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ENGAGING STATE-OWNED ENTERPRISES IN CLIMATE ACTION

BY PHILIPPE BENOIT
SEPTEMBER 2019

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EXECUTIVE SUMMARY

Policy makers, academics, and others have devoted significant effort over the past three decades to considering how best to incentivize households and private companies to reduce their greenhouse gas (GHG) emissions. There has been much less discussion about how best to incentivize state-owned enterprises (SOEs) -- companies that are either wholly or majority owned by a government -- to cut emissions. Yet when it comes to energy sector GHGs, these state companies are among the world's leading emitters. They are major emitters at both the country and global levels, notably from electricity generation. In the aggregate, they emit over 6.2 gigatonnes of carbon dioxide equivalent per year in energy sector GHGs, which is more than every country except China. Public sector companies are also major providers of low-carbon alternatives, such as renewables and nuclear power, and importantly, they often operate under incentives that are quite different from those facing their private sector counterparts.

Given the emissions profile of SOEs, the nature of their corporate mandates, and their ownership structure, Columbia University's Center on Global Energy Policy undertook research to examine how best to engage these companies in efforts to lower greenhouse gas emissions as part of its ongoing work on climate change. The paper explores the role of these public sector companies in climate change, examines the effectiveness of market-oriented solutions such as carbon taxes in changing SOE behavior, and evaluates some other potential strategies for reducing their emissions. In short, the paper finds the following:

- The state-ownership structure of SOEs allows governments to exercise shareholder power to press for the implementation of their climate policy preferences. Providing public sector financing and making associated infrastructure improvements are other ways that a government can encourage its SOEs to invest in low-carbon alternatives.
- In contrast, many SOEs operate with nonfinancial mandates, market protections, and other conditions that limit their responsiveness to carbon pricing mechanisms that are effective in changing private sector behavior.
- There are other ways to alter public sector companies so that they embrace a greener pathway without being directed, especially if a firm's management determines the pathway will serve its corporate interests. This can be especially important for state-owned companies that have the political weight to resist government climate policy pressures.
- In emerging economies with large SOE emissions and with governments willingly direct their SOEs, using these companies to reduce emissions is a policy tactic that can present implementation and other advantages because it requires the government to target a limited number of companies that the state already owns and controls.
- How much a government prioritizes climate change relative to other goals is the most critical factor that will determine the extent to which its SOEs prioritize low-carbon investments. Successfully merging climate goals into growth objectives, at both the broader economic and the SOE-company levels, increases the likelihood that a state company will engage in the low-carbon transition in a sustained manner.

1. INTRODUCTION

State-owned enterprises (SOEs)[1] represent some of the largest participants in the global energy sector, which generates the largest share of greenhouse gas (GHG) emissions.[2] These public sector companies are responsible for an important share of current emissions as they produce and consume energy.[3] Enlisting them in the effort to reduce future GHG emissions is critical to making serious progress toward climate goals. The government ownership structure of SOEs provides both opportunities and challenges for governments as they explore options to implement the low-carbon transition. This ownership structure sets SOEs apart from private sector companies.

While state-owned firms can provide many of the same products and services as private companies, they are often not driven by profit or equity valuation motives alone or at all in some cases. Rather, they are frequently mandated to fulfill nonfinancial government goals, such as generating employment for workers, providing low-cost electricity to households and businesses, or delivering transport services to city inhabitants. Indeed, an SOE might be tasked with providing these services at very low or even negative profit margins in order to ensure that higher government priorities are fulfilled. It is also important to note that the role and economic weight of state-owned companies differs by country;[4] the policy discourse around them is often about ways to improve their economic performance and options to reform them[5] and not about the role that they will need to play in reducing GHG emissions.

Given their various distinctive features, enlisting SOEs in the effort to address climate change might require different tools than those used for private companies. There is robust literature about the methods, such as carbon pricing mechanisms, that can be used to induce the private sector to reduce GHG emissions. Much less has been written about how state-owned companies respond to such methods or what kind of prodding would result in lowering their emissions.

The energy sector produces about 70 percent of global GHG emissions.[6] Since 2013, annual CO_2 emissions from fuel combustion have exceeded 32 metric gigatonnes[7] ($GtCO_2$),[8] with methane and other energy-related emissions adding to this total.[9] The electricity subsector produces 40 percent of CO_2 energy emissions, the largest share, followed sequentially by transport, industry, and buildings.[10] On a national basis, China is the largest emitter of energy sector GHGs, followed by the United States and then India, Russia, and Japan.[11] The European Union (EU) as a group falls between the United States and India. Climate models to limit global temperature increase to 2°C require that CO_2 energy emissions drop by 40 percent by 2040 and by an even larger amount under more ambitious climate goals.[12] Consequently, government climate strategies worldwide need to target the energy sector heavily.

SOEs produce energy GHG emissions in a number of different ways. For example, they combust coal in power plants to generate electricity, burn fossil fuels to produce heat for their industrial processes, and consume gasoline and diesel in their transport systems. These companies produce much of the world's coal, oil, and gas; operate a large portion of fossil fuel power plants as well as most of the biggest "zero-carbon" ones, and finance

many of the largest energy investments. In addition to oil and gas producers, power utilities, and banks, they are steel manufacturers, construction companies, water supply and waste treatment firms, airlines, and urban transit system operators. They are owned by national and subnational government authorities.[13] Many of the world's largest companies are state owned.[14] Numerous SOEs are individually large emitters. For example, a group of fewer than 50 state-owned companies has been estimated to emit more energy GHGs than the entire EU and its 500 million inhabitants.[15] Today, state-owned companies are major drivers of emissions, and they will continue to remain so over the next several decades when governments will look to strengthen and implement their climate strategies.

As emissions continue to rise, the urgency of designing and implementing effective low-carbon strategies increases, including the need to address GHG emissions from state-owned companies. This paper identifies and analyzes some of the main opportunities and challenges to reduce these emissions that result from the government's ownership and other specificities of these entities. The intended audience is both governments and the climate community that are working to identify, analyze, and develop policies and programs to produce a low-carbon transition. The analysis is especially relevant for emerging economies, such as China, where state companies are both significant CO_2 emitters and are actively directed by governments. It also applies to various OECD and other countries where state-owned companies are present in key sectors, such as power and transport, to address climate change.

Today, government commitment to climate goals is often modest, especially as compared to short-term economic growth objectives. However, consistent with the terms of the 2015 Paris Climate Agreement,[16] that ambition is expected to increase. Research into developing stronger mechanisms to support increasing ambition is an important part of the effort to achieve climate change goals, both nationally and internationally. This paper examines some of the different ways that SOEs drive energy emissions (section 2) and highlights several key features that distinguish these companies from private sector ones (section 3). The paper then discusses how those differences can alter the way that carbon pricing and other market-based approaches impact SOE behavior (section 4) and how these features can also open additional avenues for a government to influence its SOEs (section 5). Finally, the paper discusses two critical factors that will affect the choice of tools and their potential effectiveness in influencing state-owned companies, namely the government's willingness to guide SOE action and the priority it accords to the low-carbon transition as compared to other goals (section 6).

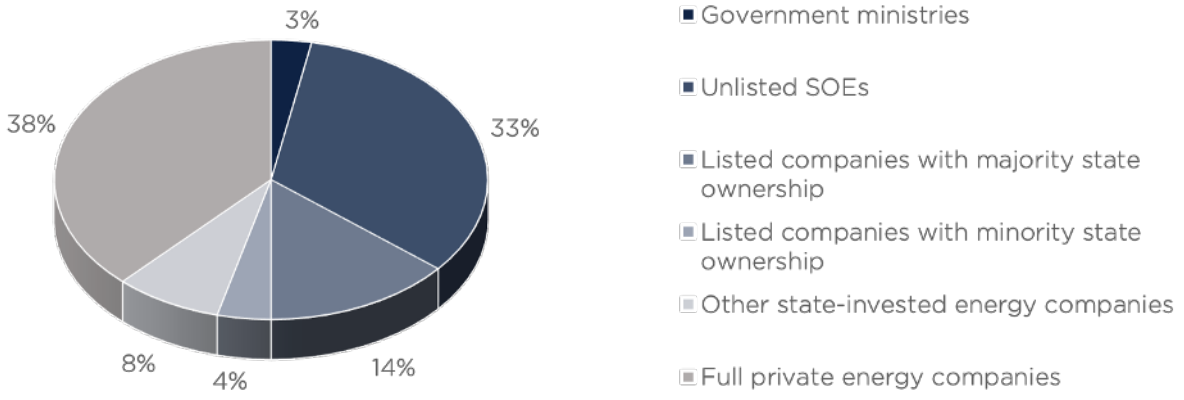
2. STATE-OWNED ENTERPRISES AND GREENHOUSE GAS EMISSIONS

This section examines state companies in greater detail, discussing their emissions as energy suppliers and consumers, their role as project funders, and other characteristics relevant to the effort to manage climate change.

2.1. SOE Emissions

State-Owned Companies in the Power Sector. SOEs and government ministries control 50 percent of global power generation capacity (figure 2-1). These generation assets are critical to the climate change mitigation effort because either they produce CO_2 emissions by combusting fossil fuels to produce electricity, or alternatively, they avoid emissions through their use of renewables and nuclear technologies.

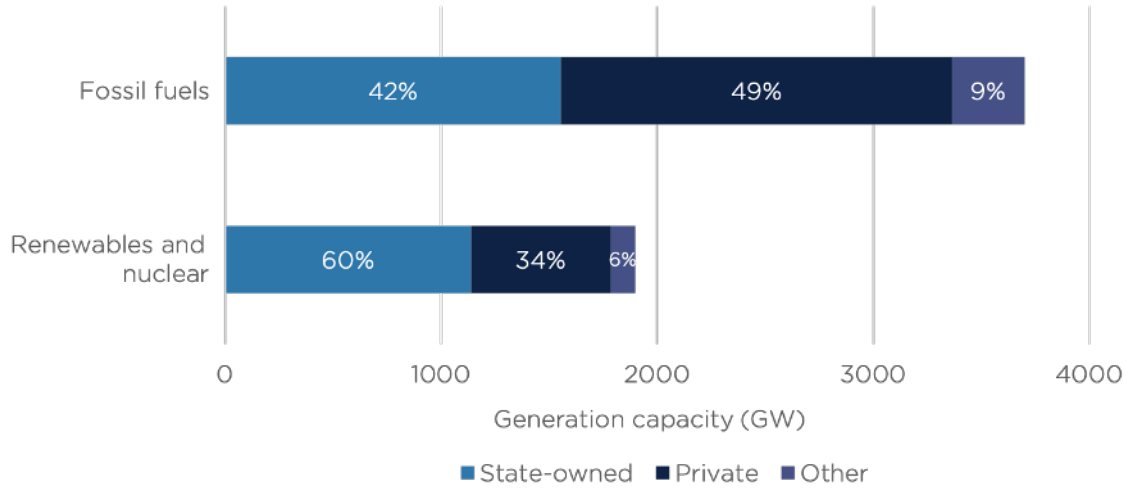
Figure 2-1: SOEs and government ministries own over 50 percent of power generating capacity



Source: N. Prag, State-Owned Enterprises and the Low-Carbon Transition *(OECD, 2018). Based on data for power plants in operation or under construction in 2016.*

Fossil fuel electricity generation produces over 13.2 $GTCO_2$ in emissions per year,[17] more than the emissions from fuel combustion in the transport and buildings sectors combined. These emissions are principally from coal-fired power plants, followed by natural gas ones, with a small portion coming from oil.[18] About 42 percent of fossil fuel generation capacity globally is state owned (figure 2-2).

Figure 2-2: Governments own a significant percentage of fossil fuel generation and an even higher share of "zero-carbon" generation globally



Source: Energy, Climate Change, and Environment: 2016 Insights *(IEA, 2016). Data is for 2012. Renewables data is for utility scale (e.g., excludes small household photovoltaic systems).*

While state companies are responsible for a significant share of electricity emissions globally, it is worth looking more deeply at China, the country with the largest amount of power sector emissions. Nearly all these emissions have been from coal generation,[19] which has produced over 4.24 GtO_2 annually each of the last several years.[20] The public sector (including both national- and subnational-level governmental authorities)[21] controls over 90 percent of China's coal power generation capacity,[22] producing over 3.8 $GtCO_2$ in annual emissions,[23] which is more than 40 percent of China's total energy sector O_2 emissions and 10 percent of the global aggregate.[24] Consequently, China's state-controlled power producers are extremely important actors in the efforts to address climate change both nationally and internationally.[25]

The public sector is also often a major operator and owner of transmission and distribution networks[26] and actually provides a bigger share of investments in these networks than in generation.[27] The operation of these systems can affect power sector emissions in various ways. For example, dispatch and other system operational practices help to determine the energy mix at any point in time and, notably, how much of high- versus low-carbon generation is activated. In addition, when these transmission and distribution networks operate with high technical losses, the outcome is wasted generation activities that can result in higher emissions.

State Producers of Oil, Natural Gas, and Coal. There has been a fair amount of discussion in the context of energy and climate change about the companies that produce fossil fuels. Although most of the emissions from the combustion of these fuels are actually generated by others (such as households when they burn gasoline in their cars, power companies when they use natural gas to fuel their turbines, and manufacturers when they use coal to fire

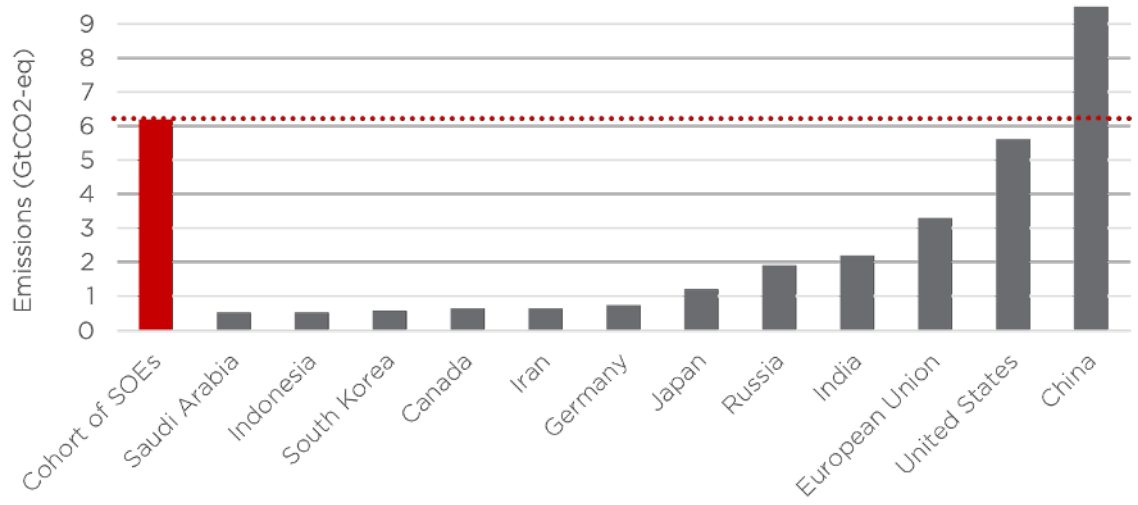
their factory boilers), fossil fuel production companies generate significant GHG emissions in their own extraction and other operations, including from vented and fugitive methane.[28] For example, the International Energy Agency (IEA) estimates that GHG emissions from the extraction, processing, and related transport of oil and gas, together with downstream, gas-related methane emissions, totaled 5.2 gigatonnes of carbon dioxide equivalent ($GtCO_2$-eq) in 2017—nearly 15 percent of the global energy sector total for all GHG emissions.[29]

State companies are major players in fossil fuel production. State-owned oil companies (i.e., "national oil companies" or NOCs) are among the largest oil- and gas-producing companies globally, including the world's biggest oil producer (Saudi Aramco) and natural gas producer (Russia's Gazprom). In the coal sector, Coal India Limited is among the world's largest coal producers,[30] while state companies dominate the coal sector in the largest producing country, China.[31] Improving the efficiency of operations, reducing methane emissions, and deploying carbon capture and storage (CCS) technologies are some of the ways that state-owned fossil fuel companies can lower the GHG emissions generated from the production of these fuels. Moreover, the production and marketing strategies of NOCs can have important impacts on the pricing of crude oil, gasoline, and other petroleum products and by extension on global oil demand and consumption.

SOEs Are Present in Energy-Intensive Industries and as Other Large Energy Consumers. Emissions from fuel combustion and industrial processes totaled 8.3 $GtCO_2$ in 2014,[32] 70 percent of which came from industries such as iron and steel, chemicals, and cement. SOEs are major players in these industries, globally and particularly in emerging economies. These state-owned companies include India's largest steel producer[33] and Indonesia's largest cement producer,[34] as well as several Chinese firms that number among the world's largest cement producers.[35] In the transportation sector, several of the world's largest airlines are state owned,[36] as are the urban transit and metro systems of many major cities, such as New York, Paris, Mexico City, and New Delhi.[37] Their investment and operational decisions will affect energy sector emissions. For example, the acquisition of efficient smelters for steel, research into and the deployment of low-emission technologies for cement production, the choice of electric buses over diesel-powered ones, and strategic operational decisions to increase the attractiveness of transit systems compared to passenger vehicle transport can reduce emissions.

SOEs Have Cumulative Emissions That Are Too Large to Overlook. Although no complete accounting of the emissions of state-owned companies has to date been undertaken, a preliminary estimate points to aggregate energy GHG emissions from these companies of over 6.2 $GtCO_2$-eq globally.[38] This amount is larger than the total energy emissions of every country except China (figure 2-3). Not surprisingly, the majority of the emissions included in this estimate are from China, whose state companies generate over half of its energy sector emissions.[39] A more comprehensive inventory of SOE emissions (including their magnitude and geographic and sectoral distributions, the types of GHGs involved, the activities generating the emissions, and the levels and degree of concentration across different types and numbers of enterprises) would provide useful insights to help governments and SOEs strengthen their emissions reduction strategies.[40]

Figure 2-3: State-owned companies emit more energy GHGs than every country, except China



Source: Country data from Climate Watch database.[41] Emissions for the cohort of SOEs are the author's calculations based on IEA, CPI, and other data.[42]

2.2. Clean Energy Provider

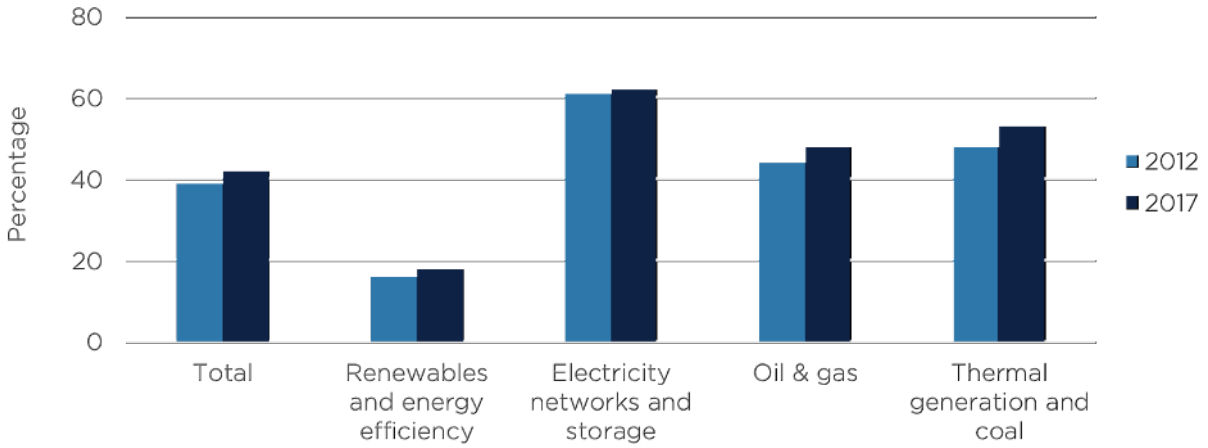
The low-carbon transition will not only need reduced fossil fuel use,[43] it will also require more clean energy;[44] this is an area where state-owned entities are active and in certain cases even dominant. Globally, 60 percent of generation capacity in utility-scale renewables and nuclear is state owned (earlier, figure 2-2). In Brazil, China, Mexico, and elsewhere, SOEs own the majority of large-scale hydropower generation, including the world's biggest sites such as the Three Gorges Dam in China and the Itaipu Dam on the Brazil/Paraguay border. State companies have also played important roles in the development of wind and solar power. In China, they have been major actors in many areas including as plant developers, energy infrastructure providers, plants and systems maintenance companies, and retail market suppliers.[45] State power utilities have also been major purchasers of renewables electricity production, providing a market to support investments in clean energy alternatives.

Carbon capture and storage is another low-carbon technology where SOEs have been active. For example, the Boundary Dam project, one of the earliest CCS power projects at scale, was undertaken by a power utility owned by the Canadian province of Saskatchewan and supported by funding from Canada's federal government.[46] According to a survey conducted by the IEA in 2016, nearly one-third of the CCS projects in operation or under construction and two-thirds of the large-scale projects in earlier stages of development were majority owned or led by state companies.[47]

2.3. High-Carbon and Low-Carbon Project Funding

The public sector is a major source of funding for energy investments, including through budgetary transfers to energy SOEs, retained earnings generated by the company itself, and loans from public sector financial institutions (several of which count among the world's largest companies).[48] In 2017 the public sector funded over 40 percent of energy sector investments, including in both high-carbon thermal generation/coal and low-carbon renewables/energy efficiency, at a higher share than five years before (figure 2-4). Public sector funding for large-scale energy projects is especially important in developing countries.[49] For example, Chinese state-owned banks provided over 80 percent of the bank financing given to the coal power subsector.[50] Similarly, in Brazil, the state-owned financial institution Banco Nacional de Desenvolvimento Economico e Social has been a leading source of financing for energy projects; it provided over BRL 6.5 billion in 2014 in financing for renewables and energy efficiency, including to both public and private sector companies.[51] Public sector financial institutions have been and will continue to be major suppliers of capital for both low- and high-carbon energy investments.[52]

Figure 2-4: Governments/SOEs are increasing their participation in funding energy infrastructure investments



Source: M. Waldron/A. Blasi presentation on IEA's Energy Investment Report 2018 *(New York City, Sept. 25, 2018)*

2.4. Roles in Emerging and Developed Economies

State-owned companies generally play a larger role in emerging economies than in developed countries, representing at least 50 percent of the top 10 firms of Brazil, China, India, Indonesia, Russia, and Saudi Arabia, as compared to only 17 percent and 11 percent for France and Germany, respectively.[53] Similarly, the share of SOE infrastructure revenues was three times higher in emerging economies than in developed countries.[54] Emerging economies are where virtually all the anticipated growth in energy demand will take place[55] and, correspondingly,

where much of the future emissions reduction is needed[56]—and it is in these economies that state companies play a particularly significant role.

2.5. Climate Resilience Efforts

Public sector companies across the globe are owners and operators of significant energy delivery systems (including electricity transmission and distribution networks)[57] that are vulnerable to extreme weather events and other climate-related disruptions. As a consequence, these companies have an important role in improving the resilience of the sector, including through the development and deployment of new technologies, additional investments in infrastructure, the adoption of innovative business practices, and strengthened stakeholder cooperation (including between public and private sector actors). Success in building more resilient energy systems will depend in part on the effective engagement of state companies in these areas.

3. THE NATURE OF SOEs

There are important differences between public and private sector companies that inform how state companies can be directed or incentivized to reduce emissions. This section discusses several distinctive characteristics of SOEs that will affect the choice and effectiveness of the tools available to influence their behavior on climate issues.

3.1. Government Shareholder Rights

State ownership gives the government a critical lever to influence the emissions of its SOEs, one that it does not have with private companies. The government shareholder can exercise this power through formal corporate governance structures (such as shareholder resolutions) or through more informal channels (for example, through periodic consultations with the SOE's executives). Shareholder rights give governments the ability in theory to simply direct their SOEs to decarbonize. However, this has generally not occurred in practice, in part as a consequence of the following three factors: many governments have short-term growth and other objectives that have taken precedence over climate goals; certain governments are hesitant to interfere with state companies for economic, ideological, and other reasons; and many SOEs enjoy varying degrees of political influence that they can deploy to resist government guidance.

3.2. Access to Public Sector Resources

State-owned entities exist within a network of other state-owned and state-controlled companies, agencies, and ministries that governments can mobilize to support them. For example, governments can arrange preferential loans from public sector banks. Governments have in many instances been more willing and able to mobilize substantial public sector support for their SOEs than for a private sector company because assistance to the latter can raise concerns about preferential treatment or unjustified government backing to private interests. Moreover, common governmental ownership can often make it easier to coordinate actions among public sector entities than with the private sector, including for permitting and other regulatory actions. By making the extensive and varied resources of the public sector available to an SOE, a government can provide critical support to help its company move forward with low-carbon investments.

3.3. Public Sector versus Private Company Corporate Mandates

Unlike private companies, state-owned firms are frequently not driven by financial objectives such as profit maximization or equity value creation. Rather, often their mandate is to fulfill some nonfinancial economic or strategic objective. For example, many state power utilities were created to provide sufficient and reliable low-cost electricity to businesses and households to support national economic growth and social development objectives instead of to produce profits. Similarly, state-owned transit systems were often created to provide commuter services to the public rather than to generate retained earnings. For some of

these "service" companies, large profits can even engender hostility from their government shareholder and the public. In response, these companies are often more motivated to expand their asset base (which can serve to enhance their economic importance and related commercial and political power) as opposed to increasing profits.

For other state-owned companies, generating revenues and profits are core corporate mandates, potentially accompanied by strategic and political objectives. For example, many national oil companies (NOCs) were created for the specific strategic and financial purposes of giving governments direct control over the development, marketing, and monetization of the country's natural resources and to generate large revenues for the government. In many cases, these NOCs will also have a parallel service function of supplying cheap products to the local market. NOCs with a mandate to exploit fossil fuels will likely find it particularly challenging to move aggressively to low-carbon alternatives (as compared, for example, to an urban transit company that can switch to clean energy service options). State firms often also need to fulfill some political or social mandate; examples include power companies charged with providing electricity to rural schools and hospitals, manufacturing companies tasked with providing employment, or companies repeatedly called upon to fund political elites. Multiple and disparate mandates can present challenges that can slow the ability of SOEs to shift their business practices, including implementing any changes needed to undertake the low-carbon transition.

3.4. Protections from Competition and Other Market Forces

Governments often insulate state-owned companies from competition and other market forces to varying degrees. Several factors, such as the nature of the company's mandate, the structure of the relevant industry, and the government's willingness to rely on market forces, influence how much a government protects its SOEs from these forces. In many cases, a government's willingness to insulate state companies from market forces is related to the benefits they want the company to provide (e.g., by ensuring public sector control over strategic businesses), the presence of social requirements (e.g., expanding electricity access to poorer households), or the imposition of noncommercial financial conditions. Many public sector power companies have been granted monopoly rights in production and/or distribution, for example, but they also often operate under electricity tariff regimes set by the government at levels that generate minimal profits or even losses.[58]

Some governments hesitate to protect their SOEs in order to allow market forces to guide company action. In other cases, governments expose their companies to some degree of competition in certain specified areas. Many private sector independent power producers are allowed to compete with SOEs in certain generation activities. The degree to which a state company's sector is exposed to international markets also impacts the extent to which a government tries to or can insulate the company. For example, while some NOCs are granted exclusive rights to develop domestic resources or to supply the domestic market, they will still face competition in selling their product in international markets. In contrast, in the electricity sector, the government can more often largely determine much of the market conditions facing its power companies because these companies frequently only operate within the country.

Insulation from competition and other market forces can dampen the responsiveness of SOEs

to price and other commercial signals. It arguably can also help to engender an inflexible business culture, a criticism often directed at large state companies, making it more difficult for them to undertake many of the innovations that are required for the low-carbon transition.

3.5. Government Control versus Corporate Autonomy

Different SOEs enjoy differing levels of operational and financial autonomy. Some have robust governance structures that are designed to enable management to operate the company on a commercial basis with limited political interference. In other cases, management is purposefully subjected to closer and more intense political pressures. Several factors generally determine a state-owned company's commercial autonomy: whether the government prefers to direct its SOEs or rather to deal with them at arm's length through broader market instruments; the regulatory framework, including whether the formal governance structure provides for managerial and board independence;[59] the technical and market conditions under which the company operates; and the SOE's own capacity to resist government pressure. Additionally, another important factor is whether a state firm generates its own revenues or is dependent on government budgetary or other support. Many power SOEs rely on budgetary and other public financing to fund capital investments. The government can influence the company's investment choices through the conditions it attaches to this funding. In contrast, some NOCs enjoy significant financial independence and corresponding operational autonomy (which is also often justified by the highly technical nature of oil and gas operations and the company's need to operate in sophisticated international markets). Greater commercial autonomy is often granted to improve operational efficiency,[60] but it can weaken the government's ability to impose a new low-carbon direction on its own company.

4. SOEs AND MARKET-BASED APPROACHES TO EMISSIONS REDUCTIONS

Given the structural differences between public and private companies discussed earlier, this section examines how market-based approaches to reducing GHG emissions may fall short or need to be adjusted to incite action from SOEs. It also touches on how nonpricing market regulations (such as performance standards) can influence them.

4.1. Carbon Pricing Mechanisms: Taxes and Cap and Trade

Carbon taxes and emissions trading systems (ETSs) are market-based pricing mechanisms designed to spur the efficient reallocation of resources toward a low-carbon future and have received significant attention within the climate community, academia, and governments. There are important and visible examples of these carbon pricing mechanisms being implemented, such as the groundbreaking European Union's ETS,[61] the carbon tax in Sweden,[62] and more recently China's several subnational ETS pilots and proposed national system.[63] Carbon pricing mechanisms can influence the behavior of companies (as well as households and other consumers) by changing the relative pricing and the economics of various energy choices; their adoption can also be a way for a government to signal to economic and other actors its political will to decarbonize.

To date, the price under many carbon pricing initiatives (whether the level of the tax or the cost the allowances under an ETS) has not been sufficiently high to significantly influence investment and operational decisions.[64] This low-carbon price has often reflected modest government commitment to climate goals,[65] although in certain cases it also resulted from unanticipated complex pricing dynamics that have required structural improvements.[66] Looking forward, to the extent government commitment to reducing GHG emissions increases, higher carbon prices can be anticipated under these market-based mechanisms.

Separate from the price level, the impact of carbon taxes or an ETS on an SOE will depend on its various corporate, commercial, and financial features, such as the nature of the company's corporate mandate and the degree to which it is protected from competitive forces. For example, as described below, carbon pricing mechanisms are likely to have a muted impact on the numerous SOEs that have service rather than profit mandates and are insulated from market forces.

Carbon Taxes. State-owned companies that are exposed to market forces and operate under a strong commercial mandate, with autonomy, can be anticipated to respond to a carbon tax in many ways like their private sector counterparts.[67] However, these taxes are less effective on the numerous SOEs that have service delivery mandates, are insulated from market forces, and/or operate under heavy political mandates. The imposition of a carbon tax can significantly reduce the profitability for a power company of burning coal as compared to using natural gas or renewables. However, the company may be reluctant to switch fuels if power production is its principal corporate mandate and it has concerns that switching fuels may decrease its ease and certainty in generating electricity, and this reluctance may exist

even in the face of the substantially higher fuel costs and lower profits that result from the imposition of the carbon tax. A state company may also seek additional budgetary transfers from the government to cover its increased fuel costs or threaten to reduce electricity production with attendant undesirable economic impacts (as occurred in China in response to an earlier government policy that increased coal prices relative to electricity tariffs).[68] These various factors can reduce the impact of a carbon tax on a state company as compared to its private sector counterpart. That said, high prices from a carbon tax may ultimately press even an SOE to take some action if they reach a level that threatens the company's ability to sustain its operations, and this action might involve the desired fuel switching.

Emissions Trading Systems. The effectiveness of an ETS in incentivizing a state-owned company is subject to many of the same factors and limitations as a carbon tax—its impact will depend in part on the SOE's mandate and the commercial context in which the company operates.[69] The design of an ETS should take into account whether state-owned companies are needed for the system to succeed and, if so, their corporate and commercial features.

An ETS targeting SOEs focused on the delivery of low-cost electricity independent of profits should differ from the EU ETS that targets multiple competing, publicly listed companies with a strong business culture oriented to stock value. One of the ways in which these two types of companies may act differently under an ETS involves their incentive to sell allowances, a necessary condition for active trading. While a private sector company can generate additional profits from selling excess emissions allowances to a competitor, it is unclear whether a service-oriented public company would benefit meaningfully from the sale. Consequently, less trading could be anticipated in an ETS that targets these types of SOEs.[70] In such a case, mandating some release of allowances (e.g., by requiring holders of excess allowances to make them available for purchase) may be important to provide liquidity for trades. Similarly, SOEs operating in nonliberalized markets may not be well equipped from a business practices perspective to engage in the trading of paper certificates, as was noted in the case of China's ETS.[71] Training and management incentives can potentially help generate more ETS activity in this type of environment.

The ETS structure presents a potential advantage over carbon taxes as a tool to reduce emissions: the caps on emissions embedded within this type of system can be designed through the use of volumetric limits to reduce explicitly the capacity of SOEs—and other economic actors—to emit.[72] Coupled with an effective monitoring and enforcement system, governments can use the caps within an ETS system to progressively and explicitly lower the level of emissions across SOEs in a systematic and prescriptive manner. This approach of imposing caps may also better match policy environments that favor command and control approaches rather than market pricing incentives.

4.2. Market-Oriented Analytic Tools: Shadow Carbon Pricing and Stranded Assets

Other market-oriented financial approaches that have been invoked to help guide investment decisions in support of the low-carbon transition, such as the internal use of shadow carbon pricing and the stranded assets analysis, may also prove useful in inciting action from state-owned companies.

Shadow Carbon Pricing. In the absence of an externally imposed price on carbon, many companies have adopted internal policies and practices for evaluating projects that incorporate a "shadow" price on carbon. Shadow pricing can be a useful tool to help state companies (like their private sector counterparts) to make more efficient choices consistent with the low-carbon transition, allowing for a carbon-informed evaluation of proposed alternative capital investments.[73] Moreover, by increasing the notional "internal" cost of using fossil fuels and the relative pricing of high-carbon activities, shadow carbon pricing can also help companies to reduce the risk of overinvesting in fossil fuel projects in the event of more stringent future climate-related regulations and other constraints. Various SOE energy companies, as well as several of the world's largest private sector energy companies, are now using shadow carbon pricing.[74]

Stranded Assets Analysis. There has been increasing discussion about the climate-related risk of "stranded assets" as part of efforts to reduce investments in high-carbon assets. This is principally the risk that investors would not recoup their investment in a fossil fuel power plant or other asset because climate or other related policies and market forces will curtail the economic life or otherwise limit the operations of the fossil fuel facility to the point of preventing a sufficient financial return.[75] Properly valuing and integrating this financial risk into a project analysis can deter investors from making certain fossil fuel investments, which in turn would support the low-carbon transition. This analysis also relates to the potential to overvalue fossil fuel companies by overestimating their ability to develop their reserves in the face of the prospect of increasingly stringent carbon restrictions, which overvaluation creates a risk for stock purchasers and other investors.[76]

This stranded assets analytic approach can be used by governments and state companies to avoid overinvesting in high-carbon assets. To date, the stranded assets discourse has arguably had less relevance and utility for governments because it has been oriented to the company-level financial returns that drive private sector investors, rather than the broader economic returns that motivate government decisions. Reorienting the analysis for a proposed investment to its economic costs and benefits can help the government better assess whether the spending would generate sufficient returns to justify the expenditure or result in an overinvestment in a high-carbon asset with limited returns that wastes public resources (box 4.1).

Box 4.1. Stranded assets: An economic analysis for SOEs and their government shareholder that differs from their private sector counterparts

Governments can better evaluate the advisability of a potential investment through an economic analysis rather than a financial one.[77] While typically, private sector companies look to extract an adequate financial return at the company level, governments invest through their SOEs to generate benefits for the economy as a whole. Similarly, while a financial analysis is used to show companies their potential revenues and monetary returns from an investment, an economic analysis shows the government the potential benefits to the country from gains to a variety of actors in addition to the company, such as households and businesses that receive electricity, the domestic industry that obtains natural gas for its plants, or the government that gains budgetary resources from taxes and royalties on the international sale of oil by its NOC.

This distinction between an economic and a financial analysis can be illustrated by a power generation investment. Some of the key differences relate to the valuation of construction costs and the outputs. For example (in simplified terms):

- A financial analysis for a power plant compares (i) the amount to be expended in building the facility (for example, the cost of the engineering, procurement, and construction [EPC] contract) to (ii) the anticipated revenues to be received by the company from electricity sales and capacity payments, net of taxes and operating costs.
- The economic analysis used by governments compares (i) the cost of this investment using (in contrast to the EPC contract) border prices for imported turbines and other goods and services that are the net of import duties, and calculations for local labor and other local materials that typically differ from the EPC contract amount, to (ii) the benefits generated for the economy through the consumption of the supplied electricity (often calculated on a "willingness-to-pay" basis), as well as (iii) the costs and benefits from a broader set of externalities (including, for example, negative local environmental impacts).

Development banks and governments are increasingly incorporating into their economic analysis a shadow price for the social cost of carbon emissions that is designed to cover the corresponding climate externalities.[78] This is less common in a financial analysis (although, as noted earlier, companies are increasingly incorporating some shadow carbon pricing into their financial evaluations).[79]

A stranded assets analysis that focuses on financial returns at the company level is not adapted to the needs of a government shareholder concerned with broader economic costs and benefits. Developing and providing governments and their state companies with a stranded assets analytic methodology that is oriented to economic costs and benefits can help them to better decide whether a potential fossil fuel investment (such as a coal- or gas-fueled power plant) presents an unacceptable stranded assets risk.

4.3. "Nonpricing" Mechanisms: Performance Standards and Other Regulations

Governments have explored a variety of regulations as an alternative or complement to carbon pricing mechanisms,[80] such as standards that target GHG emissions, energy performance, vehicle emissions, or renewables portfolio shares as well as monitoring and reporting requirements.[81] Climate regulations can be a useful mechanism to lower emissions from SOEs. In addition, there can be important climate co-benefits from regulations designed to target other goals, such as air quality or energy conservation. Governments must set the right norms and carry out robust monitoring and enforcement actions to ensure regulations are impactful.

Many economists and other analysts view these types of regulations as less desirable tools to address emissions than carbon pricing mechanisms in part because they are judged to be less economically efficient.[82] Yet, while carbon pricing may have a more muted impact on a variety of SOEs than on their private sector companies, regulations are likely to have a comparable impact on both types of companies, provided, among other things, that the public sector's enforcement is similarly stringent for both kinds of companies. In some situations, an SOE may be especially responsive to specific government regulations to satisfy its government shareholder. Governments can also leverage their ownership rights to drive regulatory compliance from their state-owned companies, for example, by conveying to the SOE's executives the importance they attach to robust compliance with the regulation.

5. OPPORTUNITIES TO REDUCE SOE EMISSIONS

A government's ownership status gives it a powerful array of tools to prompt its public sector companies to reduce their emissions. These tools include exercising its shareholder rights to influence corporate decisions and mobilizing public sector assistance to support SOE low-carbon investments. Governments have also created new, specialized low-carbon SOEs to advance their climate efforts. A distinct additional potential driver of SOE climate action is an internally generated management decision that the company's own corporate interests will be served by advancing the low-carbon transition.

5.1. Government Shareholder Power

Shareholder Directives and Directions. One of the key ways that a government shareholder can drive low-carbon action by its SOEs is through the formal corporate shareholder governance structure of the company itself, including its board of directors. A government can issue shareholder resolutions and other directives to the board in favor of reducing emissions, which are then transmitted to company senior management. A government shareholder can also employ informal measures to guide low-carbon action that take advantage of its position as the dominant shareholder, for example, by organizing periodic discussions between high-ranking government officials and company executives. Governments have extensive legal and institutional powers to direct the operational strategies of their state companies that they do not enjoy with respect to private sector companies (absent legislative or other regulatory action).[83] This is particularly relevant for SOEs that operate in political-economic environments where government direction to public sector companies is common, such as China. In practice, this power can be constrained by various factors, including the corporate and political weight of the SOE itself (box 5.1).

Box 5.1. SOE "independence": Some capacity to resist government guidance

Some state-owned companies enjoy a significant degree of operational independence from their government shareholder. In certain cases, the company's formal governance structure provides for this independence through provisions designed to support the SOE's commercial autonomy (e.g., by requiring independent board members) so as to promote efficiency and reduce the potential for political interference. Other SOEs enjoy substantial financial, economic, and political weight, potentially greater than their supervising ministry. Many NOCs generate massive revenues from their own operations that dwarf government ministries and are a major source of government budgetary resources. Power companies often enjoy substantial influence because they frequently control large amounts of assets, generate electricity that is critical to the economy, and receive substantial revenues from its sale.[84] In certain contexts, SOEs even have the ability to influence government policy.[85] This independence can hinder government efforts to prompt their SOEs to reduce emissions, especially if a state company sees benefits from continuing high-carbon operations.

The difficulties a government may face in its effort to influence SOE action can be exacerbated if the company is owned by a different level of government responding to a different set of priorities. For example, national climate policy directives may be more difficult to impose on a company owned and controlled at the regional level if the regional authorities foresee an adverse impact on local employment.

In circumstances where the SOE enjoys substantial independence, demonstrating how a lower carbon pathway can serve corporate interests may prove more effective than external governmental pressure (as discussed later in this section). In addition, even when a state-owned company holds a fair degree of independence, it remains sensitive to the desires of the country's president, sovereign, or other top leadership. However, because climate policies are often developed and implemented at lower levels of government that have more limited power, the country's top leadership may need to ensure large and powerful SOEs engage in the low-carbon transition.

Government directives and direction can address a wide variety of company actions that will impact emissions by influencing the choice of technology (for example, favoring the construction of low-carbon power plants rather than traditional thermal ones) or requiring the adoption of low-carbon solutions (such as carbon capture and storage). Mandating greater energy efficiency in the SOE's operations is another way to lower emissions, including for heavy industry and oil and gas producers. The government shareholder can also encourage its companies to innovate their business practices, direct them to increase spending on research and development,[86] encourage them to become active traders in a newly established ETS, or instruct them to join specific international collaborative efforts.[87]

Aligning SOE Corporate Mandates with the Climate Change Effort. An important way in which a government can support the engagement of its SOE in the low-carbon transition is to ensure that the enterprise's corporate mandate is aligned with climate goals. A study by the OECD found that policy misalignment can weaken the low-carbon transition effort, while alignment can provide important synergies.[88] This assessment also applies to SOE corporate mandates. In practice, however, a government may hesitate to shift the mandates of its SOEs toward embracing strong climate action if it prioritizes other goals, such as short-term growth based on fossil fuels.

Senior Management Controls: Power of Appointment and Replacement. A government shareholder's power to appoint and remove senior executives gives it another lever through which to influence state company decision-making. It is already a common practice for incoming governments to replace the chief executive officer of strategic state-owned energy companies. For a government looking to shift its SOEs to a low-carbon pathway, installing senior executives who have the commitment, vision, and managerial capacity to carry out the low-carbon transition can be useful, just as removing those who resist this path can also create the right incentives for prompting effective management action. The government can also use the executive compensation system to influence SOE senior management, including through promotion and financial benefits. In China, SOE executives are often members of the Communist Party, which integrates SOE management into the country's political decision-making structure.[89]

"Climate-Friendly" Middle Management and Other Human Resources Policies. While leadership at the top of a public sector company is critical to effecting change within the company, change also requires action by middle management and other staff. As a result, it is important for a government shareholder seeking to move its SOE along the low-carbon pathway to ensure that the company's internal recruitment and organizational and evaluation systems are aligned with low-carbon action. For example, establishing human resources policies that reward employees for innovations or other actions that lower emissions or recruiting low-carbon specialists with bureaucratic authority within the SOE can be effective in changing business practices.[90] These types of human resources programs can often be important to ensure sustainable change over the longer term, especially as senior executives often depart SOEs more frequently than the lower levels of management and staff who heavily influence the day-to-day operations of these companies.

SOE Procurement. Governments can shape the asset base of SOEs to reduce emissions through the issuance of procurement directives (including public procurement regulations) that favor low-carbon solutions.[91] They can also direct an SOE to coordinate with other public sector purchasers to favor low-carbon technologies that in turn can help create a larger market that encourages manufacturers to build out their low-carbon product line.[92] In addition, as SOEs are often big enterprises that purchase a large amount of goods and services themselves, governments can influence the broader supply chain by mandating that their SOEs require low-carbon products and solutions from their private sector and other suppliers.[93]

Monitoring and Enforcement. Regardless of the approach, it is important for a government to follow up on its guidance with monitoring plans and to put in place both rewards to support

success and sanctions to address failure. This can be particularly important in contexts where SOE independence means that government shareholder directions don't necessarily translate into conforming company action.

5.2. Public Sector Financing and Infrastructure Improvements

Financing. A government can support emissions reductions by providing financing to its companies for low-carbon investments. This financial assistance can take on a variety of forms, such as budgetary transfers, government equity injections, targeted credit lines, and preferential lending terms. It is often easier for a government to provide the large-scale financial assistance required for energy investments to a public sector company than to a private sector firm and its investors.

State-owned commercial and development banks are important sources of financing that can be used by a government to support its green agenda. These banks can support the low-carbon transition in numerous ways, including by (i) providing dedicated lines of credit for low-carbon projects; (ii) according favorable lending terms for these projects; (iii) excluding high-carbon investments from funding;[94] and (iv) imposing due diligence and other climate change mitigation conditions on financing (e.g., environmental impact assessments that address climate impacts). The government can influence the lending practices and programs of these financial SOEs in the various ways discussed earlier, including through both formal directives to the bank's board and informal direction to the bank's senior management. The low-carbon policies and programs of state-owned banks can also influence the investments of private sector companies. For example, state banks can catalyze private sector investment in low-carbon technologies by offering dedicated lines of credit and favorable lending terms for clean energy projects.

Associated Infrastructure. Government can also provide critical associated infrastructure improvements needed to support an SOE's prospective low-carbon investments. For example, governments can help connect isolated large-scale hydro, wind, and solar power generation sites to the national electricity grid. This can involve a combination of public sector entities such as an independent systems operator responsible for managing the grid and its extension, a public sector transmission line construction company to build the interconnection, a state bank to provide the financing, and a regulatory agency to provide the appropriate permitting. The independent systems operator can also assure that once the plant is operational, the renewables generation is provided with adequate access to the grid. Similarly, state-owned industries can be supported in switching from coal use to natural gas through the installation of pipelines and other infrastructure to deliver the gas, facilities that other specialized energy SOEs can often construct. The deployment of electric transport vehicles depends on the development of an adequate charging infrastructure, which the public sector is often well placed to provide. Building a smart grid requires expanded internet infrastructure that, in many countries, will be implemented, financed, or facilitated by the public sector. Associated infrastructure can often also help private sector low-carbon action (e.g., pipelines can help private industry as well to replace coal with gas, and electric charging points can similarly support private bus operators).[95]

5.3. New Low-Carbon SOEs

Governments can also create new state-owned companies to expand activities in low-carbon technologies. This can include operational enterprises (for example, to manufacture or install solar panels), specialized banks that fund low-carbon investments, and other types of companies. For example, in 2009 the Indian government created Energy Efficiency Services Limited, a public sector energy services company, to fund and implement energy efficiency investments.[96] Establishing a new company will often require budgetary or other public sector financial support. Creating a new SOE can be particularly appropriate in the case of an emerging technology where incumbent companies do not already exist.

5.4. Innate Capacity of SOEs

One of the potentially most powerful sources of effective change lies within the company itself if its management decides that engaging in the low-carbon transition will support the SOE's corporate interests. Many of these enterprises are very large corporations that control an enormous amount of assets and financial resources; several are among the world's biggest companies.[97] They also often enjoy a high degree of technical and commercial expertise and operate in sophisticated businesses, such as electricity, nuclear power, oil and gas, steel, and finance. This constitutes a powerful combination of resources available to SOE management to craft and implement its corporate strategy—one that can seek to exploit the commercial opportunities provided by a low-carbon-oriented pathway. For example, SOE management could decide that providing low-carbon services would enable the company to expand existing markets or open new ones. Alternatively, an SOE could move to lower its emissions to get ahead of regulatory restrictions and other changes in market conditions foreseen by company management. Where appropriate, exploiting these commercial opportunities and anticipating these types of regulatory and market changes can make "business sense."[98] Commissioning analytic work (e.g., at the behest of the company, its government shareholder, or an external stakeholder) to identify how the SOE's medium to longer-term corporate interests can be served by engaging in the low-carbon transition can help to generate senior management support.

Many SOEs that are considering reorienting their business to a low-carbon model would benefit from undertaking a strategic corporate planning exercise to explore potential pathways that could be expanded—that is, "enhanced"—to cover the breadth of economic and social, as well as financial concerns, that a state-owned company may face (box 5.2). The exercise can produce a sound low-carbon road map that the SOE can then implement or, alternatively, that can be activated at a later point as government climate ambitions grows (and the pressure on the company to decarbonize increases). The exercise might also reveal some near-term actions the SOE can take to reduce emissions that also serve financial and other corporate goals (such as lowering costs or expanding market share).

Box 5.2. An "enhanced" corporate strategic planning exercise to help SOEs pivot to a low-carbon pathway

A strategic corporate planning exercise can help to identify how an SOE can transition its business to a low-carbon pathway. For many companies, whether state owned or private, shifting their operations away from fossil fuel production or consumption can prove a daunting and complex task, in particular for an enterprise with significant high-carbon assets (such as a large fleet of coal power plants). A strategic planning exercise (often used by major private sector firms) can help a company to identify preferred options to effect this transformation.

For many SOEs specifically, this type of shift can raise additional special challenges as they serve various economic and social goals that extend beyond traditional corporate concerns. For example, retiring a fleet of coal power plants not only presents complex financial issues for a power generator (whether state or private) but can also (i) adversely affect employment in other sensitive sectors that support plant operations, such as coal mining; (ii) reduce revenues for strategic railways that ship coal;[99] and (iii) raise supply and reliability concerns for electricity customers—issues that can be of great importance to the government shareholder of a state-owned power company.

Addressing this wider set of corporate and broader economic issues requires an expanded, or "enhanced," strategic corporate planning exercise. Given the variety of interests and stakeholders involved, this exercise should preferably be commissioned and undertaken by the SOE and its government shareholder together.

6. TWO OVERARCHING POLICY FACTORS

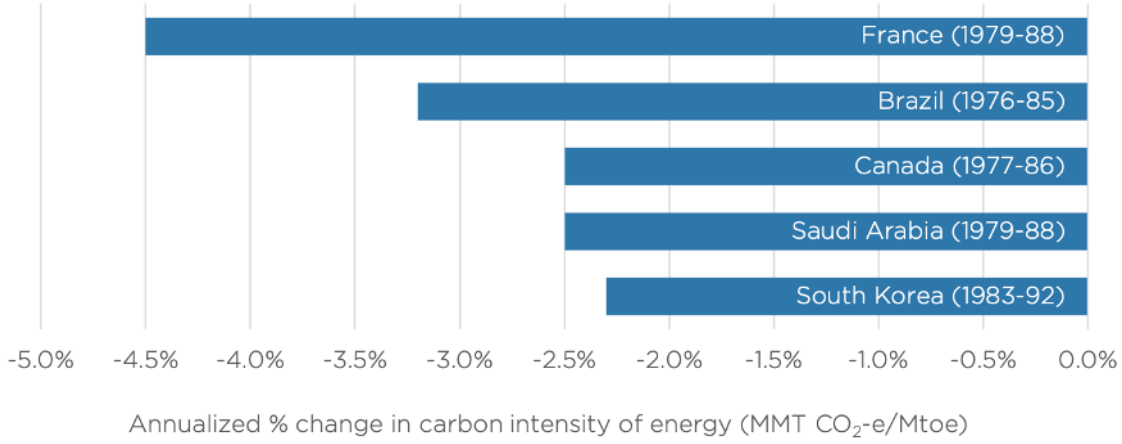
There are two critical factors related to the government's overarching policy framework that will affect the availability and effectiveness of the various mechanisms presented earlier. The first is the "willingness" of the government to actively guide state company action, which is largely a function of its political-economic approach. The second, and perhaps most important, is the degree to which the government prioritizes climate relative to other policy goals, such as short-term growth.

6.1. Government Willingness to Direct SOE Action

Governments enjoy the legal, financial, and organizational power to drive low-carbon action taken by their SOEs. However, the willingness of governments to manage or direct their public sector companies varies by country and even by company, depending on factors such as economic ideology, stakeholder expectations, regulatory provisions, and unwritten norms. Some countries (including numerous OECD members) favor market forces and private-sector-dominated growth, while others rely relatively more on command and control systems and the public sector (notably, China).[100] Similarly, while certain countries generally try to exercise limited influence over the operational decisions of their SOEs (such as the United States),[101] others exert greater formal and informal control over their state-owned companies (for example, various emerging economies). An SOE's formal governance and legal structures can also affect the government's willingness to direct the company's actions—a legislatively mandated independent board can act as a disincentive or even barrier to government efforts to direct company operations, for example. These political, cultural, and governance factors can determine the extent to which a government is willing, and able, to drive the corporate actions of its SOEs toward the low-carbon transition.[102]

Several governments have been effective in using their public sector companies to restructure the energy sector and reduce emissions. A Breakthrough Institute study shows that the fastest historical declines in carbon intensity have occurred in public-sector-dominated energy sectors (figure 6-1)—these shifts, however, were not driven by climate considerations. Of course, public sector companies cannot drive emission reductions in all countries. For example, the countries shown in figure 6-1 generally had systems characterized by heavy SOE energy sector participation, which is not the case in many economies.[103] In addition, these energy sector restructurings were made through investments in large-scale projects in hydropower, nuclear, and natural gas,[104] for which SOEs are often relatively well adapted. Going forward, the decarbonization of the power sector will likely need to take place in part through smaller-scale investments, notably in solar power. This is an area where SOEs have not been very active to date and arguably are not as well equipped to lead.

Figure 6-1: Fastest declines in energy carbon intensity have been driven by SOEs and public sector investments



Source: J. McBride, The Breakthrough Institute (2019).[105]

A government's choice whether to rely significantly on public sector companies to advance the low-carbon transition should be based on a number of factors and considerations that will vary by country. It is likely to be appropriate in many of the emerging economies in Asia and other regions where SOEs are major actors in driving energy emissions; these are also countries where most of the anticipated growth in energy demand and related emissions is projected to occur.[106]

6.2. Government Prioritization of Climate versus Other Goals

Ultimately, the government's prioritization of the low-carbon transition relative to other policy goals will likely be the most important factor in determining the degree to which its SOEs effectively engage in this transition. Although virtually all countries have developed climate strategies and have pledged to reduce their emissions as part of their nationally determined contributions incorporated into the Paris Climate Agreement, most governments have not prioritized the low-carbon transition domestically. Similarly, climate goals have typically received relatively modest support as compared to short-term economic growth objectives that are often tied to fossil fuel use. Moreover, numerous governments have been concerned that imposing stringent climate standards on their companies may negatively affect competitiveness, especially for firms operating in international markets where their competitors face weaker requirements. The result is a generalized climate policy framework that isn't very robust, in particular relative to what is needed to achieve the Paris Climate Agreement's goals.[107]

The Paris Climate Agreement does contain provisions calling for countries to increase their climate ambitions and strengthen their climate policies over time.[108] However, it is also

important to find other ways to increase government motivation to reduce emissions (box 6.1). These can include developing and publicizing the synergies between climate action and medium to long-term economic growth, spurring innovations that reduce the cost of clean technologies and increasing the availability of international climate finance. Developing ways to enable SOEs to meet their corporate mandates (such as the provision of reliable low-cost electricity) in a low-carbon manner will be key.

Box 6.1. Several avenues to increase government commitment to the low-carbon transition

Merging economic growth and social development objectives with the low-carbon transition can help governments prioritize emissions reduction efforts. Fully evaluating the longer-term economic impacts of clean energy solutions relative to a high-carbon pathway can help to increase their appeal. Further innovations to drive down the costs of clean technologies can increase their attractiveness for both governments and their SOEs. Increasing international financing can also help and has been sought by various developing countries to implement their low-carbon strategies.[109] In addition, other domestic priorities such as reducing local pollution or diminishing energy import dependency, both of which can be accomplished by developing domestic solar and wind power, can also reduce emissions. Emphasizing these other goals can help generate greater government support for lowering greenhouse gas emissions.

At an international level, the low-carbon transition has lost some momentum since the successful consensus reached at the Conference of the Parties (COP) 21 in Paris in 2015. This, in turn, has arguably reduced some of the efforts that were being made by governments to reduce their emissions. Rebuilding the international consensus around the goals of the Paris Climate Agreement, including notably through a renewed commitment by the United States, would also help to generate greater support from many governments for low-carbon action.

However, to the extent that maintaining growth in the short term, and beyond, remains the key objective for many governments (including in numerous emerging economies and advanced economies), a pressing challenge is to strengthen the link between emissions reductions and near-term increased prosperity. Finding ways to advance climate goals while still meeting these growth objectives will be key to nurturing strong and sustained government commitment to the low-carbon transition, and this will also increase the likelihood of sustained ongoing engagement by its SOEs in this transition.

7. CONCLUSIONS

The analysis in this paper points to the following main findings and initial set of recommendations:

- **SOEs are major drivers of energy sector GHG emissions globally,** as a group emitting over 6.2 GTCO2-eq, which is more than every country except China. They are also major providers of low-carbon alternatives, notably utility-scale renewables and nuclear power. The actions of these state-owned companies will be a major factor that determines the degree of success in achieving climate goals, in particular for many emerging economies and at a global level.
- **An inventory of SOE emissions should be undertaken to better understand their magnitude and distribution.** This inventory can provide details about the geographic and sectoral distribution of the emissions, the types of GHGs involved, the activities generating the emissions, and the levels and degree of concentration across different types and numbers of enterprises. This information would help to inform the development of emissions reductions strategies that can draw on the common characteristics of these companies.
- **SOEs have several distinctive features that affect the applicability of different climate tools, most notably the government's ownership stake.** This structure often results in these companies having noncommercial mandates, market protections, and other features that limit their responsiveness to carbon pricing mechanisms. It also gives government potent additional tools to press state companies to implement its climate policy preferences—tools that it does not enjoy with private sector firms.
- **Governments should use a multitiered approach to prompt their SOEs to lower emissions.** An integrated approach might include issuing government directives to the SOE through the corporate governance structure, providing public sector financing and associated infrastructure improvements for low-carbon investments, establishing an emissions trading system, and strengthening regulatory energy performance standards for equipment. These measures can lower state company emissions even in the current context of often moderate government commitment to climate action. Governments have incorporated some of these measures into their national low-carbon strategies, but more can be done to exploit state control over public sector companies to advance climate action.
- **An SOE might also embrace a greener pathway without being directed if its management determines the pathway will serve its corporate interests.** This approach can be especially important for state-owned companies that have the political weight to resist government climate policy pressures, and it is also helpful in the current context where governmental support for climate action (and the related pressure on companies) could be described generally as moderate.

- **The priority that a government gives to addressing climate change relative to other goals is the most critical factor that will determine the extent to which its public sector companies engage in the low-carbon transition.** Successfully merging climate goals into growth objectives, at both the broader economic and the SOE-company levels, will increase the likelihood that the state company engages in the low-carbon transition and will help to nurture stronger and more sustained government and SOE commitments to that transition.
- **In countries with large SOE emissions, using public sector companies to reduce emissions is a policy approach that can provide implementation and other advantages for the government because this method involves the government driving the actions of a discrete number of companies that it already owns and controls.** This can be particularly useful in those high-emitting countries where government frequently directs state company action, as is the case in numerous emerging economies. Moreover, as a government increases its climate ambition, pursuant to the Paris Climate Agreement or otherwise, and looks to develop the next set of climate policies to meet that ambition, it can strengthen the measures set out in this paper to use state-owned companies to generate additional emissions reductions.
- **Public sector companies and their government shareholders should undertake an enhanced strategic corporate planning exercise to explore low-carbon options,** which should look at the broad set of economic, financial, and social considerations often served by SOEs. Such an exercise can help to develop a sound low-carbon road map for the company that can be implemented in the near term or activated at a later point as the country strengthens its climate action. The exercise can also reveal measures that simultaneously serve nonclimate corporate/governmental goals and advance climate action.
- **More research is needed on how to more effectively engage SOEs in the low-carbon transition.** There has been relatively limited analysis of this issue, but the importance globally of these companies in reducing GHG emissions is only growing, especially in emerging economies with rising energy demand.

NOTES

1. In this paper "state-owned enterprises" refers to companies that are either wholly or majority owned by a government, whether at the national/federal or subnational level. Some of these companies have minority private shareholders and/or are listed on stock markets. For example, France's state-owned Electricite de France (EDF) has about 16 percent of private (nongovernment) shareholding (source: EDF corporate information, accessed February 16, 2019, https://www.edf.fr/en/the-edf-group/dedicated-sections/investors-shareholders/the-edf-share/capital-structure,). Many of China's state-owned power companies are listed on the Hong Kong and other Chinese stock markets. See, for example, M. Herve-Mignucci, X. Wang, D. Nelson, and U. Varadarajan, *Slowing the Growth of Coal Power in China: the Role of Finance in State-Owned Enterprises* (Climate Policy Initiative [CPI], November 2015), https://climatepolicyinitiative.org/publication/slowing-the-growth-of-coal-power-outside-china-the-role-of-chinese-finance/.

2. This paper builds on the author's prior research and publications, including (i) P. Benoit, "Reducing Energy Greenhouse Gas Emissions to Meet Our Climate Goals: An Overview," in Coping with the Climate Crisis (New York City, Columbia University Press [CUP], 2018), 15–43; (ii) L. Adkins, P. Benoit, and G. Kamiya, "Measures beyond Pricing and Regulation to Motivate State-Owned Enterprises and Private Businesses," in *Energy, Climate Change, and Environment: 2016 Insights* (Paris, International Energy Agency [IEA], 2016), 77–84; and (iii) P. Benoit, "State-Owned Enterprises and Their Domestic Financial Base: Two Keys to Financing Our Low-Carbon Future," in *Electricity in a Climate-Constrained World* (Paris, IEA, 2012), 25–32. IEA publications referenced in this paper are available at https://www.iea.org.

3. The relationship between the energy sector and anthropogenic (human-generated) GHG emissions is complex. A detailed description is beyond the scope of this paper but is covered in other publications (see, e.g., Energy and Climate Change [Paris, IEA, 2015]). The following, however, are some elements of particular relevance to this paper. The primary GHG produced by the energy sector is carbon dioxide (CO_2), followed by methane. Globally, the energy sector is the largest generator of specifically CO_2, and most of those emissions come from fuel combustion. Another important source of fossil-fuel-related CO_2 emissions is the chemical processes involved in the manufacturing of cement and other products. Oil and gas production is a major source of vented and fugitive methane emissions. References to carbon dioxide emissions are given in CO_2 terms (e.g., $GtCO_2$), while figures that include gases in addition to CO_2 (notably, methane) are expressed in CO_2-equivalent terms (e.g., $GtCO_2$-eq). The Climate Watch 2018 database (https://www.climatewatchdata.org)) provides overall GHG data through 2014 (as of August 2019). The IEA's World Energy Outlook series focuses its data presentation on CO_2 emissions from fuel combustion and provides (as of August 2019) figures through 2017.

4. See, for example, variations in the importance of SOEs in the top 10 firms of different countries (OECD analysis, Kowalski, *International Trade and Investment by State Enterprises*, Trade Policy Papers No. 184 [OECD, 2015], figure 1, and analysis in H.

Bergsager and A. Korppoo, *China's State-Owned Enterprises as Climate Policy Actors: The Power and Steel Sectors* (Nordic Council of Ministers, 2013), 58.

5. For example, the World Bank and the OECD have published extensively on this subject.

6. See, for example, Climate Watch database (accessed August 8, 2019, https://www.climatewatchdata.org) and the IEA calculations in *Energy and Climate Change* (IEA, 2015) at figure 1.3.

7. The figures in this paper are expressed in metric tons.

8. See, for example, data for 2016 for CO_2 emissions from the combustion of fossil fuels set out in the *World Energy Outlook 2018* (Paris, IEA, 2018); the series of *World Energy Outlooks* are referred to as WEO followed by the year of publication, in this case "WEO 2018."

9. See, for example, Climate Watch database for additional non-CO_2 energy GHG emissions (https://www.climatewatchdata.org).

10. Electricity CO_2 emissions in 2016 equaled 13.247 $GtCO_2$ out of a total of 32.053 $GtCO_2$ (WEO 2018). The IEA report *CO_2 emissions from Fuel Combustion* (IEA, 2018) provides a sectoral breakdown for 2016, with electricity and heat grouped together (at figure 11). Under this allocation, transport represented 24 percent of CO_2 emissions from fuel combustion, followed by industry with 19 percent, and buildings with 8 percent; electricity and heat represented 42 percent. Most of the electricity and heat related emissions, in turn, relate to consumption in industry and buildings.

11. Climate Watch database (accessed August 8, 2019, https://www.climatewatchdata.org).

12. See, for example, discussion of emissions pathways in *Energy Technology Perspectives 2017* (Paris, IEA, 2017), including figure 1.8.

13. For example, Mexico's and France's power utilities are owned by the national government, while China's provincial and other subnational authorities own a significant, albeit minority, share of power assets (*Slowing the Growth of Coal Power in China: The Role of Finance in State-Owned Enterprises* [CPI, 2015], figure ES-1). Typically, transit systems are controlled at a subsovereign level while NOCs are controlled at the national level.

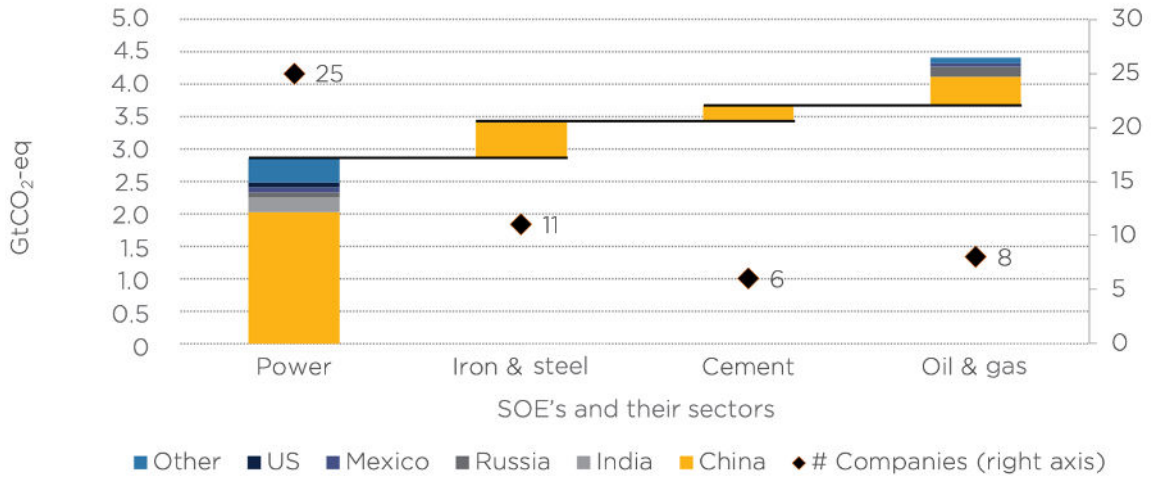
14. The SOE, Saudi Aramco, was the world's most profitable company in 2018 with a corporate net income of $111 billion, larger than the combined profits of Apple Inc. (the next most profitable company) and ExxonMobil (source: R. Jones and S. Said, "Aramco Emerges ahead of Apple as World's Most Profitable Company," *Wall Street Journal*, April 1, 2019, accessed April 7, 2019, https://www.wsj.com/articles/aramco-is-the-most-profitable-company-on-earth-ratings-agencies-say-11554102173). Below is a list of the largest SOEs as they appear on the Forbes Global 500 List based on total revenues. The Forbes Global 500 List only includes companies that publish financial data and report part or all of their figures to a government agency; it does not include various large energy companies, such as Saudi Aramco. By way of comparison, ExxonMobil ranked 9th on this Forbes list, EDF ranked 94th, and Mexico's NOC PEMEX ranked 107th.

Forbes rank	Company	Country	Sales ($B)	Sector
2	State Grid	CN	$348	Utilities
3	Sinopec	CN	$326	Energy
4	China National Petroleum	CN	$326	Energy
23	China State Construction Engineering	CN	$156	Engineering & construction
26	ICBC	CN	$153	Financials
29	Ping An Insurance	CN	$144	Financials
31	China Construction Bank	CN	$138	Financials
36	SAIC Motor	CN	$128	Motor vehicles & parts
40	Agricultural Bank of China	CN	$122	Financials
42	China Life Insurance	CN	$120	Financials
45	Japan Post Holdings	JP	$116	Financials
46	Bank of China	CN	$115	Financials
49	Gazprom	RU	$111	Energy
53	China Mobile Communications	CN	$110	Telecommunications
55	Nippon Telegraph and Telephone	JP	$106	Telecommunications
56	China Railway Engineering Group	CN	$102	Engineering & construction
58	China Railway Construction	CN	$100	Engineering & construction
65	Dongfeng Motor	CN	$93	Motor vehicles & parts
73	Petrobras	BR	$88	Energy
81	Deutsche Telekom	GE	$84	Telecommunications

Source: J. Chen analysis of Forbes Global 500 List (accessed March 12, 2019, http://fortune.com/global500/list/).

15. The EU's 500 million inhabitants, together with its industries, businesses, and governments, in total generated about 3.3 $GtCO_2$-eq of energy GHG emissions in 2014 (source: Climate Watch database, accessed August 8, 2019, https://www.climatewatchdata.org). By comparison, a preliminary estimate from the IEA indicates that a group of fewer than 50 state-owned companies emitted over 4.0 GtCO2-eq, more than the entire EU. The group comprised power companies, oil and gas producers, iron and steel firms, and cement companies from Brazil, China (with the largest share), India, Russia, Mexico, and the United States. See *Energy, Climate Change and Environment: 2016 Insights* (IEA, 2016), executive summary and chapter 6. Below is a graphic representation of the sectors and countries included in the IEA's estimate together with their relative contribution to the calculation.

Endnote Figure 1: Sectoral and country breakdown of emissions of IEA's estimated 50 SOEs



Source: Presentation by P. Benoit (IEA), "Energy and Climate: From Paris to Marrakesh and Beyond," Marrakesh, Sept. 8, 2016, based on analysis by G. Kamiya (IEA).

16. Paris Agreement, December 2015, accessed May 24, 2019, https://unfccc.int/files/meetings/paris_nov_2015/application/pdf/paris_agreement_english_.pdf.
17. See, for examples, IEA data for 2015 and 2016 (WEO 2017; WEO 2018).
18. Globally, in 2016, coal power generation produced 9.5 $GTCO_2$ in emissions, natural gas another 2.9 $GTCO_2$, and oil 0.8 $GTCO_2$ (WEO 2018).
19. Coal generation produced 97 percent of China's power sector CO_2 emissions in 2016 (WEO 2018).
20. See, for example, annual 2014, 2015, and 2016 data for CO_2 emissions from coal generation in China's power sector in WEO 2016, WEO 2017, and WEO 2018.
21. China's provincial authorities own a significant, albeit minority, share of the country's installed coal power capacity (source: *Slowing the Growth of Coal Power in China: The Role of Finance in State-Owned Enterprises* [CPI, 2015], figure ES-1).
22. See *Slowing the Growth of Coal Power in China: The Role of Finance in State-Owned Enterprises* (CPI, 2015), which estimated that 90 percent of installed coal power capacity in 2013 was state controlled, with another 4 percent controlled by self-producers including

industrial companies that were also often owned by the state. The remaining 6 percent was controlled by other domestic and foreign investors.

23. Calculation is based on a pro rata allocation of total coal power emissions between (i) state-controlled coal power plants, which represented between 90 and 94 percent of total installed coal powered capacity and (ii) coal power capacity held by other domestic and foreign investors (source: *Slowing the Growth of Coal Power in China: The Role of Finance in State-Owned Enterprises* [CPI, 2015]).

24. WEO 2018.

25. See also B. Mayer, M. Rajavuori, and M. Fang, "The Contribution of State-Owned Enterprises to Climate Change Mitigation in China," *Climate Law* 7 (2017): 97–124, https://brill.com/view/journals/clla/7/2-3/article-p97_97.xml?lang=en.

26. For example, France's transmission system is managed by the public sector company Reseau de transport d'electricite (RTE), the largest operator in Europe with over 100,000 km of lines (https://www.rte-france.com/, accessed May 12, 2019), which in turn is a subsidiary of EDF, the publicly owned power company (see endnote 1). This is also true in other countries such as Mexico, India, and Brazil, as well as China where the public sector company State Grid Corporation of China has over one billion customers and is also one of the world's largest companies (see Forbes list in endnote 14).

27. See, for example. N. Prag, *State-Owned Enterprises and the Low-Carbon Transition* (OECD, 2018), figure 2 (https://www.oecd-ilibrary.org/environment/state-owned-enterprises-and-the-low-carbon-transition_06ff826b-en).

28. This is an issue that is gaining increasing attention regarding climate change mitigation efforts. See, for example, the analysis of the Environmental Defense Fund as well as the recent initiative by several oil companies to reduce their methane emissions under the Oil and Gas Climate Initiative (a grouping of both national oil companies, such as Saudi Aramco, PEMEX, and Petrobras, and private sector ones, such as Shell and BP).

29. WEO 2018, figure 11.8.

30. See https://www.coalindia.in/index.html (accessed August 4, 2019).

31. China is by far the largest coal-producing country in the world. It produced 2,538 Mtoe of coal in 2017, nearly half of total global coal production that year (WEO 2018, at table 5.3). Its sector includes large state-owned coal companies such as China Energy Investment Corporation (formerly Shenhua Group Corporation Limited) and China National Coal Group Co., Ltd. In non-OECD countries generally, the state owns over 65 percent of the hard coal production capacity (see figures 2.4 of *World Energy Investment Outlook* [Paris, IEA, 2014]).

32. *Energy Technology Perspectives 2017* (IEA, 2017) at p. 163. These figures include not only emissions from the combustion of fuel (reflected in WEO figures) but also "process" emissions—i.e., CO_2 emissions generated from chemical and other processes involved in the manufacture of cement and other materials. Process emissions represented 23 percent

of total CO_2 emissions attributable to industry under this approach (at p. 165).

33. See website for the Steel Authority of India Limited, accessed February 20, 2019, https://sail.co.in/sites/default/files/investor/Annual_Report_2016-17_0.pdf.

34. PT Semen Indonesia Tbk, which has a 40 percent market share in Indonesia (source: *Nikkei Asian Review*, accessed February 20, 2019, https://asia.nikkei.com/Companies/PT-Semen-Indonesia-Persero-Tbk.

35. See, for example, "Top 11 Largest Cement Companies in the World," *Daily Records*, January 2, 2019, accessed March 14, 2019, http://www.thedailyrecords.com/2018-2019-2020-2021/world-famous-top-10-list/highest-selling-brands-products-companies-reviews/largest-cement-companies-world-us/6546/.

36. Turkish Airlines, Emirates, China Southern Airlines, and China Eastern Airlines are several examples.

37. Key features of the state-owned enterprises operating the transit systems (bus and rail) in New York and Paris and the metro systems in Mexico City and New Delhi are as follows:

    - The Metropolitan Transit Authority (MTA) is a New York State public benefit corporation that carries on average over 8.6 million passengers a day on its subway, commuter rail, and bus network; it is the largest public transit authority in North America (source: "The MTA Network," accessed April 7, 2019, http://web.mta.info/mta/network.htm). In 2017 the MTA generated over $6 billion in farebox revenues and spent $600 million on energy; the MTA also spent an additional $600 million on materials and supplies (source: MTA 2018 Adopted Budget, February Financial Plan 2018–2021, accessed April 7, 2019, http://web.mta.info/mta/budget/pdf/MTA-2018-AdoptedBudgetFebruaryFinancialPlan_2018-21.pdf.

    - The Paris regional Regie Autonome des Transport Parisiens (RATP) is a state-owned public transport operator with about eight million passengers per day, for a total in 2010 of about three billion (source: *Le traffic de la RATP reprend des couleurs*, January 27, 2011, accessed April 7, 2019, http://www.mobilicites.com/011-442-Le-trafic-de-la-RATP-reprend-des-couleurs.html).

    - Mexico City Metro is the second largest metro system in the Americas and is operated by Sistema de Transporte Colectivo, a government-owned public agency (source: Global Mass Transit Report, "Rapid Transit in Mexico City," September 1, 2016, accessed April 7, 2019, https://www.globalmasstransit.net/archive.php?id=23169).

    - The Delhi Metro is owned jointly by the Government of India and the Government of the National Capital Territory of Delhi (source: Delhi Metro Rail Corporation Ltd. webpage, accessed April 7, 2019, http://www.delhimetrorail.com/about_us.aspx).

38. This total is a preliminary estimate based on the following components. First, as estimated in this paper, emissions from China's state-controlled coal power plants total over 3.8 $GtCO_2$ (i.e., 90 percent of total coal power emissions of 4.24 $GtCO_2$). Second, the group

of 50 SOEs analyzed by the IEA (see endnote 15) includes three dozen SOEs outside of China's coal power sector, namely 11 power sector SOEs from outside of China and 25 enterprises from the iron and steel, cement, and oil and gas sectors worldwide; the emissions for this second component total 2.4 $GtCO_2$-eq. SOE emissions are even larger if other state enterprises are included, such as urban transit systems.

39. China's state-controlled company emissions can roughly be estimated to total over 5.0 $GtCO_2$-eq, based on (i) over 3.8 $GtCO_2$ from state-controlled coal power plants, as estimated in this paper (i.e., 90 percent of total coal power emissions of 4.24 $GtCO_2$), plus (ii) over 1.2 $GtCO_2$-eq from Chinese iron and steel, cement, and oil and gas sector SOEs included in the group of 50 SOEs analyzed by the IEA (see endnote 15). By comparison, China's energy sector GHG emissions totaled 9.5 $GtCO_2$-eq in 2014 (source: Climate Watch database, accessed August 8, 2019, https://www.climatewatchdata.org).

40. The information generated by this type of inventory should, for example, reveal common issues facing distinct SOEs and help to inform the development of emissions reductions strategies of use to different companies and their shareholders (e.g., common challenges facing different power producers across China, encountered by cement companies in India and Indonesia, or present for urban transit systems around the world).

41. Country data are for 2014, the most recent year provided in the Climate Watch database, accessed August 8, 2019, https://www.climatewatchdata.org. Data for countries and SOEs include CO_2 process emissions and methane; they are expressed in CO_2-eq.

42. Author's calculations are described in endnote 38. The emissions for each SOE in the cohort are also included in the data for the country where it operates. This figure could be adjusted to exclude these SOE emissions from the country data, which would increase the difference between the total emissions of the SOE cohort and the countries.

43. See, for example, the IEA's climate scenario in WEO 2018 under which fossil fuel use drops in its climate scenario from 11,100 Mtoe in 2016 to 8,200 Mtoe in 2040.

44. The IEA's climate scenario presented in WEO 2018 provides for global use of clean energy resources (renewables and nuclear) to increase from 2,600 Mtoe in 2016 to 5,500 Mtoe in 2040.

45. H. Lai and M. Warner, eds., *Managing China's Energy Sector: Between the Market and the State* (United Kingdom: Routledge Publishing, 2016), table 2 at p. 38, accessed May 16, 2019, https://www.worldcat.org/title/managing-chinas-energy-sector-between-the-market-and-the-state/oclc/898926104.

46. The project received $240 million from the Canadian federal government, as well as provincial-level support. See description of project in "Boundary Dam Fact Sheet," MIT, accessed April 4, 2019, https://sequestration.mit.edu/tools/projects/boundary_dam.html.

47. *20 Years of Carbon Capture and Storage: Accelerating Future Deployment* (Paris, IEA, 2016) at p. 101.

48. See Forbes Global 500 List in endnote 14.

49. Some of this funding is from multilateral development banks, such as the World Bank, the Asian Development Bank, the Inter-American Development Bank, and the European Investment Bank. These organizations provide billions of dollars in financing every year for energy and other projects in developing countries that affect GHG emissions. The Asian Infrastructure Investment Bank is a new entrant into this category. These development banks play a particularly visible financial and advisory role in the effort to manage climate change. While they are not typically viewed as an SOE, these organizations are in fact subject to many of the same forces as a public sector company, just by the multiple governments that are their shareholders.

50. *Slowing the Growth of Coal Power in China: The Role of Finance in State-Owned Enterprises* (CPI, 2015) at p. 10.

51. OECD, *Environmental Performance Reviews: Brazil 2015* (OECD, 2015).

52. P. Benoit, "State-Owned Enterprises and Their Domestic Financial Base: Two Keys to Financing Our Low-Carbon Future," in *Electricity in a Climate-Constrained World* (IEA, 2012), 25–32.

53. See the OECD analysis in P. Kowalski and K. Perepechay, *International Trade and Investment by State Enterprises*, OECD Trade Policy Papers No. 184 (OECD, 2015), figure 1.

54. The OECD estimated that SOEs generated 39 percent of infrastructure net sales in emerging economies in 2014 as compared to 13 percent in advanced (i.e., developed) ones (source: *OECD Business and Finance Outlook 2015* [OECD, 2016], at figure 2.15).

55. See, for example, WEO 2018.

56. About 70 percent of the emissions reduction activities under the IEA's climate "2 Degrees Scenario" take place in developing and other non-OECD countries (source: *Energy Technologies Perspectives 2014 and 2015* [IEA, 2014, 2015]).

57. See, for example, the earlier discussion of state ownership of electricity transmission and distribution networks, including the description of China's State Grid and France's RTE. Puerto Rico's power sector is similarly controlled by a public sector company that is facing a major reconstruction and resilience challenge from repeated hurricanes. In the petroleum sector, Mexico's PEMEX is responsible for shipping much of the oil to local gasoline stations.

58. Numerous private sector utilities also operate with similar regulatory protections, pricing environments, and service obligations, for example, in highly regulated electricity distribution markets where natural monopoly conditions may be viewed as justifying various protections for private sector operators. However, in contrast to an SOE, these companies are ultimately in business to generate financial returns for their private sector shareholders in addition to meeting their regulatory obligations. As a result, a regulated private sector company is likely to be more sensitive than its service-oriented SOE counterpart to, for example, the type of pricing changes engendered by carbon pricing

mechanisms because of their potential to impact the company's overall profitability and stock value and, by extension, the financial interests of its private shareholders.

59. This could be the case, for example, if there are requirements regarding independent directors and staggered terms.

60. While, generally, some degree of commercial autonomy is viewed as enabling more efficient SOE operations, it is important to recognize that autonomy does not guarantee that management will behave appropriately. In all cases, systems that provide for external monitoring and control of SOEs is important, just as they are for private sector companies.

61. The EU ETS was established in 2005 and is the first such international system. It is the world's largest ETS, covering about 45 percent of the EU's greenhouse gas emissions (see European Commission website, accessed April 2, 2019, https://ec.europa.eu/clima/policies/ets_en). The EU ETS includes over 6,000 separately registered companies (some of which are affiliated), covering over 11,000 installations (source: C. Bleuez, carbonmarketdata.com).

62. See the description of the Swedish system in "Sweden's carbon tax," Government Offices of Sweden, accessed August 2, 2019, https://www.government.se/government-policy/taxes-and-tariffs/swedens-carbon-tax/ and the summary assessment of the tax in F. Funke and L. Mattauch, "Why Is Carbon Pricing in Some Countries More Successful Than in Others?," August 10, 2018, in Our World in Data, accessed May 12, 2019, https://ourworldindata.org/carbon-pricing-popular.

63. China implemented several city and provincial-level pilot ETSs beginning in 2013 and 2014 and more recently announced its intention to put into place a national system that will be focused on the power sector in the initial phase. See J. Elkind and N. Kaufman, "Can China's CO_2 Trading System Avoid the Pitfalls of Other Emissions Trading Schemes," February 27, 2018, Commentary from Columbia's Center on Global Energy Policy (CGEP), accessed May 14, 2019, https://energypolicy.columbia.edu/research/commentary/can-china-s-co2-trading-system-avoid-pitfalls-other-emissions-trading-schemes. The first trade is anticipated in 2020 (see "China Expects First Trade in National System in 2020," *Reuters*, March 30, 2019, accessed May 28, 2019, https://www.reuters.com/article/climate-change-china/update-1-china-expects-first-trade-in-national-emissions-scheme-in-2020-idUSL3N21H02B.

64. For example, as noted by the IEA, "After more than a decade of using carbon markets globally, . . . carbon pricing policies are not delivering their theoretical potential. Realistically achievable carbon prices in the short to medium term do not appear high enough to drive the investment and operational changes needed to decarboni[z]e electricity systems," *Energy, Climate Change, and Environment: 2016 Insights* (IEA, 2016) at p. 43.

65. Absent certain notable exceptions (such as Sweden's carbon tax), carbon pricing mechanisms have not delivered to date on their promise in part because many governments have been unable and unwilling to implement frameworks that generate the type of robust carbon pricing incentives needed to shift resources to low-carbon

alternatives. See, for example, the discussion in P. Benoit, "Reducing Energy Greenhouse Gas Emissions to Meet Our Climate Goals: An Overview," in *Coping with the Climate Crisis* (CUP, 2018).

66. See, for example, the EU's recent adjustments to its ETS (https://ec.europa.eu/clima/policies/ets_en, accessed April 14, 2019).

67. Equinor's CCS operations illustrates how a carbon tax (introduced by Norway in 1991) can encourage an SOE operating with commercial autonomy to invest in low-carbon technologies. As explained by Olav Skalmeraas, vice president of Equinor, "The CO_2 tax was one of the triggers for [Equinor's] plans to separate the CO_2 from the gas offshore and inject it into deep geological layers near the gas and CO_2 processing platform. Norwegian CO_2 taxes . . . for the offshore oil and gas sector . . . [are priced] around USD 60 per tonne" (Commentary 1, *20 Years of Carbon Capture and Storage: Accelerating Future Deployment*, [IEA, 2016]).

68. R. Baron, A. Aasrud, J. Sinton, N. Campbell, Jiang K., and Zhuang X., *Policy Options for Low-Carbon Power Generation in China—Designing an Emissions Trading System for China's Electricity Sector* (IEA, 2012): "Without a means of passing on to consumers the higher generation costs resulting from a CO_2 price, there is a risk that generation could be curtailed. This is already an issue of some sensitivity, as prices have played a role in some past outages. While coal prices have mainly been deregulated, electricity prices have not. The financial losses incurred by some coal generators facing high coal prices has at times led them to curtail output, leading to past instances of power shortages, at the expense of economic activity"(9).

69. As the IEA advised regarding the design of an ETS for China's electricity sector, "The dominance of state-owned enterprises presents both challenges and opportunities in the context of controlling CO_2 emissions with emission trading. On the one hand, state-owned enterprises typically have direct access to funding, including for low-carbon investments. On the other hand, state-owned enterprises may not always respond to economic incentives like enterprises driven by profit maximization. This makes the operational and investment responses to market-based policy instruments, such as an emissions trading system, unpredictable." R. Baron et al. *Policy Options for Low-Carbon Power Generation in China—Designing an Emissions Trading System for China's Electricity Sector*" (IEA, 2012) at p. 7.

70. See, for example, a report on the China power sector emissions trading simulation conducted by the IEA: C. Guelff and L. Adkins, *Emissions Trading in the People's Republic of China: A Simulation for the Power Sector* (IEA, 2014).

71. Yu Xiang and Alex Y. Lo observed with respect to China's ETS pilots that "Most of the firms affected by [China's pilot] ETSs are large state-owned enterprises . . . Although new policies and regulations have created some market demand for emission allowances and credits, these enterprises concentrate on complying with regulatory requirements and have . . . low interest in trading emission credits as a form of financial investment" (15). "Carbon Finance and the Carbon Market in China," *Nature Climate Change* 5, (December 2014): 15–16, accessed February 16, 2019, https://www.nature.com/articles/nclimate2462.

72. See guidance in R. Baron et al., *Policy Options for Low-Carbon Power Generation in China—Designing an Emissions Trading System for China's Electricity Sector*," (IEA, 2012). The approach adopted by China to its national ETS is slightly different as the system does not use volumetric emissions limits but rather a "rate-based" approach that looks at emissions relative to output compared to a benchmark. See, for example, the discussion in J. Elkind and N. Kaufman, "Can China's CO_2 Trading System Avoid the Pitfalls of Other Emissions Trading Schemes," February 27, 2018 (CGEP), https://energypolicy.columbia.edu/research/commentary/can-china-s-co2-trading-system-avoid-pitfalls-other-emissions-trading-schemes.

73. See, for example, A. Cassady and G. Taraska, *Proxy Carbon Pricing: A Tool for Fiscally Rational and Climate Compatible Governance*, Center for American Progress, April 2016, https://cdn.americanprogress.org/wp-content/uploads/2016/04/13143140/CarbonPricing.pdf.

74. For example, Sustainable Prosperity listed the state power utilities Ontario Power Generation and SaskPower and the NOC Equinor as using shadow prices (*Shadow Carbon Pricing in the Canadian Energy Sector*, Policy Brief, March 2013, accessed May 24, 2019, https://institute.smartprosperity.ca/sites/default/files/publications/files/Shadow%20Carbon%20Pricing%20in%20the%20Canadian%20Energy%20Sector.pdf. ExxonMobil, Chevron, Duke Energy, and ConocoPhillips are some of the major energy companies that have been reported to use a shadow carbon price (A. Cassady and G. Taraska, *Proxy Carbon Pricing: A Tool for Fiscally Rational and Climate Compatible Governance*, Center for American Progress, 2016).

75. There are numerous descriptions provided of stranded assets. According to the IEA, "Some investment in fossil-fuel based energy assets, as a result of changes brought about by climate policy, may not be able to earn an economic return prior to the end of their economic live and risk becoming stranded assets—not recovering all or part of their investment during the time that they are operation." WEO 2014 at box 1.5. See, for example, discussion in "Mark Carney Warns Investors Face 'Huge' Climate Change Losses," *Financial Times*, September 29, 2015, accessed March 26, 2019, https://www.ft.com/content/622de3da-66e6-11e5-97d0-1456a776a4f5.

76. See, for example, discussion in "Mark Carney Warns Investors Face 'Huge' Climate Change Losses," *Financial Times*, September 29, 2015, accessed March 26, 2019, https://www.ft.com/content/622de3da-66e6-11e5-97d0-1456a776a4f5.

77. See, for example, the economic analysis used by the World Bank to analyze projects from the country/government perspective.

78. The World Bank issued the following guidance in 2017: "To incorporate carbon externalities into the economic analysis either in the form of cost benefit analysis or cost-effectiveness analysis, the annual shadow price of carbon (US$/t CO_2-e) is multiplied by the annual GHG emissions (t CO_2-e) over the economic lifetime of the project. The value of shadow price of carbon (SPC) can be used either in a cost-effectiveness or in a cost-benefit setting," from "Guidance Note on Shadow Price of Carbon in Economic Analysis," November 12, 2017,

accessed March 26, 2019, http://pubdocs.worldbank.org/en/911381516303509498/2017-Shadow-Price-of-Carbon-Guidance-Note-FINAL-CLEARED.pdf.

79. Although a shadow carbon price and the stranded assets analysis can both operate to reduce the risk of overinvestment in high-carbon assets, the underlying approaches differ substantially. For example, while the notional costs of a shadow carbon price increase with the amount of CO_2 that would be produced by a prospective investment, a stranded assets analysis focuses more on the risk of curtailed production from future climate policies and the resulting loss of anticipated revenues.

80. See discussion on designing regulations and carbon taxes that are complementary in J. Gundlach, R. Minsk, and N. Kaufman, "Interactions between a Federal Carbon Tax and Other Climate Policies," CGEP, March 2019, accessed May 6, 2019, https://energypolicy.columbia.edu/research/report/interactions-between-federal-carbon-tax-and-other-climate-policies.

81. Many of these measures are proposed in the various nationally determined contributions prepared by countries and incorporated into the Paris Climate Agreement.

82. Similarly, the Washington Post's Editorial Board recently set out its policy proposal for strong climate change action founded on carbon pricing; it included the following recommendation: "Start with carbon pricing. Then fill in the gaps" with tools such as regulatory performance standards. The piece did also recognize that "carbon pricing can do a lot—but not everything;" for example, pricing will likely not stimulate all the innovation required under the low-carbon transition (Editorial Board, "Want a Green New Deal? Here's a Better One," *Washington Post*, The Post's View, February 24, 2019, accessed April 4, 2019, https://www.washingtonpost.com/opinions/want-a-green-new-deal-heres-a-better-one/2019/02/24/2d7e491c-36d2-11e9-af5b-b51b7ff322e9_story.html?utm_term=.0a444e5050e9.

83. Although governments typically exercise control over private sector actors through the adoption of regulations, decrees, and legislative acts (including permitting and similar requirements), in certain country contexts (often where the rule of law is weaker), government officials do move to direct actions by individual private companies, including through informal requests or by giving "advice." In these contexts, government officials may incentivize private sector "compliance" by raising the threat that the company would face difficulties in obtaining permits and encounter other bureaucratic obstacles if it fails to follow their advice.

84. See, for example, B. Mayer et al.: "Even as Central Enterprises are under [the] supervision [of the government's State-Owned Assets Supervision and Administration Commission], they have proven to be particularly difficult to control in the power sector, given their significant economic and political power" from "The Contribution of State-Owned Enterprises to Climate Change Mitigation in China," *Climate Law* 7 (2017): 119.

85. H. Bergsager and A. Korppoo (2013, 58) observed regarding China that "one should not underestimate the influence of the SOEs in policy-making," which they explained results

in part from the tight network between SOE executives and Communist Party officials (H. Bergsager and A. Korppoo, *China's State-Owned Enterprises as Climate Policy Actors: The Power and Steel Sectors* (Nordic Council of Ministers, 2013), accessed February 12, 2019, http://www.diva-portal.org/smash/get/diva2:702164/FULLTEXT01.pdf.

86. Governments can also promote coordinated research activities involving their public sector entities, including between national research laboratories and their energy and manufacturing companies.

87. *Energy, Climate Change, and Environment: 2016 Insights* (IEA, 2016).

88. *Aligning Policies for a Low-Carbon Economy* (OECD, 2015), accessed February 26, 2019, https://www.oecd.org/environment/Aligning-Policies-for-a-Low-carbon-Economy.pdf.

89. N. Prag, *State-Owned Enterprises and the Low-Carbon Transition* (OECD, 2018), https://www.oecd-ilibrary.org/environment/state-owned-enterprises-and-the-low-carbon-transition_06ff826b-en, citing Chen Ji presentation, *China's Low Carbon Energy Transition: The Role of SOEs*, September 26, 2016.

90. See, for example, A. Wang, "The Search for Sustainable Legitimacy: Environmental Law and Bureaucracy in China," *Harvard Environmental Law Review* 37 (2013): 366–440, accessed May 6, 2019, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2128167.

91. R. Baron, *The Role of Public Procurement in the Low-Carbon Innovation* (OECD, 2016), https://www.oecd.org/sd-roundtable/papersandpublications/The%20Role%20of%20Public%20Procurement%20in%20Low-carbon%20Innovation.pdf.

92. A number of European cities joined forces in a procurement bid to encourage manufacturers to propose low-carbon engines for garbage trucks. R. Baron, at box 2, *The Role of Public Procurement in the Low-Carbon Innovation* (OECD 2016).

93. Promoting the decarbonization of supply chains is an effort already being undertaken by several large private companies, such as Walmart, one of the largest companies in the world (see, e.g., Walmart Project Gigaton, https://corporate.walmart.com/newsroom/2017/04/19/walmart-launches-project-gigaton-to-reduce-emissions-in-companys-supply-chain, accessed August 2, 2019).

94. The president of the World Bank, the multigovernment-owned bank (see endnote 49), announced in December 2017 that the organization would no longer finance upstream oil and gas projects after 2019 (World Bank Group Announcements at One Planet Summit, accessed February 12, 2019, https://www.worldbank.org/en/news/press-release/2017/12/12/world-bank-group-announcements-at-one-planet-summit).

95. The city of Shenzhen invested in charging terminals to support the deployment of 16,000 electric buses (Patrick Sisson, "How a Chinese City Turned All Its 16,000 Buses Electric," *Curbed*, May 4, 2018, accessed March 22, 2019, https://www.curbed.com/2018/5/4/17320838/china-bus-shenzhen-electric-bus-transportation.

96. See Energy Efficiency Services Limited's website at https://eeslindia.org/content/raj/eesl/en/home.html.

97. See, for example, the several SOEs referenced in endnote 14, including those ranked at the top of the Forbes 500 Global List.

98. Norway's national oil company, Equinor ASA, formerly known as Statoil, foresees a changing operating environment that is leading it to increase its activities in nonpetroleum energy sources while it maintains its core oil and gas business. For example, it is targeting about 15 to 20 percent of its investments to be in new energy solutions by 2030. As the Chairman of Equinor stated in 2018 as the company prepared to change its name from Statoil, "The world is changing, and so is Statoil . . . The biggest transition our modern-day energy systems have ever seen is underway, and we aim to be at the forefront of this development." Reported in "Statoil No Longer Wants 'Oil' in Its Name," Bloomberg, March 15, 2018, accessed March 26, 2019, https://www.bloomberg.com/news/articles/2018-03-15/statoil-changes-name-to-remove-oil-in-renewable-energy-push. Climate change concerns are raising fundamental questions for both public sector and private oil companies, notably to what extent they should move from being a petroleum producer to an "energy company" that delivers a broader set of products and services. For example, private sector BP, like Equinor, is exploring this under its long-term strategic program, "Advancing the Energy Transition", accessed May 14, 2019, https://www.bp.com/energytransition/.

99. In India, coal generates about 44 percent of the freight revenues of Indian Railways (K. Ghosh, "Indian Railways Survives by Ferrying Coal, Not Passengers," *Quartz India*, July 26, 2018, accessed April 16, 2019, https://qz.com/india/1336094/indian-railways-survives-by-ferrying-coal-not-passengers/.

100. For example, as was noted in the report *China's State-Owned Enterprises as Climate Policy Actors: The Power and Steel Sectors* by H. Bergsager and A. Korppoo (Nordic Council of Ministers, 2013): "Western economic thinking has automatically labelled SOEs as potentially inefficient actors, due to their soft budget constraint as a result of access to state funds and bail-outs in case of losses, as well as to the monopolistic features of their operations. Indeed, such reservations are not unfounded. However, the Chinese political system views SOEs differently. The bureaucracy has opted for control over market-driven efficiency. . . . [SOEs are] seen as a more efficient option than a situation of small, locally managed/owned companies, in terms of technology as well as policy implementation" (58).

101. However, even the United States government has tried to influence SOE action. President Trump recently expressly requested that the Tennessee Valley Authority (TVA), a power SOE, keep a particular coal-fired power plant in operation. The TVA, however, subsequently decided to shutter the plant, citing economic reasons. "TVA Rebuffs Trump, Votes to Close Coal Plants," *Politico*, February 14, 2019, accessed March 18, 2019, https://www.politico.com/story/2019/02/14/tva-trump-coal-plants-1170008.

102. As was noted by B. Mayer et al.: "In Western countries, . . . SOEs are generally kept at arm's length from the government . . . thus significantly reducing a government's ability to use SOEs as tools for a public policy objective, such as climate change mitigation.

By contrast, in the Chinese context, a high degree of formal and informal interaction between government authorities and SOEs makes them an obvious mitigation tool," from "The Contribution of State-Owned Enterprises to Climate Change Mitigation in China," Climate Law 7 (2017): 101.

103. For example, in the United States, the overall economic structure and business culture coupled with limited SOE involvement in the energy sector presents a less fertile context to rely on SOE action to effect the low-carbon transition as compared to the countries listed in figure 6-1. However, even in the United States, public sector enterprises, such as urban transit systems, will have a role to play in reducing emissions.

104. Michael Goff, "Where Does Decarbonization Come From?," The Breakthrough Institute, December 4, 2017, accessed May 2, 2019, https://thebreakthrough.org/issues/energy/where-does-decarbonization-come-from.

105. Jameson McBride, "The Green New Deal and the Legacy of Public Power," The Breakthrough Institute, December 17, 2018, accessed May 2, 2019, https://thebreakthrough.org/issues/energy/the-green-new-deal-and-the-legacy-of-public-power.

106. See, for example, "International Energy Outlook 2017," U.S. Energy Information Administration, September 14, 2017, at p. 133 (https://www.eia.gov/outlooks/ieo/pdf/0484(2017).pdf, accessed August 8, 2019). See also WEO 2018.

107. See, for example, WEO 2018, figure 2.10.

108. For example, Article 4.3 of the Paris Climate Agreement provides that "Each Party's successive nationally determined contribution will represent a progression beyond the Party's then current nationally determined contribution and reflect its highest possible ambition, reflecting its common but differentiated responsibilities and respective capabilities, in the light of different national circumstances." Paris Agreement, December 2015, accessed May 2, 2019, https://unfccc.int/files/meetings/paris_nov_2015/application/pdf/paris_agreement_english_.pdf.

109. India's nationally determined contribution under the Paris Climate Agreement refers to the need for international climate finance to help to cover the deployment cost of clean technologies, p. 31, accessed May 2, 2019, https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/India%20First/INDIA%20INDC%20TO%20UNFCCC.pdf.

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