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Chapter IV

A state of change: climate and development policy

INTRODUCTION

The previous chapters have suggested that there are climate-friendly alternatives for development that steer clear of carbon-intensive technologies. This chapter considers the national policies that might be necessary to support what amounts to a new industrial revolution in developing countries.

Economic and technological revolutions in the last two centuries have opened up opportunities for “latecomers” to kick-start a process of rapid growth and development. However, not all were able, or allowed, to seize those opportunities. Meanwhile, the economic gains to “first movers” have often been cumulative, resulting in divergent economic development patterns and rising gaps in incomes, technological capacity and energy use.

Those precedents are a concern for developing countries, which fear being priced out of new low-carbon technologies while being asked to forgo the cheaper, older technologies that others have relied on in the past. Moreover, the latest technological revolution is unfolding at a time of profound global economic and financial stress that makes it even harder for poor and vulnerable countries and communities to shift to a new economic and technological paradigm.

The Commission on Growth and Development, an international collaboration that sought to identify policies and strategies to support economic growth and poverty reduction, argued that a conceptual impasse has been reached in the debate on how to cut carbon emissions while allowing developing countries to grow.¹ To remove that impasse, this chapter argues for a big push, blending pro-investment macroeconomic and industrial policies in order to move to a transformative low-emissions growth path. The integrated development strategy needed to achieve this, in turn, requires a strong and dynamic developmental state to manage it and sufficient policy space to be able to adapt climate measures to local needs and sensitivities.

The following sections look at how the traditional functions of the developmental state relate to the climate challenge, the role of industrial

policy in an investment-led strategy for meeting climate and development goals, and some specific measures that could help policymakers in developing countries begin the transition to a low-emissions, high-growth strategy.

THE DEVELOPMENTAL STATE IN A WARMING WORLD

An investment-led strategy

All the well-known stories of successful economic development have involved a sustained burst of growth that raised overall incomes and living standards significantly. When countries follow an inclusive development path, growth is accompanied by poverty reduction and improvements on a broad set of social indicators. This path does not emerge spontaneously, however, and even after a period of rapid growth, countries can get stuck or fall back.

A sustained acceleration of growth usually requires rapid capital accumulation and shifts in the structure of economic activity towards high-productivity sectors. An important part of the early development policy debate focused on how to quickly raise the share of investment in national income to a level that would trigger a virtuous circle of rising productivity, increasing wages, technological upgrading and social improvements. The required investments are often closely connected, depend on reaching a minimum scale to be efficient, and may become profitable only over a long time period. The presence of scale economies, complementarities, threshold effects and externalities limits the role that market forces by themselves can play in realizing the desired investment path. Infrastructure development in general and energy supply in particular have always been critical elements in this story and, as discussed in previous chapters, the importance of the latter has grown in the context of climate change.

Focusing the “big push” on selected leading sectors can attract further investment through the dynamic effect of decreasing costs and the expansion of strong backward and forward linkages. In this regard, the strategy is less about detailed planning and more about strategic support and coordination, with a significant role for public investment in triggering growth and crowding in complementary private investment. A given rate of capital accumulation can, of course, generate different rates of output growth, depending on its nature and composition and on the efficiency with which production capacity is utilised. Policies will have a significant bearing on the outcome. Over the years, the minimum scale of investments needed to launch and maintain an industrialization drive has risen steadily.

In most success stories, a developmental state has helped promote long-term growth and structural change by increasing the supply of investible resources and socializing long-term investment risk. Along with targeting resources into high-productivity activities, states have provided predictable and affordable credit through a managed financial system, adopted pro-investment macroeconomic policies, and directly invested in some key sectors. The East Asian economies have often been held up as exemplary embodiments of the developmental state, but there are many other such examples (for an example from United States history, see box IV.1).

Box IV.1: The Tennessee Valley Authority: A successful big push

The post-war economic boom in the American South, which followed large public capital investments during the New Deal and the Second World War, is a successful example of a big push. By triggering an increase in the rates of return to private investment, the infusion of public capital through the Tennessee Valley Authority (TVA) provided a major impetus for the rapid post-war industrialization of the Southern economy. (The focus here is exclusively on the historical role of the TVA, not on its current operations and policies.)

The TVA was established in 1933 as part of the New Deal, intended by President Franklin D. Roosevelt to lift the United States out of the depths of the Great Depression. It was conceived both as a development agency, mandated to raise living standards in the Tennessee River Valley, and as a construction and management agency mandated to build and operate dams and structures along the Tennessee River, whose drainage basin over seven states covers some 40,900 square miles (or 105,900 square kilometres). The TVA was to function as, in Roosevelt's words, "a corporation clothed with the power of government but possessed of the flexibility and initiative of a private enterprise."

Over the 12-year period from its inception in 1933 to the end of the Second World War in 1945, the TVA established its institutional framework, built broad-based local support for its programmes, and developed a physical infrastructure that would serve as the backbone for its accomplishments. This infrastructure included a vast system of multi-purpose dams and reservoirs designed to harness the potential of the Tennessee River and an extensive transmission system created to provide cheap electricity throughout the region. Early and intense efforts to improve agriculture, land use and forestry practices helped to restore and maintain a healthy environmental base, while access to small-scale credit and technical assistance programmes provided the citizens of the Valley with the tools they needed to improve their own lives. It was during those early years that the Tennessee Valley Authority established what may have become its greatest legacy: the integration of a healthy natural resource base, a strong infrastructure, and human capacity to foster the social and economic development of a region.

The need for TVA arose from the dire social and economic conditions in the Tennessee Valley in the 1930s. As the Great Depression of the 1930s deepened

Box IV.1 (cont'd)

and conditions in the Tennessee Valley (and elsewhere in the nation) worsened, Roosevelt sought to create an innovative programme that would revitalize the economy and boost morale. The creation of TVA represented a “bold experiment” aimed at accomplishing the unified development of a river basin. Flood control, navigation and power generation were not ends in themselves, but the means to advance social and economic development.

Although rich in natural resources, the region was largely rural and undeveloped, poverty-stricken and characterized by degraded environmental conditions. Per capita income was among the lowest in the United States, few people had running water or electricity, and poor sanitary conditions resulted in some of the highest rates of disease and infant mortality in the country. In some areas near the Tennessee River, 1 out of every 3 people had malaria. Illiteracy rates were high and the quality of education was poor. Severe erosion, extensive deforestation and exhausted mines were indicative of a deteriorating environment. Additionally, the navigation potential of the Tennessee River remained untapped owing to hazardous shoals, while the heavy rainfall in the region subjected many areas to repeated and serious flooding. The people of the Tennessee Valley were trapped in a cycle of poverty. The social problems in the Valley could be addressed only by improving the economy, which would depend on a healthy resource base, including land, water and forests.

The vitality of the TVA as an institution was bolstered by its early, tangible and largely positive impact on the lives of the people of the Tennessee Valley. Two major dam construction projects were initiated in the agency's first year of operation. Over the next 12 years, bolstered by the need to support the war effort, progress was remarkable: the navigation channel on the Tennessee River was completed; 26 dams were incorporated into the TVA water control system; and TVA became the largest power producer in the United States. Additionally, farm production levels tripled owing to successful efforts to reduce soil erosion, improve farm practices and introduce fertilizers. Although controversies arose over relocations required during dam building, the Valley residents were put back to work and the overall standard of living improved. TVA won the support of citizens and local governments and gained a national reputation for its work in the area of water resources, land management, forestry, agriculture and energy production.

Sources: Bateman et al., 2009, and Miller and Reidinger, 1998.

Some developed countries built this kind of investment-led approach to the climate challenge into the stimulus packages they adopted in response to the economic downturn, with investments designed to create “green jobs”. Developing countries, however, need to aim for something much bigger, effectively a new industrial revolution that relies on low-emissions and, in due course, carbon-free energy sources. This new investment path, which should involve a broad range of sectors and regions, would weaken the climate constraint on economic growth. Related investments will be needed to raise agricultural productivity, improve forest management, and

ensure a more reliable water supply and a more efficient transport system—all of which will entail the steady expansion of green jobs.

From technological learning to leapfrogging

While economic growth depends on a fast pace of investment accumulation, it is sustained by ongoing structural and technological changes which underpin productivity and income growth. Without constant innovation and learning, the economy will remain locked into production methods that use less advanced technology and will fail to diversify into more dynamic activities. Since improved technological knowledge is often embodied in capital goods, rapid capital formation and technological progress are strongly complementary. A pro-investment macroeconomic policy is therefore necessary to strengthen technological development, but private firms will still tend to under-invest in technological knowledge and innovation. Thus catch-up growth requires a good deal of active policy support for building technological capacity, including importing technologies and learning to use them.

Technologies usually evolve with institutions that support them, so there is a tendency to favour (or “lock in”) incumbents and “lock out” new technologies. States can help by removing regulatory and institutional barriers that generally favour incumbent technologies. They can also directly support new technologies through their procurement policies and through subsidies, and can provide temporary support to those adversely impacted by the resulting shifts in activity.

Governments have also often provided support for tertiary education, publicly funded research, development and deployment (RD&D) and subsidized research undertaken in the private sector, as well as industry-level training. In recent years, such efforts have focused on establishing national systems of innovation, including stronger partnerships between public and private institutions promoting technological development; however, serious financial and institutional obstacles to building such systems have been identified in many developing countries.²

Given the scope of the challenge, the innovation and learning that are critical to a new low-emissions growth path should involve not just the most advanced economic sectors, but also traditional sectors such as agriculture and forestry. Information and communications technologies should play a central role, with their vast potential to support the smart and efficient production, distribution and use of energy; those technologies also offer

many organizational, marketing and research-oriented capabilities which will be useful in fostering productivity growth and finding new markets.

An important concept in sustainable energy development is leapfrogging: that is, the hope that developing countries can avoid the traditional, resource-intensive pattern of economic and energy development by “leapfrogging” to the most advanced technologies available, rather than retracing the steps taken by already-industrialized countries. The idea has gained ground among policymakers, researchers, and to some extent, in the private sector.

However, while leapfrogging has the potential to yield important savings over the long run, it faces significant obstacles. On the supply side, there may be barriers to accessing the required technology, whether because of the widespread obstacles to importing it (see chap. V), or because of a lack of expertise needed to link technology to local conditions. Obstacles may also exist on the demand side, if a limited market size prevents economies of scale that would make new technologies locally competitive within an acceptable time frame. Thus, there is a role for governments to build markets for new technologies, for example, by providing low-cost loans to households and businesses, and distributing information about new innovations.

Still, as noted in chap. III, there is an urgent need for a significant scaling up of adaptation capacity. In order to take advantage of the new opportunities, it will be necessary to invest in training institutes and schools and expand the availability of basic education, as well as vocational and technical training. Information technologies also open up new possibilities for remote training.

The “hardware” side of training, or training in core technical skills, may be more important for least developed countries that need to reach the threshold of a skilled labour force in order to be able to absorb technology. In contrast, higher-income developing countries may be more in need of “software” skills, including in business promotion and networking. For small economies, such as small island developing States, regional cooperation can be crucial as a means to achieve economies of scale.

Managing creative destruction

Development is a continuing process of adjustment and transformation. Changes in the economic system require new incentives and regulations to ensure that adjustments are smooth. Institutional change is also needed to ensure open discussion, consultation and broad participation, and

to prevent those who stand to lose from thwarting the process. Success rests, to a great extent, on the developmental state's capacity to provide a coherent vision of the future and manage the challenges engendered by change, including overcoming vested interests and supporting those who are losing out.

Phasing out “dirty” technologies, in turn, will not only require finding substitutes, but also avoiding the installation of new, dirty facilities with high sunk costs that lock industries and countries into high-emitting technologies for years to come. Managing such adjustments will be critical to achieving the smooth transition to a low-emissions, high-growth pathway.

These are non-marginal changes that are unlikely to emerge from the play of market forces alone. Old technologies are still cheaper, and we can expect their price to remain relatively low for the foreseeable future. Old technologies are also readily available for replication and installation. While some green technologies are already cost-competitive, others remain expensive, and still others need to be developed.

Governments can fundamentally shape energy demand through land-use, urban and regional planning—that is, through careful spatial planning of different types of economic activities to minimize demand for energy, maximise opportunities for cogeneration, and allow for the efficient development of mass transit systems as well as non-motorized forms of transport.

Thus, tackling climate change requires a strong set of legislative and regulatory incentives to prevent the players from becoming sidetracked by or locked into carbon-intensive options. This will involve significant coordination among different spheres of government. It also means that an integrated development strategy must cover energy, natural resource use, the energy- and natural resource-intensity of production, and a vision of urban development and transportation. The strategy should be launched collaboratively by the state and the private sector.

Diversification challenges

As discussed in the previous chapter, for many developing countries, adapting to unavoidable shocks from global warming is a major policy challenge. While adaptation needs are multifaceted, the core challenge for many countries is to diversify their economies, to reduce their dependence on a few (often climate-sensitive, resource-based) industries, and to shift to new energy sources and to less energy-intensive sectors (see box IV.2).

Box IV.2: Diversification of the productive system in South Africa

Historically, low electricity prices have been seen as central to South Africa's competitiveness. The use of cheap and abundant coal has provided relatively low-cost electricity, leaving little incentive for greater energy efficiency. Industrial development has, to a significant extent, been built around energy-intensive sectors. These sectors are sensitive to changes in energy prices, so that particular attention needs to be given to them in the move to a low-emissions economy. While current government policy has embraced sustainable development goals, the country continues to provide significant incentives for investment in energy-intensive industries. These industries are still an important source of employment, investment and income.

Continuing this approach carries a high risk that the economy will be "locked into" energy-intensive industries, when environmental, economic and social pressures may push South Africa in the opposite direction. Significant investment in energy-intensive industries in the 1990s has had just that effect, and new megaprojects continue to be planned.

An active industrial policy is required to target sectors that are less energy-intensive and enable South Africa's economy to diversify, move away from the country's mineral-energy complex and shift to capital and intermediate goods. This would represent a major shift and could take decades to complete. However, given the lock-in effect, decisions taken today will be critical in changing the trajectory of South Africa's energy development path. "Bending the curve" requires a long-term perspective, but it also involves policy changes in the immediate future.

The most effective and affordable short-term strategy for reducing greenhouse gases emissions in South Africa is an energy-efficiency programme. The next strategy would be to change the fuel mix to reduce the share of coal in the total primary energy supply. In the medium term, reduced-carbon and non-carbon energy supplies, such as natural gas, hydroelectricity (imported from the region) and solar thermal technologies could be introduced. These measures can together achieve significant emissions reductions, but further action will also be required, possibly with the help of international funding.

Renewable energy options in South Africa have been considered both in terms of electricity-generating renewable technologies (a combination of biomass, solar thermal technologies and wind energy) and a biofuels industry. Investing in more labour-intensive technologies such as renewables would create more "green jobs". Other, more ambitious renewable energy interventions are possible, particularly one involving a massive effort to develop solar energy technologies, since South Africa has excellent solar resources, but this would again depend on the electricity price. Current evidence indicates that solar water heating (for domestic, commercial and potentially industrial applications) is economically viable, even given current low prices. Developing the potential of solar energy in South Africa would probably require a massive state-driven research project and an investment programme similar to the synthetic fuels programme of the 1960s and 1970s.

Other supply-side options that require further investigation include new coal technologies and unconventional coal technologies such as fluidized-bed

Box IV.2 (cont'd)

combustion, as well as carbon capture and storage combined with coal gasification. There are currently no reliable estimates for the cost of these programmes, especially given the lack of oil or gas wells in South Africa, a factor that introduces significant technical complications with respect to CO₂ storage. There are also plans to develop a biofuels industry, but on a relatively small scale, limited by cost and the availability of land and water.

To achieve the desired transformation, South Africa will need to promote less emissions-intensive industries and sectors, while tackling the challenge posed by the energy-intensive sectors through a combination of reviewing the existing policy framework, promoting specific energy-intensity targets, conducting international negotiations on the best location for such industries, and carrying out diversification within these sectors. The aim of these strategies would be to protect South Africa's competitive advantage in the short and medium terms, while building other competitive advantages in the long term.

Source: Winkler and Marquand, 2009.

Agriculture, as one of the most climate-sensitive sectors in many countries, will require smart new policies that integrate adaptation and mitigation. One key strategy is to build knowledge of new technologies such as sustainable irrigation methods and crop selection and diversification. A proactive approach can prevent production losses and a further aggravation of the food crisis and poverty in rural areas, especially in Africa.

At present, agriculture is the main emitter of nitrous oxides and methane (both with high global warming potential), contributing about 14 per cent of global greenhouse gas emissions in 2005, more than the transportation sector.³ At the same time, agriculture is an area with large and relatively inexpensive mitigation potential. One study estimated that by 2030, agricultural emissions could be more than halved from business-as-usual levels through a combination of measures that would cost less than \$10 per ton of CO₂ equivalent (CO₂e) abated; many measures would have negative costs because of productivity benefits.⁴ Low-cost measures include improving soil quality (for example, restoring degraded lands) and cropland and grazing land management (for example, reducing fertilizer use, reducing tillage and eliminating burning of crop residues in the field).⁵ Thus, sustainable agriculture can contribute to meeting climate change mitigation goals as well as the Millennium Development Goals for reducing income poverty and hunger. However, taking advantage of the mitigation and carbon sink potential in agriculture will require capacity-building programmes, with investments in technical training, provision of extension services, and programmes for sharing good practices.

The production of biofuels from biomass is another potential means of mitigating climate change and generating income in the agricultural sector. However, this will require further research on sustainable production methods and management of the potential competition between biofuel and food production, along with extensive farmer and farm worker training. If the biofuel industry grows, it will require not only a large unskilled labour force, but also skilled labour. Training will be needed in the technical and managerial skills needed in the nascent biofuel processing industries.

The appropriate diversification strategy for each country will be context-specific. It depends, among other factors, on the level of development, technological capacities, size of the economy, natural resource base, government capacities and established state-business relations. It is important to remember that a development strategy extends beyond manufacturing, and can include new uses of natural resources and the development of modern services.

The revival of industrial policy

There is growing recognition that there is no “one size fits all” policy approach to development—especially when it is combined with the climate challenge. For many years, developing countries were pressed to adopt a narrow band of generic, market-friendly measures, and to roll back the state. Unfortunately, those policies have seriously debilitated public sector capacity in some countries and left an institutional hiatus which needs to be filled.⁶

Governments have a long history of improving the efficiency of the market system by correcting for market failure, especially in non-competitive markets, and of accelerating growth by providing missing inputs and promoting public-private collaboration in long-term investment, research and development, education and training, etc. Still, government is no less fallible than markets, and unpredictable government actions can also hinder long-term investment. More secure property rights can help address the latter; in addition, stronger and more reliable civil service capacities and public institutions will be needed.

The large up-front investments needed in both mitigation and adaptation will require a coordinated effort to mobilize domestic and external resources and to channel them into high-productivity, energy-efficient activities. Macroeconomic policy instruments would need to be deployed to support a development mandate dedicated to productive investment, structural

change and rapid growth. In order for this to be possible, financial markets must be regulated in a manner that protects the autonomy of national governments.⁷

Fiscal and monetary policies should give priority to increasing public spending, including investments in renewable energy, cleaner energy processes, education, health and infrastructure. This will also entail the use of subsidized credit, credit guarantees, tax breaks, accelerated depreciation allowances, and other policy measures to boost profits in private firms in the desired sectors. The effects of such policies will be greater if commercial banks make loans more easily available for such investments. However, as discussed in chap. VI, development banks may have a larger role to play in some countries.

Because a big investment push is likely to target a limited range of industries and sectors and involve substantial public investment, there has been much warning about potentially crowding out private investment. In such scenarios, additional government spending has little positive, or even a negative effect on total output, because of its adverse effects on interest rate-sensitive components of private expenditure. Neither theory nor empirical evidence provides a basis for clear-cut conclusions in these respects, however, and our own big-push scenario allows for considerable crowding in (see chap. I).

Yet pro-investment macroeconomic policies are not enough. There is also a need for effective industrial policies, with some key ingredients: targeted incentives, regulation, coordination of investment decisions, and control mechanisms. These elements can be implemented through diverse instruments, according to the particular characteristics of the sector and country.

In many developing countries, such measures have been used to attract foreign direct investment. These countries have the experience and instruments required to target and tailor industrial policies towards a big push in clean energy and towards diversification in support of greater economic resilience. Some have been more successful than others, however, in using these policies. The subsidies and rents created by these measures need to be conditioned on enhanced performance, linked, for example, to technological upgrading, and limits must be set on how long they can be used. These and other lessons will need to be absorbed as industrial policies are implemented to meet the climate challenge. Of course, the first step is to shift out of reverse and into forward gear: currently, many countries still have policies favouring high-emissions sectors such as hydrocarbons.

A logical, though not easy, starting point is to reorient support from these sectors towards renewable or cleaner energy sources.

Developing countries operate today in a global policy environment that is much changed from two or three decades ago. In particular, there has been a tendency to discipline national economic policies through multilateral, regional or bilateral agreements that restrict countries' ability to adopt certain types of industrial policies. For example, direct export subsidies are now illegal for all but least developed countries, as are domestic content requirements on enterprises that are linked to trade, quantitative restrictions on imports, and patent laws that fall short of international standards. However, there remains much scope for coherent industrial policies, especially if countries do not further erode their policy autonomy.

The ethanol industry in Brazil demonstrates how critical government support can be, particularly in the early phases of a new technology, and how support may need to be sustained until the technology has taken firm root in the marketplace (box IV.3). The government of Brazil, at both

Box IV.3: Brazil's sugar cane-based ethanol industry

Brazil's ethanol industry was established in the 1930s. With more sugar than it could use, the government determined that sugar cane should be utilised for ethanol production and required that ethanol be added to gasoline. Following the international oil crisis in 1973, the industry expanded in importance. The government launched the National Alcohol Programme (Pro-Álcool) in 1975 to increase production yields, modernize and expand distilleries, and establish new production plants. Although ethanol production was initially subsidized heavily, over time the subsidies have been eliminated.

Policies that were key to Brazil's success in promoting ethanol use include (a) obligating the state-owned oil company, Petrobras, to purchase a guaranteed amount of ethanol; (b) providing economic incentives to agro-industrial enterprises in the early 1980s to produce ethanol, including loans with low, subsidized interest rates; (c) encouraging consumers by guaranteeing a price of ethanol at the pump at 59 per cent of the price of gasoline; (d) requiring the automobile industry to produce cars able to run partially or totally on biofuels; (e) allowing renewable energy-based independent producers of electric power to compete with traditional public utility firms in the electricity market at large; (f) stimulating and supporting private ownership of sugar mills, which helped increase competition and efficiency; and (g) stimulating rural activities based on biomass energy to increase employment in rural areas.

The Sugar Cane Technology Centre, a privately funded research institute in São Paulo, played a central role in improving ethanol production technology, investing about \$20 million per year in research at the peak of the programme. Researchers at the Centre and other institutions also found ways to use sugar cane fibre residue,

Box IV.3 (cont'd)

known as bagasse, to produce energy, building on existing methods of burning bagasse to power steam turbines for electricity generation and using the remaining heat from the turbines for the distillation process. They developed cauldrons operating at greater pressure so that more energy could be produced, allowing many ethanol plants to become self-powered. This contributed significantly to keeping ethanol production costs low.

Thanks to steady productivity improvements, the cost of producing ethanol declined by an annual average of 3.8 per cent from 1980 to 1985 and of 5.7 per cent from 1985 to 2005. As cumulative experience increased, the cost per unit of energy declined (see figure).

In 2009, Brazil was the second biggest producer of ethanol in the world (25 billion litres) after the United States (38 billion litres), according to the Renewable Fuels Association. Close to 80 per cent of Brazil's ethanol is for the domestic market, where much of the demand has been driven by the success of flex-fuel vehicles. Introduced in 2003, such vehicles can run on gasoline, ethanol or a mix of both; in March 2010, they surpassed 10 million units. According to Brazil's National Association of Automotive Vehicle Manufacturers (ANFAVEA), 86 per cent of cars sold in 2010—almost 3 million—were flex-fuel, and since 2009, flex-fuel motorcycles have been sold in Brazil as well, quickly gaining popularity.

Brazil is also experimenting with another biofuel made from sugarcane, a biodiesel. In 2011, after a successful field test in São Paulo of buses fueled in part by sugarcane diesel, a contract was announced for 160 buses in the city to run on a 10 per cent sugarcane diesel blend through 2012.

The government's reasons for supporting biofuels have expanded to include concerns about greenhouse gas emissions and climate change, rural employment

Box IV.3 (cont'd)

and equity issues, and local air pollution. The use of ethanol as a replacement for gasoline—in flex-fuel vehicles and blended into all conventional fuel—has led to an overall reduction of 9.2 million tons of carbon per year in carbon emissions in Brazil (10 per cent of the total). When used as an additive, ethanol also displaces highly toxic and volatile components of gasoline (such as lead, benzene, toluene and xylene).

Brazil now offers its expertise to other countries, especially developing countries that could produce biofuels but still depend on oil. However, Brazil's own success has been marred recently by supply shortages and a surge in sugar prices since 2010 that significantly increased the cost of Brazilian ethanol and led the country to start importing U.S. ethanol. To reduce the need for imports and subdue inflation, the government lowered the ethanol mandatory blending rate for gasoline from 25 per cent to 18 per cent. In addition, the state-run development bank BNDES announced in June 2011 that it would provide 30 billion to 35 billion reais (\$19 billion to \$22 billion) to finance expansion in the sugar cane sector through 2014.

Sources: Goldemberg, 2008; Goldemberg et al., 2004; Moreira, 2006; Almeida, 2007; Food and Agriculture Organization of the United Nations, 2008; Nakicenovic, 2009; United Nations, 2008; Institute for International Trade Negotiations of Brazil (ICONE); Brazilian Sugar Cane Industry Association (UNICA), 2010; Riveras and Winters, 2011; Amyris Brasil 2011.

federal and state levels, had an essential role to play in providing incentives to scale up production and in setting up a clear institutional framework. This role included setting technical standards, supporting the technologies involved in ethanol production and use, providing financial advantages, and ensuring appropriate market conditions.

Replacing old technologies, like gasoline in the case of Brazil, with renewable sources requires complementary investments along the supply chain. In the particular case of gasoline, consumers are reluctant to buy cars using a new fuel that may be difficult to find. Service station owners are not interested in investing in a parallel fuel distribution system, since the number of potential users is initially very small. This is why government policies to spur investment and drive demand for selected technologies are so important.

Additionally, in most countries, government is the single largest consumer. Thus, government procurement policies, including methods such as tendering and holding of reverse auctions, can be an important instrument. As major purchasers of electricity and vehicles, governments can give a significant boost to low-emissions options through procurement bidding specifications. Such green procurement could also extend to new construction of government buildings, ranging from offices to schools and hospitals.

Specific industrial policies will vary depending on the particular country, with some placing a greater reliance on technologies acquired from abroad through trade and foreign investment, and others exerting greater effort on behalf of local technology development. The balance between the two types of policies may well shift over time as a country familiarizes itself with imported technologies and acquires the capability to replicate, adapt and improve them.

For some developing countries with strong technological capabilities, there may be even scope for pushing the technological frontier outwards. Thus far, there are relatively few examples of developing countries that have established and maintained a strong lead in technologies of global significance, in markets of global scope. This is changing, however, as a number of middle-income developing countries acquire stronger technological capabilities and establish innovation systems.

SOME POLICY STEPS TOWARDS A LOW-EMISSIONS FUTURE

In developing countries, there is a need for policies that foster strategic deployment of new technologies, in view of the advantages to be gained by building up new industries and accelerating movement down the learning (and hence, cost) curves. Strategic deployment generally requires a range of incentives, regulation and direct public investment.

Some of the major technologies involved, which are now or could soon be ready for large-scale deployment, include:

- Advanced technologies (such as gasification) for generating electricity from coal and biomass: a suite of technologies whose accelerated deployment will bring higher efficiency, reduced emissions and compatibility with carbon dioxide capture and storage technologies;
- Low-energy building technologies, for markets that are too often impeded by barriers associated with the construction industry and rental markets;
- Primary renewables, notably solar photovoltaics, for which potential scale economies remain large, and wind energy, a proven contributor to emission reductions which involves local learning and related industrial innovation.

A range of government subsidies to producers or users of new technology can be designed to speed technology deployment. Subsidies can take a variety of forms, such as:

- Investment tax credits to firms that bring a new technology to market can lower the upfront investment costs of producing a new type of

equipment, and can be tied either to costs or to the level of production. These policies work to increase the supply of a new technology on the market.

- Production tax credits are subsidies granted for a particular type of electricity generation on a per-unit-of-production basis, making renewables such as wind more competitive with respect to higher-emissions production methods.
- To increase demand for a new technology, tax credits or rebates can be granted to purchasers as well as producers, reducing the cost differences between old and new technologies and making the lower-emitting or more efficient new products relatively more attractive. For example, many governments offer tax rebates to consumers who purchase high-efficiency appliances.
- Loan guarantees can subsidize industry by shifting the risk of failure or default to the government, thereby lowering the costs of capital for private firms below what would be available on the open market for an unproved but promising technology.
- Limiting legal liability to the users of a new technology, another implicit subsidy, insulates parties from possible economic damages. This approach may be relevant for carbon capture and sequestration technology, where a release of geologically sequestered CO₂ could potentially undo climate benefits and cause additional harm, giving rise to litigation against the developer.

Energy efficiency

As previously noted, there is a potential for substantial emissions reductions from improving energy efficiency. The building sector, transport and industry appear to offer sizeable opportunities for low-cost improvements; there are also potential, if less well-researched, gains to be reaped in agriculture. There are also other potential benefits from creating jobs in new business activities.

In South Africa, for example, the leading opportunities for energy efficiency include improved building design and improved heating, ventilating and air conditioning (HVAC) efficiency. A “cleaner and more efficient residential energy scenario” involves energy-efficient housing shells, efficiency measures such as deployment of compact fluorescent lamps (CFLs) and geyser (hot-water heater) insulation blankets, and a number

of fuel-switching options, including installation of solar water heating, replacement of other fuels with liquefied petroleum gas (LPG) for cooking, and replacement of paraffin (kerosene) with electricity for lighting, linked to substantial increases in residential electrification. Despite the promotion of win-win gains, however, widespread implementation requires some initial investments and efforts to overcome informational, institutional, social, financial and technical barriers.⁸

There are a range of incentives that can reduce initial costs associated with increasing energy efficiency, including subsidies or grants for energy efficiency investments, tax relief for purchase of energy-efficient equipment, subsidies for energy audits, and loans or guarantee funds for energy efficiency projects. Tax incentives, guarantees and other financing measures can help investors overcome the possible constraints on paying the upfront cost of efficiency improvements.

Cleaner coal

Coal is an abundant, low-cost energy resource, but it is also carbon-intensive and polluting. In 2008, the International Energy Agency (IEA) reports, 43 per cent of CO₂ emissions from fuel combustion were produced from coal, compared with 37 per cent from oil and 20 per cent from gas. Under current policies, the IEA has projected, demand for coal will rise by nearly 60 per cent from 2008 to 2035.⁹

Globally, two market problems currently limit the development and adoption of cleaner coal technologies: it costs less to pollute than to control pollution, and barriers such as high development costs slow technological change. Accelerating deployment will require changes at the national and international levels. Businesses want investment certainty through stable policies which recognize the costs and risks of long-term capital investment in pollution control, new combustion designs such as integrated gasification combined cycle plants, and carbon capture and sequestration (CCS) technologies.

Deployment of clean coal technologies must encompass the entire coal supply chain, and parallel progress is needed in technical and non-technical areas for coal to remain an acceptable component in a country's energy mix. A modern coal-fired power plant cannot be considered in isolation from the coal mines, transport infrastructure, and coal markets that supply it. This again underscores the importance of integrated policy responses.

One major challenge will be to develop and deploy CCS systems, a critical technology for coal's long-term future, but one that has not yet been

demonstrated on a commercial scale at any coal-fired power plant. This may be an opportunity for some developing countries, and China is already participating in R&D initiatives that aim at accelerating progress.

More broadly, China has an unprecedented opportunity to become a major player in the global market for cleaner, more efficient coal technologies. It has already developed some unique technologies that other countries may want to adopt, and it will certainly create more. It should work with other governments to create a global market for clean energy technologies, and allow its manufacturers to respond with commercially relevant products, for local markets and for export.

Greater efforts in R&D are needed globally, and additional spending alone is not an adequate response to the challenges faced by the energy industry as a whole. China has shown a willingness to participate in international partnerships and joint ventures in many fields aimed at researching, developing and demonstrating new technologies. In the case of cleaner coal, such active participation can speed progress towards those technologies that are most appropriate for commercial markets within China and elsewhere.

Renewables

Strategic deployment of new technologies brings advantages by building up new industries, gaining economies of scale, and accelerating movement down learning curves. At the same time, strategic deployment generally requires regulation, which fosters adoption of technologies that would otherwise be uneconomical; in this way, the benefits of learning by doing and other scale economies are secured.

Even with the expansion of coal consumption in China and India, its growth rate does not match that of renewables, which is doubling every two to five years. In 2010, China became the world leader in total installed wind capacity, adding 18.9 gigawatts of capacity in that year alone, for a 73 per cent increase, and accounting for more than half the world market for new wind turbines. India is also a leader in wind power, ranked No. 5 in 2010, with 13 gigawatts of capacity.¹⁰

The optimal incentives for renewable energy deployment depend on the technology. The market for solar energy products such as photovoltaic panels, solar water heating, and solar power concentrators ranges from industrial power generation to smaller commercial-scale and domestic installations. Wind power, on the other hand, is almost entirely produced

at industrial scale by large companies. Because wind farms are financed by large corporations with access to financial markets, the wind industry has preferred the long-term payback of production tax credits, which provide a return on every kilowatt produced, as a means of making their power more competitive on the market. The biggest concern for smaller-scale solar installations, however, is not the long-term return on the power generated, but rather the initial high cost of installing a system. In this case, an investment tax credit is a better instrument for the industry, allowing producers of solar products to charge lower prices. To make a subsidy cost-effective, care should be given to eliminating free-riders (those companies that would have upgraded their equipment even without a subsidy) and reducing transaction costs.

Other policies that have been used to promote renewables include:

- Feed-in tariffs, as adopted particularly in continental Europe but also in parts of North America and China (see chap. II), which mandate a specific (premium) price to be paid for electricity generated from renewable sources such as wind and solar energy.
- Renewable obligations, known in North America as renewable portfolio standards, which require utilities to source a certain percentage of their electricity from renewable sources.¹¹
- Other technology or fuel mandates, such as Brazil's long-standing requirement that cars run entirely or partly on ethanol (see box IV.3), a requirement that has also been established in China.

China now ranks among the top countries in the number of patents for renewable energy technologies. The government had to implement diverse policies to overcome multiple barriers, including the high cost of developing renewable energy, the difficulty of connecting renewable energy to the grid,¹² institutional impediments, a lack of international investment, a weak legal and regulatory framework, and an uncertain level of future demand and thus of prices for renewable energy.

CONCLUSION

Most developing countries are reluctant to accept binding emissions targets. Their concerns are rooted in fundamental development challenges and reflected in the United Nations Framework Convention on Climate Change, which recognized that countries have "common but differentiated responsibilities". While developed countries are to "take the lead in

combating climate change”, the UNFCCC says, for developing countries, “economic and social development and poverty eradication are the first and overriding priorities”. Developing countries argue that developed countries have yet to demonstrate their leadership in tackling the climate challenge, and that being held to specific emission levels regardless of the economic consequences would be tantamount to putting a cap on their growth and perpetuating unacceptable levels of poverty and inequality.

Establishing low-emissions, high-growth development pathways will be crucial to meeting the climate challenge, reducing global inequality and tackling extreme poverty. If history is any guide, it is unlikely that market forces, by themselves, would be able to establish such pathways and serve as guides through the transition. This chapter has argued that developing countries require the presence of strong and dynamic developmental states capable of providing a coherent vision of the future, of managing the conflicts that arise from change, and of establishing the kind of integrated strategy that will be needed.

Developmental states have managed successful transitions in the past by mobilizing resources and providing missing inputs for productive activities, socializing investment risk, removing barriers, and providing temporary support to those adversely impacted by the shifts in activities. This has involved a blend of pro-investment macroeconomic and industrial policies. Fiscal and monetary policies have given priority to increasing public spending, including investments in energy, education, health and infrastructure. Subsidized credits, credit guarantees, tax breaks, accelerated depreciation allowances, and other policy measures have been used to boost profits in private firms in targeted sectors.

All these elements will certainly be needed to successfully shift to a low-emissions, high-growth pathway. Strategies will have to include a clear vision for energy production and for the energy-intensity of the production structure, for urban development and transportation, and for natural resource use and natural resource intensity of production.

Success will also require collaborations between the state and the private sector. Initial steps can be taken by fostering energy efficiency, implementing cleaner coal processes and developing renewable energy sources. Yet mitigation efforts, no matter how necessary, will not be sufficient to protect developing countries from the threats posed by climate change. The best defence against such threats remains economic diversification to eliminate dependence on a small number of activities that are particularly vulnerable to climatic shocks and changes.

NOTES

- 1 Commission on Growth and Development, 2008. *The Growth Report: Strategies for Sustained Growth and Inclusive Development*. The World Bank, Washington, D.C. http://www.growthcommission.org/index.php?option=com_content&task=view&id=96&Itemid=169.
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- 4 Enkvist, P.-A., Nauclér, T. and Rosander, J., 2007. 'A cost curve for greenhouse gas reduction.' *The McKinsey Quarterly*, No. 1. 35–45.
- 5 For a more extensive analysis of technological options for sustainable agriculture, see, for instance, chapter III of United Nations, 2011. *World Economic and Social Survey 2011: The Great Green Technological Revolution*, New York. http://www.un.org/en/development/desa/policy/wess/wess_current/2011wess.pdf
- 6 For an in-depth review of this issue, see Fieldman, G., 2011. 'Neoliberalism, the production of vulnerability and the hobbled state: Systemic barriers to climate adaptation.' *Climate and Development*, 2(2). 159–74. doi:10.1080/17565529.2011.582278.
- 7 For a more elaborate discussion, see chapter II in United Nations, 2010. *World Economic and Social Survey 2010: Retooling Global Development*, New York. http://www.un.org/en/development/desa/policy/wess/wess_archive/2010wess.pdf
- 8 Winkler, H. (ed.), 2006. *Energy Policies for Sustainable Development in South Africa: Options for the Future*. Energy Research Centre, University of Cape Town, Rondebosch, South Africa. <http://www.erc.uct.ac.za/Research/publications/06Winkler-Energy%20policies%20for%20SD.pdf>
- 9 International Energy Agency, 2010. *CO₂ Emissions from Fuel Combustion 2010 – Highlights*. Paris. <http://www.iea.org/co2highlights/co2highlights.pdf>
- 10 World Wind Energy Association, 2011. *World Wind Energy Report 2010*. Bonn. http://www.wwindea.org/home/images/stories/pdfs/worldwindenergyreport2010_s.pdf
- 11 See box II.1 (pp. 32–33) in United Nations, 2008. *World Economic and Social Survey 2008: Promoting Development, Saving the Planet*, New York. http://www.un.org/en/development/desa/policy/wess/wess_archive/2009wess.pdf
- 12 This remains a problem with wind power; just under 70 per cent of China's wind capacity was connected to the grid in 2010, according to the World Wind Energy Association.

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