and welfare under the Clean Air Act and has implemented new regulations. The first round focused on vehicles. The EPA and the National Highway Traffic Safety Administration in May 2010 issued new standards for fuel economy and greenhouse gas emissions for passenger cars and light-duty trucks requiring 35.5 miles per gallon for model years 2012–2016. The agencies estimate that this regulation will save 960 million metric tons (mmt) of greenhouse gas emissions and 1.8 billion barrels of oil over the life of the vehicles covered by the program. In September 2010, the agencies began rulemaking for light-duty vehicles for model years after 2017, and in the following month they began the first program to reduce greenhouse gas emissions and improve fuel economy for medium- and heavy-duty trucks, supported by the major auto and truck manufacturers.

Under the Clean Air Act, the EPA may be considering new regulations to impose "best available control technology" on "stationary sources," including coal-fired utility plants and large industries,. Members of Congress from coal states are poised to battle this effort if it imposes carbon capture and sequestration requirements, although the Obama administration has vowed to stave off such efforts.

Apart from the EPA, the DOE has efficiency standard–setting authority over a vast array of appliances. Proponents argue that these standards are important cornerstones of

U.S. energy efficiency, and the potential savings from new standards being introduced between 2009 and 2013 could result in carbon reductions equivalent to 63 large coal-fired plants. Standards exist for most residential appliances, and updated standards are pending for nearly all of them. The 2007 energy act in effect barred incandescent lighting as of 2012, and standards are pending for a wide range of lighting products.

Local governments control building standards, but federal model codes could be tested and developed for localities to consider implementing; if Congress agreed, over time these could be turned into minimum energy-efficiency standards. Utility regulation is a state responsibility, but standards to enable the smart grid, which may encourage the adoption of an energy services as opposed to an energy consumption model for utilities, could be promoted by the federal government. Energy efficiency is the cheapest way toward progress and offers direct savings benefits to consumers. The feds need to promote a utility energy services model that rewards energy efficiency, not power sales, coupled with new financing tools to help consumers to achieve these savings.

Regional "nation-size" markets. The federal government is not the only actor. There are regional economies the size of major nations that could be sources for advance. California's Global Warming Solutions Act requires significant carbon reductions by 2020 from a cap-and-trade program that covers large industrial sources initially, limiting their output to 147 mmt. The legislation eventually will cover transport, setting a low carbon fuel standard of 15 mmt from ethanol and biodiesel efforts and a 33% renewal portfolio standard (21 mmt). In addition to its climate initiatives, California has led in state clean energy regulatory efforts, switching its utilities to an energy services model. California's initiatives could be integrated with the efforts of the Western Climate Initiative, which was started by states and provinces along the western rim of North America to combat climate change caused by global warming, independent of their national governments.

In the northeastern United States, 10 states have joined in the Regional Greenhouse Gas Initiative. Its cap-and-trade program covers solely the power sector and provides it generous allowances, so it is less stringent than the climate bill passed by the U.S. House. But it represents another source of regional climate innovation, and the Northeast is spawning its own competitive clusters of new energy companies. Some 20 states have been contemplating their own climate initiatives. In general, encouraging state regulators to adopt an energy services model for their utilities would enable efficiencies.

The Electrification Coalition has proposed another federalism approach in supporting electric vehicles to achieve energy security goals. Because current electric vehicle ranges are best for small nations, such as Denmark and Israel, the coalition began by contemplating whether there were Denmark-sized markets in the United States that could support electric vehicles. It has supported bipartisan legislation in the House and the Senate under which metropolitan areas would compete for a multibillion-dollar pot of federal funds by designing and backing the optimal charging infrastructure, promotion, and support systems for electric vehicles. This competitive federalism, relying on and promoting regional leadership, could be another way to press energy progress. In July 2010, the Senate Energy Committee approved a bill on a 19 to 4 vote. The legislation's ultimate passage remains uncertain, but the effort suggests that progress on a competitive federalist model is possible.

Public-goods investments. Governments have long invested in public goods, particularly where there is a market failure. For example, the federal government spends some $60 billion annually on public infrastructure, such as road, transit, and water projects; far more on defense systems; and billions on public health and vaccines. There are significant arguments that a public-goods rationale should apply for large-scale energy infrastructure; an improved loan guarantee program discussed above could be a facilitator.

The energy infrastructure list would include carbon capture and sequestration systems for coal-fired utilities. The United States has approximately 1,500 such coal plants at some 600 sites; they produce one-third of U.S. carbon dioxide emissions. Demonstrations at operating scales of integrated capture and sequestration for retrofitting and rebuilding existing plants are urgently needed, given the long lead times for revamping this infrastructure. Similarly, the government has a long history of supporting the development of nuclear power, although no U.S. plants have been built for three decades. A new generation of more advanced nuclear power units is pending, offering zero emissions for baseline power, although waste and proliferation issues remain. Congress has already recognized that this technology needs financing assistance. Improvements to the electrical grid, including smart grid features, to enable the scaling of renewable sources and electric or plug-in hybrid vehicles, received federal stimulus funds, and continuing support is needed. The public-goods rationale is already recognized and being applied, but it will need expansion.

Registry for private-sector efficiencies. Most Fortune 500 firms are implementing clean energy initiatives. For example, Walmart, the nation's largest retailer, is making progress on far-reaching efficiency goals, which include operating on 100% renewable energy, creating zero waste, and encouraging its suppliers to provide sustainable products.

The federal government may revisit some form of carbon pricing in the future, so it would be valuable to develop a registry where private firms file (and extol) their efficiencies in a transparent system, based on sound metrics and monitoring, for potential credit later. The United States is going to need better data about progress, so voluntary collection might as well begin now, collaboratively between government and interested firms. Although some consider this approach window-dressing, it could provide practical encouragement for firms that want to make progress as well as practical knowledge about best practices to reduce emissions.

Can a Plan B work?

Cap-and-trade is strong on demand pull but short on technology push. Both are needed. The amalgam of policies that could constitute a Plan B is a good start. The plan includes technology push mechanisms that are stronger than those considered in the past, with a focus on both front and back ends. But the plan relies for needed demand pull on current regulatory tools and incentives, which are less economically efficient than cap-and-trade. Clearly, more Plan B elements will need to evolve. Although it is more palatable politically, and comes in a series of more manageable policy bricks (unlike the far-reaching construct of cap-and-trade), parts of the plan are still a stretch, and they will have to be built up sequentially.

To understand where the nation stands and where it needs to go, it will be necessary to quantify the energy savings for the elements included in a Plan B. Such knowledge about the energy savings from each element will indicate what needs to be altered or expanded. It cannot be stressed enough that as part of this effort, the United States needs to develop a detailed and far-reaching technology strategy. The strategy will be needed to see the technology options more clearly, to understand where progress can be made, and then to move the technologies toward commercialization at scale. Transforming the nation's complex, established energy sector is the most difficult technology implementation problem the nation has faced. But the cap-and-trade setback offers the opportunity for a fresh look.

William B. Bonvillian (bonvillian@mit.edu), formerly a senior advisor in the U.S. Senate, is coauthor with Charles Weiss of Structuring an Energy Technology Revolution *and is on the adjunct faculty at Georgetown University and John Hopkins University's School of Advanced International Studies.*