STATEMENT BEFORE SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

"Hearing to Examine the Role of the DOE and Energy Innovation in American Economic Competitiveness"

A Testimony by:

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Chairman Manchin, Ranking Member Barrasso, Members of the Committee, thank you for the opportunity to appear before you today to discuss the role of the U.S. Department of Energy (DOE) and energy innovation in American economic competitiveness. My name is Sarah Ladislaw, and I serve as managing director of the U.S. Program at RMI. Founded in 1982, RMI is an independent, nonpartisan, charitable nonprofit dedicated to transforming global energy use to create a clean, prosperous, and secure low-carbon future.

Before joining RMI this week, I served as senior vice president and director of the Energy Security and Climate Change Program at the Center for Strategic and International Studies, where I worked for the last twelve years. Before that, I worked at the U.S. Department of Energy in the Office of Policy and International Affairs. My testimony today will reflect my personal views based on my experience and past research. In particular, my testimony today will focus on several recent studies published during my time at CSIS.

The last time I testified before this Committee was in April 2019, at a hearing titled "Examining Opportunities for Energy Innovation and Other Potential Solutions to Help Address Global Climate Change." In that testimony, I stated my view that the "United States is one of the most energy-advantaged nations on the planet. Not only do we have every conceivable tool at our disposal to chart a viable pathway to a net zero-emissions, resilient energy system at home, but we also have the unparalleled ability to provide global leadership in the strategies and technologies that can bring sustainable and affordable energy supplies to the growing and developing populations of the world. We just have to decide to do it."[1] I still believe this is true today.

My testimony focused on many different issues, including the need to harness energy as a source of economic opportunity; to calibrate our efforts at home with globally resonant challenges like energy poverty alleviation, climate change, and energy security; and to focus on the critical role of energy innovation in American economic competitiveness. On this final issue, the topic of today's hearing, I want to congratulate the Committee for subsequently passing the Energy Act of 2020. During a time of political transition and under the societal strain imposed by the pandemic,

[1] Statement by Sarah Ladislaw before Senate Energy and Natural Resources Committee, "Examining Opportunities for Energy Innovation and Other Potential Solutions to Help Address Global Climate Change" April 11, 2019, https://www.energy.senate.gov/services/files/CD93296C-48FB-462C-BBE2-C64AB5307AA4

it is no small feat to pass the first broad and bipartisan energy legislation in over a decade. Focused on innovation, the Energy Act made essential contributions to research, development, and demonstration of energy storage, advanced nuclear, carbon capture, utilization, and storage, carbon removal, renewable energy, critical minerals and materials, industrial technologies, grid modernization, and other essential technologies.

Today, I'd like to revisit the issue of energy innovation and U.S. competitiveness to explain what more needs to be done and the important role that the U.S. Department of Energy, along with other agencies, can play.

The Growing Clean Energy Opportunity[2]

Over the last two decades, clean energy technologies like solar photovoltaics (PV), wind turbines, and lithium-ion batteries have gone from relatively expensive technologies produced and deployed by a small number of countries to cost-competitive technologies produced and deployed all over the world. Due to these cost declines, improved performance, and greater public and private sector support for renewable energy, the market for clean energy technology is positioned to grow even faster over the next couple of decades.

According to the clean energy research firm, BloombergNEF, in the United States alone, solar and wind installed capacity is forecast to rise from 180 gigawatts (GW) today to 1,329 GW by 2050 (under the Economic Transition Scenario in BloombergNEF's New Energy Outlook). Combined, solar and wind are likely to make up 56 percent of 2050 U.S. installed power generation capacity, up from approximately 14 percent today.

Similarly, BloombergNEF expects electric vehicles (EVs) will be cost-competitive with conventional internal-combustion engine vehicles by the middle of this decade. Once this important crossover point arrives, EV sales will accelerate, and by 2040, pure battery-electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) will account for the majority of new cars sold and 42 percent of the cars on roads in the United States. Over the next decade, this will represent a potential $67 billion market for battery sales in passenger EVs in the United States. Even today, in the presence of the global pandemic, clean energy investment has fared well. BloombergNEF estimates that companies and consumers spent over $500 billion on the energy transition in 2020, up 9 percent from 2019.[3]

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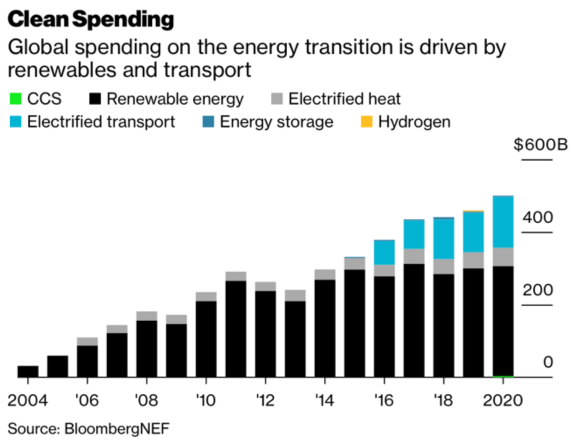
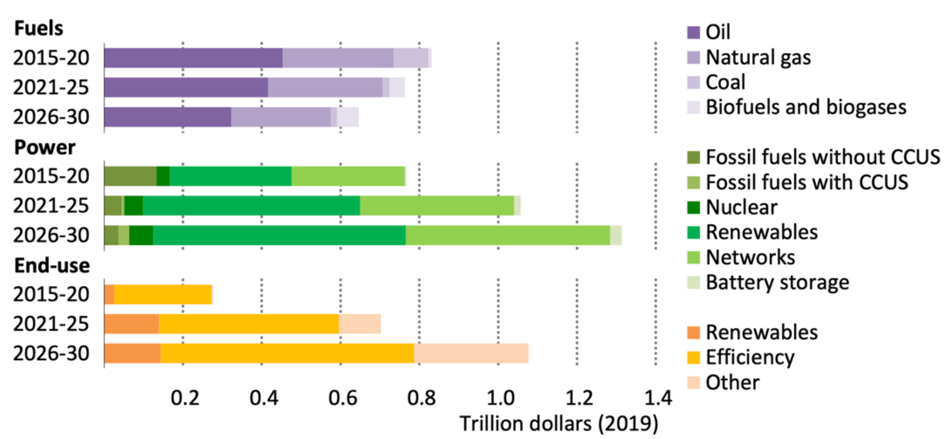
[2] Portions of this section are adapted from Sarah Ladislaw, Ethan Zindler, Nikos Tsafos, Logan Goldie-Scot, Lachlan Carey, Pol Lezcano, Jane Nakano, and Jenny Chase, "Industrial Policy, Trade, and Clean Energy Supply Chains," February 2021. A report by the CSIS Energy Security and Climate Change Program and BloombergNEF. https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/210224_Ladislaw_Industrial_Policy.pdf?DRja.V6axwyBE_PV6Chmdi5k2VqOq33n

[3] Josh Saul and Will Mathis, "Spending on Global Energy Transition Hits Record $500 Billion," *Bloomberg*, January 19, 2021, https://www.bloomberg.com/news/articles/2021-01-19/spending-on-global-energy-transition-hits-record-500-billion?sref=Tj5BOuJ2.



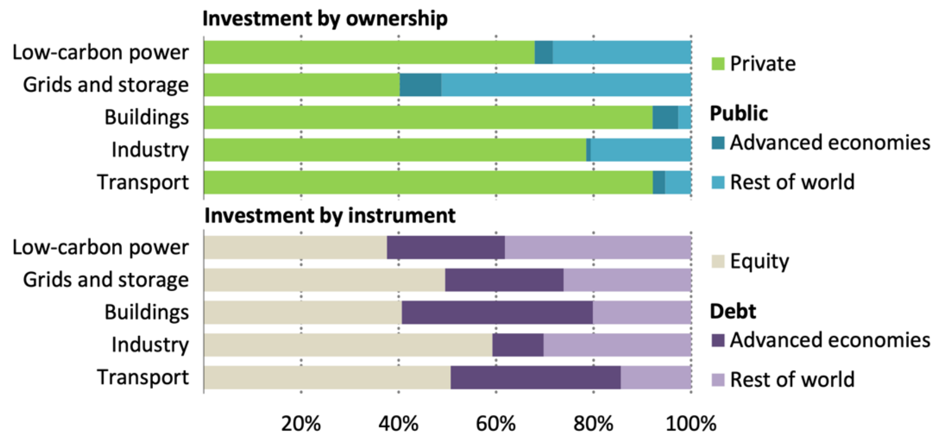
Policy plays a critical role in determining the pace and scale of growth in this market. According to the IEA, under its sustainable development scenario, investment into the energy system might reach $3.2 trillion a year, of which $2.6 trillion will be directed to low-carbon energy sources, a nearly threefold increase relative to investment from 2015 to 2019 (see figure 3.17 below).[4] While over 70 percent of the investment needed to meet this scenario comes from the private sector, government investment, policy, and regulation play a critical role in mobilizing the financing and technology deployment.[5]

Figure 3.17 ▻ Average annual energy investment in the Sustainable Development Scenario



[4] International Energy Agency, World Energy Outlook 2020, October 2020, https://www.iea.org/reports/world-energy-outlook-2020. Calculations based on Annex A Tables for Scenario Projections.
[5] International Energy Agency, World Energy Outlook 2020, October 2020, https://www.iea.org/reports/world-energy-outlook-2020, p.117.

Figure 3.18 ▷ Clean energy-related investment in the Sustainable Development Scenario, 2025-2030



Source: International Energy Agency (2020), World Energy Outlook 2020. IEA, Paris.

The clean energy and climate-smart technology market opportunity is not just in developed countries, either. According to an International Finance Corporation analysis, the climate change commitments submitted under the Paris Agreement and underlying policies of 21 emerging market economies, representing 48 percent of global emissions, have created a 23 trillion-dollar market opportunity between now and 2030.[6]

All of this is just based on the commitments to the Paris Agreement thus far. According to the United Nations Environment Program, by the end of last year, 126 countries had committed to, announced, or were considering targets to reach net-zero greenhouse gas emissions by 2050 (or 2060 in China's case). If enacted, these commitments would cover 51 percent of global emissions. Should the United States join, as suggested by the Biden administration, the share would be 63 percent of global emissions.[7] The investment needs and market for clean energy technologies implied by these policies would be enormous.

This type of expenditure can have real advantages too. For example, according to another recent IEA analysis, India would need to spend an additional $1.4 trillion, over and above what is projected for their stated policy goals, in clean energy capital expenditures between now and 2040 to align better its current path with what is required for a net-zero trajectory and more positive sustainable development outcomes.[8] Coincidently, $1.4 trillion is also the number of funds saved by avoided oil imports under this same scenario, showing that spending today can help with the climate challenge, local air pollution, and energy security concerns.

[6] "Climate Investment Opportunities in Emerging Markets: An IFC Analysis," International Finance Corporation, The World Bank, https://www.ifc.org/wps/wcm/connect/59260145-ec2e-40de-97e6-3aa78b82b3c9/3503-IFC-Climate_Investment_Opportunity-Report-Dec-FINAL.pdf?MOD=AJPERES&CVID=lBLd6Xq

[7] United Nations Environment Programme, "Emissions Gap Report 2020," December 9, 2020, https://www.unep.org/emissions-gap-report-2020.

[8] "India Energy Outlook 2021," World Energy Outlook Special Report, IEA, Paris. https://www.iea.org/reports/india-energy-outlook-2021

Clean Energy Competition

Concern over the decline in U.S. competitiveness in the field of innovation is not a new theme and was the impetus for seminal reports as the National Academy of Sciences report "Rising Above the Gathering Storm," which sought to bring a high-level, strategic focus on the state of American science and technology competitiveness. As of late, however, policymaker concerns have centered on U.S. competitiveness relative to China. According to a 2018 report from the Council on Competitiveness, "China's investment in R&D has more than doubled since 2010, reaching $451 billion in 2016, second only to the U.S. investment, and set to outpace the United States by the end of this decade. China has overtaken the United States in science and engineering publications. China has an 18.6 percent world share, while the United States has a 17.8 percent share. China has posted double-digit growth rates in international patent filings in every year since 2003, and now lags only the United States in patents filed."[9]

This concern has led to a debate over the relative merits of the U.S. and Chinese innovation approaches. Early in 2017, Senator Marco Rubio published a report on U.S. competitiveness relative to China called *Made in China 2025 and the Future of American Industry* (after China's strategic planning document). In the report, the senator outlines several areas where the Chinese have laid out a strategy to be the world leader in specific technologies. These include nuclear power, renewable electricity, battery technologies, and electric vehicles in the energy sector.[10]

Indeed, China has established a commanding lead in certain clean energy technologies like solar PV, wind, and electric vehicles. According to a recent report published by CSIS and BloombergNEF, China currently has a strong presence throughout the value chain for each of these technologies.[11]

- For lithium-ion batteries, China is the largest lithium refiner, accounting for 61 percent of total capacity. China accounts for a similarly high share of cobalt refining capacity, at 72 percent, with the balance being mainly in Europe. China holds the largest market share among the world's top three-component manufacturing (China, Japan, and Korea): 52 percent for cathodes, which is the most critical component and can account for half the cost of a manufactured cell, 78 percent for anodes, 66 percent for separators, and 62 percent for electrolytes. Around 78 percent of the world's cell manufacturing capacity is located in China, with some modest capacity in Europe and the United States. Looking

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[9] National Academies of Science, Committee on Prospering in the Global Economy of the 21st Century, "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future," 2007, Page 3. https://www.nap.edu/read/11463/chapter/2

[10] "Made in China 2025 and the Future of American Industry," U.S. Senate Committee on Small Business and Entrepreneurship, https://www.rubio.senate.gov/public/_cache/files/0acec42a-d4a8-43bd-8608-a3482371f494/262B39A37119D9DCFE023B907F54BF03.02.12.19-final-sbc-project-mic-2025-report.pdf

[11] Language in the following bullets taken from Portions of this section is adapted from Sarah Ladislaw, Ethan Zindler, Nikos Tsafos, Logan Goldie-Scot, Lachlan Carey, Pol Lezcano, Jane Nakano, and Jenny Chase, "Industrial Policy, Trade, and Clean Energy Supply Chains," February 2021. A report by the CSIS Energy Security and Climate Change Program and BloombergNEF. https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/210224_Ladislaw_Industrial_Policy.pdf?DRja.V6axwyBE_PV6Chmdi5k2VqOq33n

ahead, even if every announced U.S. project went ahead, the United States would still only have about one-tenth of China's cell manufacturing capacity by 2025.

- For solar PV manufacturing, the Chinese presence in the polysilicon market has grown over time. Since 2017, 91 percent of the new polysilicon processing capacity in the world has been built in China, and by 2019, two-thirds of the world's polysilicon manufacturing capacity was owned by Chinese firms (regardless of factory location). More than 90 percent of the world's wafer manufacturing capacity is in China, and having control over this part of the value chain has been essential to the country's dominance of the PV supply chain. Chinese companies also own about 72 percent of the world's module manufacturing capacity (regardless of factory location), a share that has stayed the same since 2016.

- For wind turbines, China's presence is still large but not quite as dominant. Of the 39 countries that make utility-scale wind equipment, only China, India, Spain, Germany, and the United States can produce all six major components: nacelles, blades, towers, generators, gearboxes, and bearings. China accounts for 58 percent of the nacelle market by plant location and 42 percent of the market based on company ownership. Other major producing countries are the United States, India, Germany, and Denmark. (In 2019, 59 percent of the world's plants were in China (by count, not capacity). For wind towers, almost half the world's manufacturing plants are in China, with Spain a distant second. Turbine manufacturing is more dispersed: almost 40 percent of the plants are located in China, but outside of China, the market is dominated largely by European manufacturers. The gearbox market is far more global since gearboxes are comparably easy to ship; roughly half of the world's plants are in China.

- Finally, for E.V.s, China is by far the largest single-country market, has a dominant presence in every component of the upstream supply chain for battery technologies, and is a growing force in the E.V. and battery innovation race. China's E.V. plan began with the rollout of conventional hybrids and more efficient gasoline vehicles, but by 2015 the focus shifted to the mass rollout of E.V.s. Unlike Western leaders in E.V. sales like Norway, China focused on expanding local manufacturing capacity in every phase of E.V. production, rather than overall sales numbers. Today, China is the largest E.V. market globally, and there has been no single policy responsible for its significant E.V. sales and battery manufacturing capacity. However, even as it dominates the upstream E.V. supply chain, China's automotive industry has yet to become internationally competitive, with few, if any, recognizable brands in global markets. This may well change as its indigenous R&D efforts bear fruit, manufacturers benefit from further economies of scale, and global consumers become more comfortable with E.V. technology.

Over the last two decades, these technologies have got from pre-competitive, niche market technologies, to mainstream, cost-competitive energy resources. In many ways, China benefitted from the prevailing attitude about clean energy technology development over the last two decades: trade in clean energy technologies could help grow the market, deploy more technology, and reduce costs. Which it did quite successfully, particularly for solar PV. But

China also deliberately cultivated a strategy to develop these technologies using multiple policy, regulatory, and investment tools on both the supply and demand side of each of these markets.

Like Europe, the United States, and Japan, China initially grew the market for solar PV, wind, and EVs through demand-side subsidies like feed-in-tariffs and renewable portfolio standards etc. China also provided almost unlimited amounts of credit and the balance sheets of major state-owned enterprises to help establish solar and wind equipment manufacturers. China's policy efforts focused both on the domestic market and export opportunities in places like Western Europe, Japan, and the United States. China's approach was so successful that in the early 2010s, the boom in Chinese manufacturing of solar and wind equipment was well underway, and Chinese exports of solar PV began to saturate a global market causing PV prices to plummet. Few manufacturers and policymakers in the West immediately recognized the threats posed by China and were thus surprised when Chinese-made PV equipment flooded across borders.[12]

China's approach to clean energy-oriented industrial policy (picking sectors, providing demand and supply-incentives, and supporting with consistent strategy) is being replicated, to an extent, by several other countries (for a more in-depth look at China's EV development strategy, see Appendix A). For example, the U.K. has launched a *Ten Point Plan for a Green Industrial Revolution*, prioritizing the development of offshore wind, low-carbon hydrogen, advanced nuclear power, zero-emissions vehicles, jet zero, and green ships.[13] Or most recently, Korea's announced "Green New Deal," which plans to spend $144 billion on renewable energy, green infrastructure, and a greener industrial sector.[14] Finally, the European Green Deal which has a series of policy, plans, investments, and mechanisms, including "A new Circular Economy Action Plan for a Cleaner and More Competitive Europe."[15] Each of these plans includes funding proposals, policies, and targets to help cultivate national competitiveness in the future of clean energy technologies. According to the International Energy Agency, fully half of the technologies need to reach net-zero emissions goals by 2050 need further development to either improve performance, reduce costs or both. A great deal that can and should be done to deploy existing, cost-competitive technologies like solar PV, wind, and EVs at a faster rate while also improving on these technologies through dedicated research and development efforts to improve future performance of these technologies. But new and improved technologies are also necessary to reduce emissions in hard-to-abate sectors and to maintain the competitive technological edge in certain industries and sectors. Compared to the more established markets of wind, solar, and

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[12] Sarah Ladislaw, Ethan Zindler, Nikos Tsafos, Logan Goldie-Scot, Lachlan Carey, Pol Lezcano, Jane Nakano, and Jenny Chase, "Industrial Policy, Trade, and Clean Energy Supply Chains," February 2021. A report by the CSIS Energy Security and Climate Change Program and BloombergNEF. https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/210224_Ladislaw_Industrial_Policy.pdf?DRja.V6axwyBE_PV6Chmdi5k2VqOq33n

[13] Ten Point Plan for a Green Industrial Revolution, November 2020. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf

[14] "South Korea's Green New Deal in the Year of Transition" February 2021, UNDP. https://www.undp.org/content/undp/en/home/blog/2021/south-korea-s-green-new-deal-in-the-year-of-transition.html

[15] European Commission website for resources and document on the Green Deal. https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en#documents

E.V.s, the relative competitiveness of each country is less developed, and the positioning to compete in these technologies of the future is getting underway.

Innovation and Coordination

The government needs an overarching innovation strategy to address the shortcomings and needs of the economy as a whole, across technologies, and throughout the federal, lab, and university complexes and programs. But the U.S. energy innovation and competitiveness strategy needs a more dedicated direction and focus. In a July 2020 report, *Race to the Top: The Case for a New U.S. International Energy Policy*, my co-author, Nikos Tsafos, and I recommended several strategies to boost American competitiveness in the clean energy race:[16]

First, define the areas where the wants to compete. Wanting to be number one irrespective of the area makes no sense. The United States continuously defines sectors that are strategic, for example, in screening foreign investment, in channeling innovation resources, in supporting exports, in setting standards, in providing subsidies, and so on. In practice, the United States has a list of priorities that are relatively shared by both political parties, but it is scary to say out loud that such a list exists or to argue that once the list is made, it should dedicate some resources to that list. That is no way to nurture a healthy and competitive economy.

Second, the amount of money that the country spends on R&D is paltry relative to the size of the energy market (even ignoring the costs associated with pollution or climate change), and it is too dispersed. Different sources give different figures, but R&D spending on energy is probably around 0.25 percent of total spending for energy goods and services. In health care, the relative ratio is closer to 1 percent, and in national defense, it is near 8.5 percent. More importantly, this budget is distributed across numerous different agencies and in pursuit of numerous different breakthroughs. The United States needs not only more resources but more targeted areas where it hopes for major innovations. The country can afford to make some big bets in the future of energy, even when and if those bets do not always pan out.

Third, R&D is not enough. The United States needs to think about the markets in which these innovations will be deployed. There is a lot of emphasis on making sure that technologies developed in a lab make it to the market, and those efforts are important. But the biggest obstacle to energy innovation is that markets favor incumbent technologies. The United States spends money to make discoveries but then prevents these discoveries from spreading due to policies that privilege existing energy resources and technologies over new ones. Of course, the United States has tools to rectify such disparities, such as tax incentives, mandates and regulations, and direct support of state institutions—depending on how much change it wants to engender. But the United States hesitates to use these well-established tools, thus undermining whatever successes it has in the lab.

Finally, the United States needs to focus on manufacturing. This is not because of an anachronistic or romantic obsession with making things. It is based, first and foremost, on the

[16] Sarah Ladislaw and Nikos Tsafos, "*Race to the Top: The Case for a New U.S. International Energy Policy*," July 2020, https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/200706_SRF_RacetotheTop_WEB_v2%20FINAL.pdf

recognition that manufacturing jobs are good jobs, with backward linkages that provide a foundation for economic prosperity. There is a security dimension, too, as the country has learned painfully during Covid-19. This is not an argument about protectionism or autarky, but the idea that it does not matter at all where a good is produced is silly. Supply chains will continue to be global, but one can still think about whether those supply chains expose the country to vulnerabilities and whether those supply chains provide as much economic opportunity as they could. A simpler emphasis on manufacturing would ensure that as the world transitions to newer energy sources, many of the widgets of the future are made in the United States and that the country retains the capability to produce resources on which it depends.

All of this points to the need for greater planning and coordination across government agencies to execute a much more deliberate strategy. This should likely happen at two levels. First, there is a role for science and technology organizations like the Office of Science and Technology Policy and the National Science Foundation to think about the bedrock conditions of our science and technology competitiveness across a wide range of industries, sectors, and applications. Thinking more broadly about the health of the U.S. innovation ecosystem is an important part of the equation.

Second, it seems important to establish a lead agency to coordinate the kind of multi-dimensional planning that a more assertive clean energy industrial strategy (or clean energy innovation strategy) requires. DOE is the obvious choice for the lead agency in such a strategy because it is responsible for or involved in the majority of energy-related R&D funding and manages the ongoing relationships with the national laboratory system. It is the home of innovative programs like ARPA-E, X-prize competitions, its technology transfer and commercialization functions. It is also the only agency with deep expertise in energy policy, technology, market, and geopolitical factors. Finally, through its existing work, it has the necessary connections with other agencies and offices, private sector entities, and state and local officials.

A good first step would be to have DOE undertake a Clean Energy Competitiveness Review to identify areas where the U.S. can best compete in developing and deploying clean energy technologies of the future. This report could take into consideration the national security consideration unearthed by the supply chain resilience review underway and also prioritize areas where there is a need to reduce dependence on certain technologies or materials or build domestic capacity to manufacture certain technologies or components. Finally, this review could include recommendations on the combinations of investment, partnerships, incentives (both demand and supply side), policies, standards, and other measures that are necessary to reach the competitive potential of certain technologies.

Clean energy innovation is a very important part of U.S. competitiveness. The market for clean energy technologies has grown and will only get larger as countries adopt more and more ambitious climate policies. China's approach to clean energy technology development, while not perfect, delivered some important success for Chinese economic competitiveness. Other countries are starting to advance similar models of clean industrial strategy to advance more ambitious climate policy in some instances and to capture economic potential in others. The United States can do well in this burgeoning clean energy competition if it chooses to focus its efforts.

Appendix A: “Case Study in Industrial Policy: Batteries and Electric Vehicles in China” from CSIS/BloombergNEF report *Industrial Policy, Trade, and Clean Energy Supply Chains*[17]

In 2012, China published its Energy-Efficient and New-Energy Vehicles Industrial Plan, the central government's latest announcement of its intention to develop a domestic EV and battery industries. Lagging behind in internal combustion engine vehicle technologies, the hope was to better position China for the era of EVs and make the most of its comparative advantages in low-cost manufacturing. Less than a decade later, China is by far the largest single-country market, has a dominant presence in every component of the upstream supply chain for battery technologies, and is a growing force in the EV and battery innovation race. China's EV plan included all the classic features of industrial policy: demand and supply incentives, public procurement, clear targets, R&D funding, and government guarantees. It began with the rollout of conventional hybrids and more efficient gasoline vehicles, but by 2015 the focus shifted to the mass rollout of E.V.s. Unlike Western leaders in EV sales like Norway, China focused on expanding local manufacturing capacity in every phase of EV production, rather than overall sales numbers. Today, China is the largest EV market in the world, and there has been no single policy responsible for its significant EV sales and battery manufacturing capacity. However, even as it dominates the upstream EV supply chain, China's automotive industry is yet to be internationally competitive, with few, if any, recognizable brands in global markets. This may well change as its indigenous R&D efforts bear fruit, manufacturers benefit from further economies of scale, and global consumers become more comfortable with EV technology.

Program Design, Implementation, and Impact

In 2011, only 40,000 EVs were sold globally, and the industry was almost exclusively found in the United States, Japan, and Europe. Just 1,000 EVs were sold in China that year. While China was not a leading EV producer in 2011, it did have a foothold in the consumer battery industry, which served as a foundation for leading E.V. and stationary storage battery manufacturers. After several failed attempts, the Chinese government adopted a new approach in April 2012 with the publication of its Energy-Efficient and New-Energy Vehicles Industrial Plan 2012–2020. The nine-year plan set a more sensible pace than previous efforts. Its near-term focus was the rollout of conventional hybrids and more efficient gasoline vehicles while research and development work continued on EVs. Beyond 2015, the focus shifted to the mass rollout of EVs.

The plan had several components and targets. First, it aimed to increase research and development in key EV and energy-efficient vehicle technologies. This was perhaps the most important development area for the Chinese EV industry. It envisaged a ramp-up in public R&D funding delivered through national research labs, universities, and companies throughout the supply chain. A key developmental target was cost and the battery life cycle. Second, the plan sought to improve industry planning. To avoid overcapacity issues seen in the PV industry and in the early EV battery market, the government aimed to develop two to three leading companies in

[17] Sarah Ladislaw, Ethan Zindler, Nikos Tsafos, Logan Goldie-Scot, Lachlan Carey, Pol Lezcano, Jane Nakano, and Jenny Chase, “Industrial Policy, Trade, and Clean Energy Supply Chains,” February 2021. A report by the CSIS Energy Security and Climate Change Program and BloombergNEF. https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/210224_Ladislaw_Industrial_Policy.pdf?DRja.V6axwyBE_PV6Chmdi5k2VqOq33n

each stage of the value chain with primary attention paid to batteries, battery materials, motors, and transmissions.

Third, the plan sought to accelerate vehicle demonstration and rollout. The government would more closely monitor the 25 demonstration cities in its "Ten Cities, Thousand Vehicles" plan to ensure public purchases of EVs actually occurred. It would also use average corporate fuel consumption targets to encourage uptake. Fourth, it called for another plan to be designed specifically for charging infrastructure to address questions of technology choice, standards, regulation, and business models. Lack of clarity on these points had stymied consumer uptake of EVs in the country. And fifth, the plan called for investment in the recycling and reuse of electric vehicle batteries. The government committed to drafting regulations on how to recycle and which companies would be responsible for doing the recycling.

The overall strategy had three target areas. First, it was to lower battery costs and improve performance. Battery modules should cost less than CNY 2000/kWh ($314/kWh) and have a life of more than 2000 cycles or ten calendar years by 2015 and should cost less than CNY 1500/kWh ($235/ kWh) by 2020. This was later updated with a target of doubling average battery pack energy density from 2016 levels by 2020 and lowering battery pack prices to $150/kWh by 2020. Second, it aimed to boost vehicle sales. By 2015, cumulative sales of BEVs and PHEVs should reach 0.5m; by 2020, cumulative sales should reach five million, and annual production capacity should reach two million. The plan was updated in 2017 to a seven million target by 2025, and the latest plan aims for BEVs to make up the majority of sales by 2035. And third, the strategy sought to improve average fuel efficiency. Passenger vehicles manufactured in 2015 would have an average fuel efficiency of at most 6.9 liters per 100km, with energy-efficient passenger vehicles reaching an average fuel efficiency of at most 5.0 liters per 100km; by 2020, these targets ratcheted to 5.0 liters per 100km for passenger vehicles and 4.5 liters per 100km for energy-efficient ones.

The Chinese government used a combination of demand and supply-side policies to further its high-level goals. Local governments also provided additional but narrower support. Direct purchase subsidies for EVs were key to boosting sales. The specific criteria have been amended a number of times over the last few years as costs of the program ballooned, but the principle has remained consistent, using incentives for both production and consumer adoption. Of the $60 billion the Chinese government is estimated to have spent on the EV industry between 2009 and 2017, around 60 percent or $37 billion was in consumer subsidies. There were fewer demand-side policies to support the battery industry in China, but the EV subsidy scheme boosted demand for batteries which in turn benefitted local companies. The push to improve energy density and battery performance also forced Chinese battery manufacturers to focus on technology development.

On the supply side, China introduced a New Energy Vehicle (NEV) credit program in 2012. Similar to California's Zero Emissions Vehicle (ZEV) mandate, China's system forces automakers to sell an escalating percentage of EVs each year. As with the direct subsidy program, the policy differentiated between performance characteristics of different technologies. There are also three multipliers—range, battery energy density, and vehicle efficiency—that are applied to the baseline NEV credits. The Chinese government also introduced foreign investment restrictions to benefit local automakers and battery suppliers. In 2015, the National Development and Reform Commission (NDRC) and Ministry of Industry and Information Technology (MIIT) jointly issued the New Investment Electrified Vehicles Corporation Management Regulation, which served as the basis for EV production permits. Securing a permit was the first step for automakers seeking to sell EVs and receive government subsidies. Foreign automakers were also required to set up joint ventures with 50:50 stakes in the country. This restriction was lifted for EV manufacturing in 2018 and for commercial vehicles in 2020, and it is scheduled to be lifted for all vehicles in 2022.

Did the Program Succeed?

The combination of a clear national strategy to develop EVs and batteries and specific policies and financial support to sustain it, has boosted EV uptake significantly. China's share of total EVs sold globally rose from 3 percent in 2011 to 26 percent in 2015 and exceeded 50 percent in both 2018 and 2019. China is and will continue to be the world's largest country market for the next decade or more based on annual sales and fleet size for both passenger and commercial vehicles. The combination of policies ensured that Chinese automakers and battery manufacturers were able to scale. As overall EV sales have surged in China, domestic automakers have reaped the benefits. Among the top 10 manufacturers serving the market from 2011–2019, just two were not entirely Chinese-owned: California-based Tesla Motors and a SAIC-General Motors joint venture. Shenzhen-based BYD topped the list, followed by Beijing-based BAIC. The combination of national and local policies has also led to Chinese battery manufacturers establishing themselves as top-tier suppliers. China's CATL was the world's largest supplier of batteries for EVs and for stationary storage in 2019.