The idea of intervening in the marketplace to jump-start nonmilitary technological innovation slips in and out of favor, having probably reached the height of fashion in the 1970s and 1980s as policymakers struggled with threats (real or perceived) ranging from the Arab oil embargoes to Japan Inc. But mainstream economists have long been skeptical, and their views hardened in the wake of the ill-conceived push for “energy independence.”

Less is more, the free market mantra goes. Direct intervention – picking winners, in the parlance of the Reagan era – is an invitation to waste and corruption as regulators and elected officials cozy up to their favorite interest groups. Free markets are far from perfect, they acknowledge, but market outcomes are more likely to serve the public interest than, say, the decisions of the House Appropriations Committee. When market failures can be identified and measured, the goal of policy should be to get the prices right – for example, to internalize the external costs of pollution, global warming, traffic congestion, etc. through market-friendly taxes or cap-and-trade schemes.

But that near-consensus is breaking down because economists (and lots of other folks) are frustrated by the lack of progress in solving daunting environmental problems. Since Congress won’t tax greenhouse gas emissions, maybe the EPA
is right to limit them by decree (see page 5) ... Since the risks of investing in unproven green technologies are so high, maybe efficiency would be served by investing more government money in the most promising candidates ... Since consumers hardly notice the impact on their monthly bills, maybe utilities should be required to help out by purchasing more energy from green sources ...

Mariana Mazzucato, an economist who is the R.M. Phillips Professor of Science and Technology at the University of Sussex and the author of *The Entrepreneurial State – Debunking Public vs. Private Sector Myths,* is long past the “maybe” stage. Indeed, I’m not sure she would lay claim to the adjective “mainstream” that most economists find so comforting. But she most definitely has an ear for the zeitgeist in questioning the ability of the private sector to innovate without a lot of help from government.

Her riff in *The Entrepreneurial State* on the sources of Apple’s success – on why Steve Jobs would never have made his first million if governments had not spent billions on research in digital technology – led a *Financial Times* reviewer (Martin Wolf) to label her analysis “brilliant.” Here, we excerpt the chapter blasting opposition to massive subsidies for wind power and solar photovoltaic panels.

I’m not convinced by her sweeping endorsement of the visible hand – in each case, the costs need to be weighed against benefits (another economist’s mantra). But her thought-provoking book certainly deserves the attention it’s getting, if only to force policy wonks to think more clearly about less-than-ideal solutions to problems in a less-than-ideal world.

— Peter Passell
We are like any international company: we deal with government. With the Chinese government, German government, U.S. government, with many international governments. And of course we get support from government in the form of research and development grants and government subsidies to grow. I think almost every U.S. solar company obtained a grant from U.S. government as well, and German companies get subsidies from the German government. Because this is a very young industry which requires government support.

— Shi Zhengrong, Founder, Suntech Power

While a host of countries are making the investment in the development, manufacture and diffusion of a “green industrial revolution,” sowing the seeds of change for such a major economic and social shift is not without its challenges. Here, I delve into the interaction of policy and development using examples of how effective innovation policies can be, and how the state plays a vital role in promoting radical new technologies — not merely by inventing new tax incentives, but by getting (and staying) involved in every aspect of the wind and solar power business.

Behind many wind and solar firms, and their core technologies, was the visible hand of the state that also contributed to the emergence of the Internet, biotech, nanotech and other radical technology sectors. In particular, government agencies provided the early-stage, high-risk funding and created an institutional environment to foster green energy. Ironically, much of the push came from the United States, but much of the benefit of state investment was seized by other countries, including Germany, Denmark and China.

It’s not always clear how to connect the dots between dominant firms and their technologies, and the efforts of governments around the world. But it is clear that no leading clean-technology firm emerged from a pure “market genesis” – that is, with the state playing no role at all.

In the last few decades wind turbines and solar panels have been two of the most rapidly deployed renewable-energy technologies on the planet, spawning industries in many regions of the world. In 2008, $194 billion was directed at emerging clean-energy technologies in an effort to provide badly needed economic stimulus to counteract the global economic crisis. An unofficial global agreement was reached: the time for clean technology had come (again). A green-energy revolution seemed to be within the realm of possibilities.
The demand for wind power contracted in 2010, however, in large part as a result of the unfolding financial crisis in the United States (now the second-largest wind power market). But solar markets nearly doubled between 2009 and 2010, surpassing wind power for the first time. Together, wind and solar power represented a $164 billion global market in 2011, compared to just $7 billion in 2000.

While the U.S. and China possess the largest quantity of wind capacity deployed worldwide, Denmark is home to the largest manufacturer of wind turbines, Vestas. Manufacturers also emerged during the 1980s in the U.S., but all disappeared as a consequence of acquisition or bankruptcy. Germany’s weather is less than ideal for solar power, yet it remains the world leader of deployed solar photovoltaic capacity. Meanwhile, China has emerged as the world’s largest producer of solar panels, out-competing U.S., Japanese and European rivals that led in prior decades. A big question, then, is how the U.S. became a leading market for green energy, but failed to produce a leading manufacturer of equipment, and conversely, how China could spawn a big manufacturing sector in the absence (until recently) of a domestic market.

To be sure, several factors contributed to the decline of the pioneering U.S. companies. Falling fossil fuel prices in the 1990s did not help. Nor did the terms of purchase contracts for wind power negotiated in the 1980s, which exposed developers to major revenue reductions for the electricity they sold in the subsequent decade. In the case of Kenetech, once the bright star of wind energy, warranty losses incurred from their newest turbine model were substantial, and other firms were vulnerable to the uncertainty emerging from the decision to liberalize energy-generation markets.

But it’s important to note that what differentiates these nations has nothing to do with their classic comparative advantages as producers of wind turbines or solar PV panels; nor does it have anything to do with a natural abundance of wind or sun. Historically, the development of wind and solar power has reflected differences in government policies meant to foster these power sources.

**TAKEOFF – AND HARD LANDING**

The first “wind rush” (1980-85) had the energy crises of the 1970s as a backdrop. A number of countries actively invested in utility-scale wind turbines as a way to mitigate dependence on fossil fuels in electricity gen-
eration. In the 1970s, Denmark, Germany and the United States all initiated massive wind energy R&D projects. The goal was typically to build one-megawatt and larger machines, creating designs that could be commercialized and exploited by existing large firms typically involved in aerospace technology or agricultural machinery.

The U.S. outspent Germany and Denmark on wind energy R&D. But despite enlisting NASA to lead the program, a viable commercial design failed to emerge. Germany’s attempt met a similar fate. Only Denmark succeeded in transforming government-funded R&D into commercial success, giving it a valuable advantage during the wind industry’s formative years.

Linda Kamp of Delft University and Kristian Nielsen of Aarhus University see the point of divergence between nations in the decision of the Danes to develop technology based on an existing wind turbine called the Gedser, which was a reliable three-bladed horizontal-axis machine. Testing of the Gedser had been financed in its early days by the Danish ratepayer-owned SEAS utility and the trade association of Danish utilities.

Later, the governments of Denmark and
the U.S. provided millions to test the design as part of efforts to develop wind turbines for modern energy grids. But despite the promise of the Gedser, the U.S. and Germany pursued lighter-weight and aerodynamically efficient (though often unreliable) designs based on prototypes originally conceived around the Second World War in Germany and the U.S.

Denmark’s push into wind turbines included state-sponsored prototype development, which brought in large manufacturers to gain experience with the technology and to create a functional supply chain. Companies including Bonus and Vestas were able to purchase patents generated by the Danish research program and smaller-scale wind turbine pioneers, giving them control over the collective knowledge and the requisite profit incentives to invest their own capital. They then applied their experience producing farm equipment to produce robust machines on a larger scale.

Denmark’s R&D activities overlapped with investment tax credits offered to wind turbine buyers. The tax credits helped launch a domestic market for wind energy, while parallel financial incentives provided by both California and the U.S. government created export opportunities for Danish producers.

“Big government” R&D in the U.S. and Germany was largely dismissed as a failure because reliable wind turbine designs that could be successfully commercialized were not produced as an immediate consequence of the effort. That condemnation misses the point, though: obviously, if governments are willing to take the big risks that business will not take, the ventures are bound to fail sometimes. But if they do not take risks, they will not succeed at all.

That particular failure, however, gave the Reagan Administration an excuse to write off government R&D initiatives as the inevitable result of trying to “pick winners” – a phrase often used by conservatives to justify the rejection of government intervention in the clean technology sector.

This view ignores some inconvenient facts about clean energy R&D. First many large, private companies with track records in technology – among them, Lockheed Martin, General Electric and the MAN Group – were partners in that failure. Each acted as a contractor under the U.S. or German programs. Second, wind turbine technology was not well understood, and scaling turbine designs successfully required more time than expected. In effect, the government and business community underestimated the challenge at hand, though critics focus on the failure of government and not of private finance. Third, it makes little sense to conclude that the initiative wasn’t worth the investment without including the benefits of the spillover effects. These projects established networks of learning among utilities, government, the business community and universities that would later prove valuable.

Unlike the U.S., which drastically slashed funding for wind turbine development, Germany did not give up on publicly funded R&D despite initial missteps. Indeed, it expanded on the research, as well as paying for a demonstration program that allowed for controlled testing of German designs. Germany also promoted multiple development paths, funding turbines of different sizes – in contrast to the U.S. program that biased R&D in favor of huge machines. Denmark’s program was less expensive and more successful than either. That’s attributable in part to the entry of the farm equipment manufacturer Vestas, which, unlike aerospace companies that emphasized light weight, understood the need for rugged design.

While the U.S. struggled to maintain a dominant manufacturing presence, it succeeded in establishing a big market for wind turbines – pushing, not merely nudging, one
Denmark’s farm equipment manufacturer Vestas, which, unlike aerospace companies that emphasized light weight, understood the need for rugged design.

into existence. The favorable conditions for wind energy fostered by the U.S. government and California by means of stimulus expenditures and subsidies were not just opportunities for American companies. They also attracted Vestas, which became the turbine supplier of choice for the Zond Corporation, a California-based wind-energy developer. With few proven wind turbine models available to choose from, Zond ordered more than 1,000 turbines from Vestas, almost single-handedly financing the early growth of Vestas’ turbine business.

When the tax subsidy program in California was allowed to expire at the end of 1985, Zond refused to pay for its last shipments of wind turbines, which had been delayed. To survive, Vestas abandoned its farm machinery business and quickly re-emerged as a world leader in wind turbine production. Note that without the forbearance of the Danish government in allowing Vestas to restructure, the company might well have disappeared.

Of the handful of new companies emerging to capitalize on the call to bring wind energy to America, U.S. Windpower (later renamed Kenetech) become an early leader. Founded in Massachusetts, it had derived knowledge of wind technology from research at the University of Massachusetts (Amherst), a public university with an active wind power program funded in part by the U.S. Department of Energy. The company subsequently moved to California, lured by state tax breaks and regulators’ mandate to California’s electricity utilities to promote renewable energy.
Kenetech was one of the few U.S.-based wind turbine manufacturers to have grown from a seed stage to an initial public offering. But the wind turbine business is risky; the company went bankrupt in 1996 due to major warranty losses incurred following the release of its state-of-the-art (but technically flawed) variable-speed wind turbine.

Unlike Vestas, though, Kenetech did not enjoy the forbearance of government lenders or private investors; about 1,000 people lost their jobs when the company couldn’t meet its financial obligations. Zond subsequently purchased Kenetech’s variable-speed wind turbine technology and developed wind turbines with the assistance of the DoE. Zond was, in turn, acquired by Enron in 1997, and when Enron collapsed in scandal, GE purchased Zond’s technologies to become one of the world’s largest wind turbine suppliers.

From that point forward, the powerful combination of government incentives for wind power at the federal and state levels, along with the resources of a big corporation, paved the way. Though threatened worldwide by Chinese competition, GE still dominates the U.S. market.

The technologies developed with substantial contributions from the U.S. Government thus played an important (if easily forgotten) role in the development of wind technology. The basic science of wind power was advanced by the DoE through initiatives at both its national labs and universities. Understanding the aerodynamics of turbine blades was of particular importance, given that wind turbine operating environments are unlike those of planes or helicopters. Computer modeling boosted the reliability and efficiency of turbine designs, and collaboration with private industry yielded improved designs with better “capacity factors” – the ratio of actual power production to theoretical production capacity. Advanced mapping of wind resources by the government also provided wind-power developers with accurate siting information.

When Washington abandoned subsidies for wind power development in the mid-1980s and slashed the DoE’s R&D budget in a backlash against attempts to promote energy innovation,
ducers. Germany also set aside national and state funding of approximately $2.2 billion to support continued wind energy R&D. The combination made Germany the hottest market for wind-power development in the world.

The country’s long-term approach to wind energy development gained momentum in the 1990s and continues today, enabling the emergence of strong manufacturers that facilitate stable annual growth in deployed wind capacity. The 20-year investment horizons provided by government incentives are twice as long as those in the U.S., reducing market uncertainty and boosting investor confidence.

the domestic market stagnated and momentum for the industry shifted to Germany.

China was a relative latecomer to wind-power technology, despite having pushed investment in renewable energy in the 1980s as a technical solution for rural electric infrastructure development. China’s partially state-owned Goldwind, a major wind turbine manufacturer, was established in 1998, and initially licensed German technology. Goldwind’s turbine business benefited from aggressive Chinese domestic content rules, which since 2003 have required 70 percent local content in all wind turbines sold in China. This effectively shut the door to foreign competition, even as China’s manufacturers strengthened their domestic supply chain.

Chinese wind-power producers also received 25-year fixed-price contracts, reducing uncertainty in demand. Wind projects had access to low-cost financing, and after 2005 the government began to fund R&D projects with grants and favorable loan terms. China is seeking 1,000 gigawatts of installed wind power capacity by 2050 – equal to the country’s total generation capacity in 2010. China surpassed the United States as the world’s biggest wind energy market in 2010. And thanks to the favorable treatment of domestic turbine manufacturers, China has also eroded the global market shares of other producers.

SOLAR’S ROCKY ROAD

The policy shifts driving the California wind market in the 1980s provided the catalyst for a global market for solar PV panels to emerge. Bell Labs had invented the first crystalline-silicon (c-Si) solar PV cell back in 1954 while the lab complex was still a part of the AT&T regulated telephone monopoly. The first major opportunities for solar PV technology were created by the DoD and NASA, which purchased solar cells made by U.S.-based Hoffman Electronics to power space satellites.

While the space race made the government a cost-be-damned customer for early solar manufacturers, the transition of solar PV technology to terra firma was facilitated in part by the cost and performance advantage it had in markets for remote power applications – signal lighting on offshore oil rigs, corrosion protection for salt-water oil drilling, remote communication towers. In most cases, however, government regulation, not cost, forced the application: the choice of solar PV/battery power for oil rigs, for example, was in part a consequence of the EPA’s ban on the disposal of spent batteries in the ocean.

Note the familiar theme here: government initiatives have helped to establish solar PV firms and markets around the world. Many examples of innovative emerging firms can be found in the U.S., where First Solar, Solyndra, SunPower and Evergreen Solar each developed state-of-the-art c-Si or thin-film solar technologies.
First Solar emerged out of efforts to commercialize cadmium telluride (CdTe) thin-film solar PV panels and became a major U.S.-based CdTe thin-film producer. The company now dominates the U.S. market for thin-film panels. Thanks to superior technology and low-cost manufacturing, the business has generated more than $2 billion in annual revenue since 2009.

First Solar’s patents have extensive links to prior DoE research. Development of the company’s CdTe technology was a collaboration of founder Harold MacMaster with the University of Toledo’s state-funded solar research facilities and the federal government’s National Renewable Energy Laboratory (NREL).

First Solar’s partnership with the NREL dates back to 1991, when the company was still known as Solar Cells. The collaboration resulted in the development of high-rate vapor transport deposition, a superior means of manufacturing glass CdTe thin-film panels, which First Solar began to produce in 2003.

Solyndra was a technological leader in solar panels, built on federal research conducted on copper indium gallium (di)selenide (CIGS) solar PV. The technique of depositing CIGS onto tubular glass gave Solyndra’s panels a unique look; more important, it enabled them to capture direct and reflected light without add-on tracking systems. Additionally, Solyndra’s panels had a unique interlocking system that made them easy to install, reducing their cost relative to other technologies.

The list goes on. SunPower manufactures high performance c-Si solar PV panels with technology that owes much to government aid. The company’s success links back to DoE research patents related to solar PV shingle panels, which take on the look of roofing shingles. Established in 1985 by Dr. Richard Swanson, SunPower had early R&D support...
from the DoE and the Electric Power Research Institute (the utility industry’s research arm) while developing technology at Stanford University.

This is not to say that government intervention in solar power always pays off. Evergreen Solar was a spinoff of the now-defunct Mobil Solar. It was started when a group of scientists defected from Mobil to develop a rival vision of string-ribbon wafer technology, forming thin films from molten silicon by exploiting the phenomenon of surface tension. Evergreen attracted $60 million in Massachusetts subsidies – the most ever offered to a single company – in return for a promise to create manufacturing jobs in the state. But the company was subsequently lured to China, which offered favorable loan terms from publicly owned banks to build a new plant. In obtaining this financing, Evergreen agreed to share its innovative technology with its partner, Jiawei Solarchina.

Evergreen completed a $42 million IPO in 2000. Taxpayer support from Massachusetts thus helped to generate a big payday for VCs and top executives, but failed to create the promised benefits for the U.S., and even transferred advanced technology to China.

Suntech of China was a global market share leader in c-Si solar PV manufacturing in 2011. Suntech has benefited from imports of PV manufacturing equipment from bankrupt U.S. companies and the acquisition of Japan’s MSK Corporation, the abundant and willing public finance of government-directed Chinese banks and the booming government-driven market for solar PV in Europe. Suntech Founder Zhengrong Shi studied solar PV and spent 13 years in Australia, working for Pacific Solar, a joint venture between the University of New South Wales and an Australian utility company, before returning to China.

Shi had been lured by the city of Wuxi, which offered him $6 million to set up solar PV manufacturing there in 2000. Suntech’s Pluto c-Si technology is a derivative of PERL c-Si technology developed at the state-supported University of New South Wales. Its products are quickly approaching the performance levels of rivals like U.S.-based SunPower.

Suntech, like most Chinese solar PV manufacturers, depends on exports to grow. It generates a substantial share of its revenues in Europe, where (as noted earlier) markets are driven by strong feed-in tariffs and other policies that cost billions of euros to European taxpayers and electricity customers. It also benefited from support in China, which granted the company a preferential 15 percent tax rate, millions in grants, and a $7 billion line of credit from the China Development Bank. (All told, as of 2010, the bank had made $47 billion in loans to Chinese solar companies on favorable terms.) These huge sums have made the difference for Chinese solar PV manufacturers, providing the resources to grow rapidly and to weather shifts in demand for their exports.

There’s an interesting hitch here – one that illuminates the differences in government support for green energy in China and the United States. After defaulting on a bond payment in March of 2013, Suntech divided its assets between Wuxi Suntech, now expected to be taken over by state-owned Wuxi Guolian, and Suntech Power, whose equity investors will be subordinate to the public banks that have been carrying the firm.

The relatively orderly outcome of Suntech’s bankruptcy stands in stark contrast with that of U.S.-based Soly ndra. Soly ndra was overwhelmingly funded by private interests, while Suntech was funded by public interests. The two firms committed the same mistakes, scaling up too rapidly and depending too much
on volatile export demand. Yet Solyndra has disappeared from the world, while Suntech survives. Suntech’s fate is not to be decided by its investors, whose first priority is to get their money back, and then some.

Solyndra’s failure highlights the “parasitic” innovation system that the U.S. has created for itself, where private financial interests rarely commit the first dollar but always have the last word. Perhaps done differently and with an eye to the value of economic development beyond short-term financial performance, Solyndra would have grown to employ thousands and to generate revenue on the magnitude of GE. Suntech’s fate, on the other hand, will be decided by the state, which made the larger investments in the firm, and which proceeded into the company’s bankruptcy with a much broader perspective on Suntech’s potential role in the Chinese economy.

In a better system, the government could have weighed the cost of letting Solyndra fail against the potential benefits of giving it another chance. It might even have considered firing the executives responsible for its financial decline – as the Chinese government did with Suntech.

American policymakers will continue to spend their time imagining success until they recognize that innovation unfolds as part of a global process, not an individual or even organizational process. Clean technology is already teaching us that changing the world requires coordination and investment from multiple states. Otherwise R&D, support for manufacturing, and support for market creation and function remain dead ends while the Earth literally suffocates on the industries we built a century ago.

**THINK GLOBALLY, ACT GLOBALLY**

I argued above that the state of California’s mandated use of renewable energy explains in part the early success of Vestas, a Danish company that is the world’s largest wind turbine manufacturer. In similar fashion, the growth of U.S. and Chinese solar-panel makers has depended on Germany’s leadership. Germany made solar PV competitive with traditional power sources by revising its feed-in tariffs policy to provide better pricing for solar PV. At the same time, Germany established a “100,000 roofs program” to encourage residential and commercial investment in the technology. The action kicked the solar PV industry into high gear, and Germany expanded its solar capacity from just 62 MWs in 2000 to over 24 GW in 2011. This is equivalent to completing 24 nuclear power plants in about 10 years.

Germany’s policies have been both a blessing and a curse. On the one hand, Germany’s growing market supported the emergence of domestic manufacturers such as Q Cells. But it also provided growth opportunities for competing firms from the U.S., China and elsewhere.

These countries have not followed Germany’s lead in establishing strong residential and business demand for solar PV. And excess capacity created in part by the “start-and-stop” government policies toward demand for solar power is currently crippling solar companies around the world. Q Cells, once a German champion, went bankrupt and is now the property of Korea’s Hanwha Group.

Meanwhile, the rise of China as a government-supported center for solar PV manufacturing has had serious fallout on the industry as a whole, prompting trade wars with both the United States and Europe. But while U.S. and European companies find themselves unable to compete, the U.S. government, for its part, has reacted with calls to end support for clean technology development; if anything, the lesson here should be that
American policymakers will continue to spend their time imagining success until they recognize that innovation unfolds as part of a global process, not an individual or even organizational process.

more support, not less, is needed.

The trade conflict only serves to strengthen the myth that industrial development occurs through invisible market forces that cannot be created or controlled by government. With the government acting as referee in the dispute, China’s public support for clean technology industry development is framed as “cheating.” At the same time, multiple countries are attempting to capture the global market for clean technology with similar policies that include direct and indirect support for firms—in other words, if China is cheating, the other countries are, as well.

Plummeting solar PV prices are supposed to be a good thing, eventually positioning solar panels to compete favorably with fossil fuels. But in this case, falling prices (and shrinking profit margins) frustrate many and ignore the shortcomings of industrial policy in countries like the U.S., which we could describe as lacking an adequate supply of “patient capital” conducive to innovation and growth, as well as a long-term vision for energy transition. What is separating China from its international peers is its courage to commit to renewable energy and innovation in the short and long runs.
Some argue there is a risk that the rapid growth of Chinese wind and solar companies will stifle innovation. The charge: Chinese companies are reducing costs and grabbing market share using older technologies, which prevents newer ones from penetrating world markets. If this is proven to be the case, governments should heed the signal that more needs to be done to ensure that critical energy innovations can establish themselves in markets that are becoming crowded with competing technologies.

But these complaints take no notice of the fact that there are advantages to the current c-Si technology, such as the availability of abundant raw materials for manufacturing. Other technologies rely on rare earths, which are in limited supply and environmentally problematic to extract. Furthermore, these complaints ignore the reality that U.S. innovations produced by companies like Innova-light and 1366 Technologies can be incorporated into Chinese panels. (1366 Technologies developed very low-cost multi-crystalline silicon manufacturing equipment with $4 million in aid from the U.S. government’s new ARPA-E program.) In any case, at some point convergence towards a dominant design is needed before mass diffusion of solar power can be achieved.

THE VISIBLE HAND

There is nothing accidental about clean technology development or the formation of markets for renewable energy. There are no “genius” firms or entrepreneurs acting independently. Rather, clean-tech firms are leveraging technologies and cashing in on the prior investments of an active public sector.

While the performance of countries has varied tremendously over the decades, Germany has provided a glimpse of the value of long-term support, China has demonstrated that a rapid scale-up of manufacturing and deployment is possible, and the United States has shown the value of R&D – but also the folly of permitting uncertainty, shifting political priorities and speculative finance to set the clean technology development agenda.

The challenge moving forward is to fund a long-term policy framework that sustains momentum in the clean energy sector that been erected over the last decade. Without long-term commitments, it is likely that clean technology will become a missed opportunity for many nations. Such a framework would include demand-side policies to promote increased use of solar and wind energy, as well as supply-side policies that promote manufacture of the technologies with “patient” capital.

The challenges of developing clean technologies go far beyond establishing public-sector energy innovation hubs, such as ARPA-E. Governments need to reduce the risk of commercializing innovations while establishing and managing the risks of competing in diversified, volatile, global energy markets. When difficulty has arisen in the past, such as when the wind power market faltered following retraction of U.S. support for renewables in the late 1980s, the tendency has been to focus on how government investment is flawed and to ignore the ways in which business contributed to that failure.

Worse, some interpret growing pains as proof that an innovative technology will never be able to compete with incumbent technology and should be shelved. This would go against the historical record, which suggests that all successful energy technologies have needed lengthy development and long-term government support. What matters more is that the effort continues as if the future of the planet depended on it – because it does.