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To Boost Energy Innovation, Pull Technologies Into the Market

Demand-pull policies for energy innovation must operate in parallel with traditional supply-push policies to speedily create a higher-performing, cleaner, more affordable, and more secure energy system.

The future of the United States' energy system is hotly contested. As Democratic and Republican candidates disagree about the implications of—and sometimes even the existence of—climate change, elected officials in both parties seek advantages for energy resources that benefit their states or districts. Legacy industries battle emerging ones for preferential treatment.

But everyone supports innovation. Both the chair of the Senate Energy and Natural Resources Committee, Democrat Joe Manchin of West Virginia, and that committee's ranking member, Republican John Barrasso of Wyoming, center and celebrate innovation in their rhetoric. While Manchin hails it as "the key to energy security," Barrasso writes that the United States must "stay ahead of the curve to stay on top."

Although such shared sentiments veil profound differences of opinion about technologies, fuels, and other features of the energy system, they formed a vital foundation for bipartisan congressional opposition to the Trump administration's proposed budget cuts. The "innovation coalition" then supported a series of legislative breakthroughs that began with the Energy Act of 2020, which passed during the lame-duck session after the election in that year, and continued into the Biden administration and the 117th Congress (2021–2022).

Increased federal funding for research and development is a central theme in the revival of US energy innovation policy, leading it to rise by some 70% between 2016 and 2023. This growth in R&D investment aims to expand the *supply* of opportunities that entrepreneurs and established businesses can draw upon to develop new and improved energy products and services.

Such "supply-push" energy innovation policy has a long pedigree at the federal level. But the legislation of the early 2020s departed from the historical norm by adding substantial "demand-pull" innovation policies to the mix. Recognizing that no battle plan survives first contact with the enemy, these policies appreciate that no prototype achieves wide adoption without significant alterations stemming from user feedback. Thus, demand-pull policies use direct spending, tax incentives, regulatory authority, and other tools to *pull* innovations into practice by encouraging users to adopt early versions of them, hastening the development of productive feedback loops. By creating market niches in which innovations can quickly evolve in this fashion, demand-pull policies complement supply-push policies.

While demand-pull energy innovation policies are far from unknown in US history, they have never been firmly embedded in a durable bipartisan consensus. Much of the recent demand-pull legislation is temporary, and some members of Congress have targeted key provisions for repeal. But without supply-push and demand-pull measures operating in parallel, energy innovation policy will not achieve its objective of speedily creating a higher-performing, cleaner, more affordable, and more secure energy system. US policymakers, particularly members of Congress, should firm up their support for demand-pull energy innovation policies.

The enduring myth of supply-push innovation

Supply-push innovation policy has its roots in the early Cold War. Policymakers in that period understood the Allied victory in World War II as stemming in large part from support for science, broadly construed. The Manhattan Project exemplified this line of thought, which helped justify massive federal investments in defense R&D. The touchstone for this consensus was Vannevar Bush's 1945 report, *Science, the Endless Frontier*, which argued for the creation of a national science foundation to promote American security, economic prosperity, and public welfare.

However, any interpretation that focuses solely on "science" in the narrative of the Manhattan Project (as the recent movie *Oppenheimer* does) neglects the myriad other factors that were required to turn research in theoretical physics into deliverable weapons. Beyond physicists and chalkboards, it took an army of engineers, builders, and operators, working at sprawling industrial sites around the country—not to mention some $30 billion in today's dollars—to turn J. Robert Oppenheimer's vision into the devastating bombs that were dropped in August 1945.

These massive capital costs were supported by policies that enabled demand-pull for the defense industry, and they evolved as the nuclear arsenal proliferated. Over the years, the Department of Defense (DOD) paid to turn ore into fissionable material and to create many essential technologies, including the computers and other electronics needed to simulate and control the weapons. Close linkages between military users and defense technology developers were foundational to US success in the Cold War, and they remain crucial today.

This combination of supply-push and demand-pull was extended into energy policy when the United States sought to develop civilian applications for nuclear technology. Admiral Hyman Rickover's nuclear navy had been the first adopter of the light-water reactor, which became the dominant design for nuclear power generation. Utilities that followed in the navy's footsteps were persuaded to do so by federal guarantees for both construction costs and liability limits that reduced the risks of early adoption. Without these demand-pull measures extending far beyond R&D, the reactors that have provided the bulk of low-carbon power for the US grid since the 1960s would have come online much more slowly, if at all.

Why supply-push alone fails to deliver innovation

Although debates over safety have until recently dominated the public discourse, the history of civilian nuclear power offers important lessons for energy innovation policy, highlighting the reluctance of potential adopters, even very deep-pocketed firms, to take financial risks. Today, the energy technology landscape is rife with the conditions that have limited the impact of supply-push policies in the past.

The most salient of these is that energy is a commodity: heat is just heat, and power is just power. Unlike the nuclear navy, most energy buyers are unwilling to pay a premium for such commodities, even if doing so might pay dividends for themselves and other customers—not to mention society and the environment—in the long run. Great ideas that could eventually lead to cleaner, more secure, cheaper, or more reliable energy are frequently ignored by the market. No matter how many potential opportunities for energy innovation the federal R&D funding creates, few will be realized unless customers buy these higher-cost products and services. That is what demand-pull policies are for—and they can play an important role in overcoming these market hurdles.

Another condition that limits supply-driven energy innovation is the complexity of energy systems. As energy systems comprise many diverse and interdependent components and subsystems, their behavior can be hard to predict at full scale. The impact of small changes to the system as a whole cannot necessarily be anticipated at the laboratory bench or even in pilot plants. Compounding the problem is that energy systems are usually "tightly coupled," so that failure in one component may cause catastrophic collapse across the entire system. Power blackouts, which can cascade across large regions, are prime examples of the perils of tight coupling. Therefore, it stands to reason that utilities and other operators of large-scale energy infrastructures prefer to be technological followers. By contrast, early adopters need to learn how to integrate and operate new technologies while shouldering heavy costs and risks. Only the hardiest private investors are willing to accept such intimidating terms without some help (or arm-twisting) from public policy.

The histories of other energy innovations that have achieved widespread adoption in recent decades show that the nuclear power story exemplifies the rule, not the exception. Solar power was pulled into the mainstream via massive demand spurred by policies like Germany's feed-in tariffs, which paid early adopters to put in rooftop systems, and California's renewable portfolio standard, which mandated that a share of utility power sales come from renewables. Energy-efficiency standards and financial incentives, similarly, pulled buyers to substitute efficient compact fluorescent and LED bulbs in place of electricity-guzzling incandescent ones.

Looking forward, analysts say grids that rely heavily on variable renewables will require what is called clean, firm power, either from power plants or energy storage systems. New technologies that promise to provide it at an affordable cost, such as advanced nuclear reactors, enhanced geothermal power, and long-duration energy storage systems, are approaching market readiness. But, due to the costs and risks that face large-scale power system innovations, neither the market nor supply-push policies alone will bring them to maturity. Demand-pull policies will be needed to debug these technologies and give potential adopters confidence that they will perform in real life as advertised.

Doing demand-pull innovation policy right

Despite this evidence and its grounding in theories of risk and complexity, the supply-side bias in US policy persists, particularly among conservatives. Writing for the Heritage Foundation's Project 2025, widely seen as a blueprint for a second Trump administration, former Federal Energy Regulatory Commissioner Bernard McNamee calls for the Department of Energy to achieve "science dominance" while reducing or eliminating demand-pull policies. "It is one thing for government to engage in fundamental scientific research," he writes. "Government, however, should not be picking winners and losers in dealing with energy resources or commercial technology. Such government favoritism can crowd out new innovations, devolve into cronyism, and raise energy prices for consumers and businesses."

Critics of demand-pull are right to ask hard questions about these policies. The potential for policies to remedy market failures does not mean that they will. Poorly designed policies may be ineffectual or even lock in subsidies indefinitely without spurring innovation. The US Renewable Fuel Standard is the poster child for this pathology. While it aimed to make biofuels derived from agricultural waste as cheap as fossil fuels, it has instead created a large, uneconomical, and environmentally damaging corn-based ethanol industry. The regional power of this industry, its influence in Congress, and the discretion that Congress afforded the executive branch to continue the subsidy, rather than force price and performance improvements in biofuels, led to this outcome.

By contrast, well-designed demand-pull innovation policies cut the premium paid for clean energy over time, enabling markets to grow—at which point government support tapers off. These policies must be designed to provide users with leverage to make trade-offs in ways that meet their needs, encourage competition among would-be innovators, reveal production and implementation challenges, and drive cost reductions and performance improvements in practice.

Public procurement is one tool that may be wielded to achieve these ends. Government customers for energy products and services can specify attributes they are willing to pay for—such as lower-carbon emissions or more secure supply chains—that would typically be ignored by private customers. Bidders for their business must show how they will comply with these requirements. Those who can do so at the lowest cost win federal contracts. Repeated rounds of bidding should narrow or eliminate the gap with conventional market prices, allowing nongovernment customers to join in. If they fail to do so, the government buyers should reconsider their requirements, dialing back their ambition to allow more time for demand-driven learning or shifting to a supply-push approach.

The DOD, for instance, has been an early adopter of advanced microgrid and energy storage systems, which allow military bases to ride out interruptions in electricity service and even provide power to nearby civilian users. By bearing the relatively high costs of newly introduced systems, DOD's patronage should lead to lower prices for follow-on commercial customers. In other energy technology areas, such as energy-efficient vehicles and buildings, however, DOD and other federal agencies have regularly worked around mandates to "buy clean," neutralizing any impact that they might have had. Inadequate funding and perverse and complex federal budget and procurement rules contributed to these failures.

Tax policy is another potent tool for demand-pull energy innovation policy. Some of the costs of energy products and services that meet specified criteria for cleanliness, security, or other desired attributes can be deducted from the buyer's taxable income or rewarded with a credit, pulling customers into the market. Stiffening the eligibility criteria or phasing out the subsidy over time should provide an incentive for producers to cut the costs of these innovations to keep them competitive. Without such discipline, producers may get complacent, since they can remain profitable as long as the incentive remains in place without approaching the price set by their unsubsidized competitors.

In recent decades, tax credits and deductions have often been granted to buyers of energy products and services with desirable characteristics. Homeowners and home builders who purchase energy-efficient appliances and building components, for example, may benefit from such policies. According to an analysis by Rachel Gold and Steven Nadel, tax provisions in the Energy Policy Act of 2005 "transformed the market for clothes washers, dishwashers, and refrigerators," as well as "new homes," and the eligibility requirements were ratcheted up as market penetration of efficient products rose. In the case of clothes washers, energy-efficient models doubled their market share, from 21% to 42% in just a couple of years. Poorly designed incentives of this sort, however, have at times unnecessarily rewarded buyers who would have made the same purchases without them, such as well-heeled Tesla owners who would have bought these luxury cars due to their appealing image and features without the benefit of a tax break.

Regulation may also create demand for energy innovations. Well-crafted regulatory standards can provide pathways for cleaner or more secure alternatives that are not yet affordable to become so over time. Companies in the regulated industry should compete to meet the standard at the lowest cost, eventually matching or bettering the cost of the incumbent approach. However, if the standard is poorly calibrated, or if unregulated imports enter the market, potential innovations may be blocked, undermining the very objectives the regulation attempts to promote.

US light-duty vehicle fuel economy standards are a case in point. Periods in which they have been tightened have sparked innovations such as hybrid-electric vehicles. Lenient standards, on the other hand, have at times allowed automakers to optimize engine power and sell heavier vehicles rather than improve efficiency or reduce emissions. For example, sales of sport utility vehicles, a previously marginal category of vehicles that were allowed by regulators to be less fuel-efficient than comparable vehicles because they were classified as light trucks, were supercharged in the 1990s to work around the tighter limits on cars.

Recent progress and further reform

In the early 2020s, all three of these demand-pull energy innovation policy tools gained momentum.

Congress gave the US Department of Energy (DOE) over $25 billion for market-oriented projects to demonstrate low-carbon power generation, hydrogen production, industrial decarbonization, and other technologies. Building on Rickover's precedent, DOD is once again using procurement to try to accelerate nuclear energy innovation, funding development of nuclear "microreactors." On the civilian side, over $5 billion in the Inflation Reduction Act was allocated to an interagency "buy clean" program for federally funded construction projects, including widely used materials like steel, concrete, asphalt, and glass. Hundreds of billions more are going to tax incentives for renewables, electric vehicles, carbon capture, and a broad array of other energy technologies. The Biden-Harris administration is also using its regulatory authority to accelerate uptake of carbon capture systems, electric vehicles, and other clean energy innovations.

Such initiatives are important steps toward better balancing supply-push and demand-pull energy innovation policies. But two risks threaten this progress. One is that policies may lapse, expire, or be repealed. For instance, much of the direct spending, including for energy demonstration projects and "buy clean" programs, is one-time funding rather than part of annual appropriations. The circumstances that led to 2021's bipartisan infrastructure law, which supplied much of this money, will be difficult to replicate.

The other risk is that poor design and implementation may undermine these policies' effectiveness. Most importantly, some of the tools have been deployed without credible mechanisms to lower costs and improve performance as sales of the targeted innovations grow, risking repeats of the ongoing Renewable Fuel Standard debacle. Tax incentives for purchasing solar panels, for instance, reward established technologies that are already cost-competitive, rather than incentivizing the development of products that may become more efficient in the long run or can be used in locations that lack large open spaces or rooftops needed by the current generation. Congress smartly included a phase-out of these incentives, but the industry is well aware that incentives scheduled to be phased-out in the past have been restored as a result of last-minute lobbying.

The next Congress should take steps to address these risks. It should definitively reject the supply-push-only approach by authorizing demand-pull policies like civilian and defense "buy clean" initiatives and by beginning to incorporate the costs of such policies into annual appropriations. These steps should be complemented by modernizing DOE's organizational structure to put demand-pull policies on an equal footing with supply-push policies and giving one of DOE's three undersecretaries the mission of driving energy innovation through demand-side policies. In parallel, Congress should require the executive branch to incorporate mechanisms into these policies that ensure they don't become permanent subsidies for static technologies. These authorizations will need to be explicit to avoid judicial meddling, which has been made easier by the Supreme Court's recent rulings limiting the executive branch's discretion. Congress should use its oversight powers to ride herd on the agencies to this end as well.

Putting federal demand-side energy innovation policies on durable, bipartisan foundations would pay dividends for the United States, strengthening its competitive position in emerging clean-tech industries. It would also be good for the rest of the world, which needs the United States to drive innovation in practice and on a large scale—not merely in principle at the laboratory bench—in order to soften geopolitical shocks to the global energy economy and slow climate change.

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