

Long-Term Low Greenhouse Gas Emission Development Strategies



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Sustainability Working Group





Long-Term Low Greenhouse Gas Emission Development Strategies: Approaches and Methodologies for Their Design

Input Document for the G20 Climate
Sustainability Working Group

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Foreword

This paper was prepared for the Argentine G20 presidency by World Resources Institute (WRI) and the United Nations Development Programme (UNDP) as a contribution to the G20 Climate Sustainability Working Group.

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Executive Summary

Long-term low greenhouse gas development strategies (long-term strategies) offer an opportunity for the G20 to set the leadership direction that will help steer the world toward a viable climate future. The G20 collectively accounts for 75 percent of global greenhouse gas emissions (Climate Transparency 2017) and 85 percent of global GDP (OECD and IEA 2017). With nearly \$70 trillion in forecasted infrastructure spending through 2040 (GIHub 2017), G20 countries have an imperative to ensure wise investments that will facilitate the transitions to low-greenhouse gas development and mitigate climate risk through long-term planning. Recent analysis shows that the G20 can generate inclusive economic growth in the short term while making ambitious progress toward long-term climate objectives (OECD 2017).

As of June 2018, six G20 countries (Canada, France, Germany, Mexico, the United Kingdom, and the United States) and two other countries (Benin and the Czech Republic) had formally communicated long-term strategies to the United Nations Framework Convention on Climate Change (UNFCCC).¹ Several other countries had initiated domestic processes to prepare these strategies well ahead of 2020, the date suggested in the Paris Agreement. Many G20 countries have experience with planning for 2030–50 time horizons that may provide foundations for their long-term strategies and lessons to other G20 members.

HIGHLIGHTS

- Long-term strategies offer an opportunity for the G20 to set the leadership direction that will help steer the world toward a viable future for the climate.
- Long-term strategies are fundamentally a voluntary and nationally driven exercise.
- Long-term strategies provide direction for near- and medium-term action and planning, avoid lock-in and stranded assets, and guide the implementation and formulation of nationally determined contributions (NDCs).

HOW TO DESIGN A LONG-TERM STRATEGY

This paper identifies the main considerations in the development of a long-term strategy.

Predesign stage: Countries may find it helpful to consider the following before preparing a long-term strategy:

- *Existing plans and policies:* Building on existing domestic plans and policies can optimize resources, ensure policy coherence, and obtain buy-in from key institutions.
- *Governance:* Long-term planning for climate change and development raises unique governance challenges, which may require strong political leadership, engagement across a wide range of ministries and actors, robust and transparent stakeholder consultation processes, and legal frameworks that support implementation.
- *International cooperation:* Early and open exchanges between countries can allow them to share lessons, discuss common challenges, and identify opportunities for collaboration.

¹ In the United States, the previous Administration submitted a Mid-Century Strategy in 2016 that included modeling scenarios with technology and implications for policy through mid-century, and communicated this product to the UNFCCC. This submission does not reflect current United States policy.

Inputs for design: The inputs countries may evaluate when designing their long-term strategies include the following:

- *Data:* Building on existing data and collecting new data can help inform long-term goal setting, as well as the identification and prioritization of short- and medium-term policies.
- *Modeling and scenarios:* Modeling and scenarios can help reveal which mitigation actions are needed to achieve long-term goals and when they should be adopted. Modeling can also be used to examine trade-offs, explore technical feasibility, and help stakeholders evaluate options in a range of possible futures.
- *Complementary qualitative approaches:* Qualitative approaches can be used to gain deeper and richer insights for long-term planning and to spark innovative thinking.

Steps for developing a long-term strategy: The steps a country may choose to take when developing a long-term strategy include the following:

- securing a political decision to initiate the process
- defining the objectives of the strategy
- identifying the elements to be included in the strategy
- collecting inputs, including data, modeling and scenarios, and complementary qualitative approaches
- providing for transparent communication
- including a review and revision processes

Elements of long-term strategies: Long-term strategies may be presented in different structures but usually include the following elements:

- *Long-term vision and goals:* Goals may include development, mitigation, and adaptation considerations.
- *Sectoral pathways:* Sectoral strategies can play an important role in the design and implementation of a long-term strategy to inform how overall objectives of the strategy can be realized. In particular, energy assets and energy planning are essential components of most G20 long-term strategies. Accordingly energy sectoral strategies are particularly important for the G20, which collectively accounts for 80 percent of global energy-related emissions (IEA and IRENA 2017).

Postdesign stage: There is a need to ensure that long-term strategies are transparently communicated, sustained in future administrations, and regularly updated:

- *Monitoring plans and revision processes:* It is useful to develop a plan for monitoring progress—along with a process for revision—to ensure that the strategy is a living document that is updated and improved upon as national circumstances change, technology evolves, and new learning takes place.
- *Communication:* A communication strategy may include promoting understanding across the political and stakeholder spectrum, addressing common needs, and allowing follow-up in the context of the Paris Agreement’s long-term goals.

This paper identifies issues that should be considered in the development of long-term strategies. It invites countries to learn from the experiences of countries that have already developed long-term strategies while building on and complementing existing domestic processes.

1. The Role of Long-Term Strategies in G20 Climate Leadership

This paper responds to the Scope of Work proposed in the Terms of Reference provided by the Argentine G20 presidency. The paper provides a robust foundational analysis to inform the long-term strategies discussed at the April 2018 Working Group meeting. Input from G20 members and other reviewers was incorporated into the paper following the meeting. This paper is also a complementary resource for the Energy Transitions Working Group.

OPPORTUNITIES FOR THE G20 TO SET LEADERSHIP DIRECTION TOWARD VIABLE CLIMATE FUTURE

The Paris Agreement and the accompanying decision text invites countries to communicate midcentury long-term low greenhouse gas emissions development strategies by 2020. These strategies have great potential to guide countries on a path to limit warming to 1.5°–2°C by the end of the century while ensuring that climate plans align with efforts to pursue strong, sustainable, balanced, and equitable growth. The strategies also begin to reveal the scale of change needed to bring national climate action in line with the Paris Agreement’s global ambition. Current pledges through nationally determined contributions (NDCs) are not ambitious enough to limit warming to well below 1.5°–2°C. Significant and sustained investments and new policy mechanisms will be needed across key opportunity areas.

As of June 2018, eight countries—Benin, Canada, the Czech Republic, France, Germany, Mexico, the United Kingdom, and the United States—had officially communicated long-term strategies to the United Nations Framework Convention on Climate Change (UNFCCC).²

Long-term strategies offer countries a unique opportunity to develop a farsighted approach to development and climate—one that builds on the development gains of previous decades and aspirations for the next. These strategies can support a range of objectives and benefits for G20 members, including the following:

- Providing a clear signal to the world that a path toward the temperature goals set in the Paris Agreement are achievable and that major economies are committed to achieving them.
- Demonstrating that countries can simultaneously pursue ambitious development objectives and climate action.
- Setting a longer-term agenda to guide near- and medium-term action and planning, avoiding lock-in and stranded assets, and helping guide the implementation and formulation of nationally determined contributions (NDCs) by providing a pathway for the country, including by identifying priority sectors that need attention or could deliver “no regrets” emissions reductions, as well as areas where international cooperation may be needed.
- Conducting long-term planning in the context of climate risks and uncertainties.
- Supporting just transitions, by sending early and predictable signals to businesses and workers and sectors tied to high-emissions economies and identifying where potential trade-offs need to be managed and planning measures adopted to accommodate the transition.

² In the United States, the previous Administration submitted a Mid-Century Strategy in 2016 that included modeling scenarios with technology and implications for policy through mid-century, and communicated this product to the UNFCCC. This submission does not reflect current United States policy.

- Engaging and catalyzing stakeholders, supporting policy progress on a range of issues beyond climate aspects.
- Fostering coherence and coordination, looking across the entire economy for mitigation opportunities.
- Helping countries plan for technology and innovation trends, and design economic policies in a way that allow them to take full advantage of opportunities.
- Revealing the economic benefits and other impacts of investing in long-term climate action.
- Shedding light on the choices and tradeoffs a country may encounter in transitioning toward a “Paris-compatible” development trajectory.

Countries have the flexibility to develop their long-term strategies as they see fit. Strategies can be tailored to national contexts. These strategies are not an end goal but rather a process to be updated and improved upon as national circumstances change, technology evolves, and new learning takes place. Long-term strategies are fundamentally different from NDCs, because they do not focus on measuring progress in mitigation but rather allow countries to engage in an open discussion on pathways for development and on aligning their long-term planning with the Paris Agreement’s long-term goals.

ABOUT THIS PAPER

This paper aims to serve as a resource for the G20. It draws lessons from countries’ experiences in order to highlight issues to consider in developing long-term strategies. It orients G20 members toward considerations around the development of long-term strategies that can deliver the benefits outlined above, including where to start, which design features to consider, what elements to include, and which data and inputs support the strategy development. The paper invites countries to consider how a process to develop a long-term strategy—a voluntary and nationally driven exercise—can build on and complement existing domestic processes while learning from the experiences of countries that have already developed long-term strategies. It is not prescriptive; rather, it presents choices that countries may face when developing long-term strategies. The paper includes examples of national long-term planning efforts—in both G20 and other countries—that yield lessons and shed light on best practices (these experiences are included in blue boxes throughout the paper).

The paper was developed building on the World Resources Institute (WRI) working paper *Early Insights on Long-Term Climate Strategies* (Ross and Fransen 2017), expert perspectives commissioned through a WRI/UNDP project on long-term strategies (www.longtermstrategies.org), lessons learned from countries with experiences in planning over long time horizons, and relevant literature. The paper was updated with input from G20 member countries.

2. Where to Start: Setting Up a National Process for a Long-Term Strategy

2.1 STEPS IN DEVELOPING A LONG-TERM STRATEGY

Developing a long-term strategy may include the following steps:

- securing a political decision to initiate the process
- defining the objectives of the strategy
- designing the elements
- collecting inputs
- communicating the strategy transparently
- establishing review and revision processes

These steps, which are not necessarily sequential, are illustrated below.

Securing a political decision to initiate the process



Strong political support is important to initiate the long-term strategy preparation process. It helps ensure that the exercise is not limited to a single ministry but involves a whole of government approach. The process could be initiated by a head of state, who would provide a mandate for its development, or by the leadership of a ministry or department and then raised with the head of state to secure his or her support.

Defining objectives of the strategy



After the mandate to establish a long-term strategy is secured, it is useful to define the strategy's objectives and scope. Any of the benefits outlined in section 1 can serve as objectives; countries may also have additional objectives that reflect their national circumstances. Article 2 of the Paris Agreement—which includes the long-term goal of limiting warming “to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels”—could serve as an objective of the strategy. The objectives could be elaborated to include a vision that includes social and economic objectives and considerations. Engaging stakeholders in defining these objectives can be beneficial.

Designing the elements



Decision-makers, with the support of experts and key stakeholders, can identify options for the design of the elements of the long-term strategy and define the strategy's ambition and scope. The elements may include a long-term vision, development considerations, mitigation elements, adaptation elements, sectoral strategies, implementation approaches, and monitoring plans and revisions processes. Section 3 presents possible elements of long-term strategies and discusses how implementation approaches can reflect alignment between long-term strategies and short-term decision-making as well as other planning processes. Engaging experts and the public in this step through consultation processes can generate helpful feedback on the long-term strategy and build support for its implementation.

Collecting inputs



Transparent communication



Establishing review and revision

Relevant data and analysis are the foundation of the long-term strategy preparation and design process. They include information on national objectives and priorities, data relevant to development goals, current and future greenhouse gas emissions, current mitigation activities, mitigation potential, future vulnerabilities across key sectors and geographies, and resource mobilization strategies (see section 4).

Clear and transparent communication of long-term strategies can help national and international stakeholders understand the goals of the strategy, as well as its underlying assumptions, and learn from the strategy. It can help send clear signals to investors and decision-makers at all levels of government (see section 5).

Given the long-term nature of the strategy, and the uncertainty related to long-term planning and technology pathways, periodically revising the strategy is essential, to ensure that it reflects the latest science, understanding, and priorities. It is beneficial to lay out clear monitoring plans and revision processes from the start (see section 3.8).

2.2 DESIGN CONSIDERATIONS

Long-term strategies call for institutional arrangements that support a coordinated and coherent approach, support from political leaders, supportive regulatory frameworks, engaged stakeholders, and access to resources. Countries can build on existing policies to lay the groundwork for implementation.

2.2.1 Governance

Long-term planning represents a departure from the norm in most political and bureaucratic environments. It requires attention to structures, processes, and incentives. Designing long-term strategies to inform climate change and development efforts raises unique governance challenges, which may require strong political leadership, engagement across a wide range of ministries and actors, supportive legal frameworks, and robust and transparent stakeholder consultation processes.

Political leadership

Strong political oversight and buy-in throughout the design process are important. High-level political leadership can help drive the strategy, foster coordination between ministries, send the right signals to the private sector, and enable linking with other ongoing political processes. Securing buy-in across political parties helps ensure that the strategy withstands the test of time.

In Canada and Mexico, the prime minister and president led the development of the long-term strategies, bolstering political recognition. In Costa Rica, New Zealand, and Sweden, the heads of states provided strong mandates for the development of the long-term strategies and the shift toward net zero emissions economies.

Institutional arrangements

The process of developing and implementing long-term strategies typically requires the engagement of central and sectoral ministries, subnational governments, nonstate actors and civil society, and (in some countries) indigenous self-governing bodies. It may necessitate the creation or reconsideration of existing institutional arrangements for long-term planning, including arrangements for coordinating among stakeholders and governmental institutions.

France's National Council for Ecological Transition was created in 2012, through the law on public participation in the environment (Government of France 2012). The 50-member council is chaired by the minister of ecology and consists of representatives from local authorities, parliament, environmental nongovernmental organizations (NGOs), social NGOs, trade unions, and business. The council guides, informs, and oversees progress on the low-greenhouse gas transition. It advises on draft laws concerning the environment, energy, and sustainable development; makes structural recommendations for transition policy; reviews reports on national progress and performance toward sustainable development metrics; and contributes to international negotiations (Government of France 2018). France's National Low-Carbon Strategy indicates that it will be implemented through the governance of the National Council (Government of France 2016).

Mexico's 2012 General Climate Change Law established multiple bodies to coordinate and inform national and subnational climate action, including its midcentury strategy. The Interministerial Commission on Climate Change (CICC) is composed of 13 federal ministries. It is mandated to develop and implement federal climate policy, oversee sector mainstreaming, and develop criteria for cross-cutting policies, among other duties. The Climate Change Council (C3) is a multistakeholder consultative council of experts that advises the CICC, provides recommendations, and promotes public consultation. The National Institute for Ecology and Climate Change (INECC) is charged with providing research and analysis to inform climate policies and evaluate their impact. These bodies also support and advise the Federal Congress, states, and the National Association of Municipal Officials (Government of Mexico 2016).

Legal frameworks

It may be appropriate to embed elements of the long-term strategy (such as targets, policy instruments, and other elements) into national laws. Doing so can provide institutional credibility, send clear mandates to relevant government ministries, and promote coherence between the long-term strategies and actual short-term policy (Sartor, Donat, and Duwe 2017). Laws can also put in place accountability mechanisms that help ensure that plans and policies at the sectoral level align with long-term climate goals (through planning and budget processes), enhancing policy coherence and signaling political commitment to domestic industries, investors, and other countries. Some countries, such as Mexico, Sweden, and the United Kingdom, already have long-term climate laws. However, not all existing long-term strategies have been preceded by a legal framework.

The United Kingdom has long led in establishing legal frameworks related to climate change, most notably via the Climate Change Act of 2008, which committed it to reducing greenhouse gas emissions by 80 percent between 1990 and 2050 (Government of UK 2018).

France has enshrined its strategy in the Energy Transition and Green Growth Act, which includes a binding 2050 target for total economy-wide greenhouse gas emissions (Government of France 2016). It has also targeted priority sectors and established a plan to ban sales of gasoline and diesel cars by 2040.

Germany's long-term strategy explicitly includes the intent to put specific legislative measures in place (Government of Germany 2016).

Mexico's General Law on Climate Change provides a mandate to craft comprehensive long-term climate policy. Its Energy Transition Law aims to fully revolutionize the energy sector in line with the objectives under the long-term strategy (Government of Mexico 2016).

Stakeholder engagement

Robust and transparent stakeholder engagement throughout the design process is important. Preparation of long-term strategies often involves engagement by a wide range of technical experts, including modelers from government agencies, universities, and think tanks. Broader stakeholder engagement—including by affected communities, businesses, and subnational governments—can inform the development of a shared vision; stakeholders may become important constituencies in the implementation of the long-term strategy. Incorporating independent advice from stakeholders has helped depoliticize the process and outcomes reached. It is important to involve a range of stakeholders that reflect the synergies and tradeoffs of the strategy's choices and to make progress toward resolving outstanding issues as they come to the fore.

Consulting with socially, economically, and politically marginalized groups can help ensure that a long-term strategy supports a fair and just transition, improves social equity, and promotes sustainable development. Consultations are also important for communities whose livelihoods are linked to fossil fuel-intensive activities and may require more than economic support and training to transition, as livelihoods also contribute to social identity.

Canada developed its midcentury strategy by leveraging the consultation mechanisms of the Pan-Canadian Framework on Clean Growth and Climate Change. Over a five-month period, innovators, indigenous nations, communities, businesses, and issue experts generated 13,000 ideas and comments, which informed the final framework and midcentury strategy.

Germany emphasized broad participation to build buy-in for its final strategy. The process did not end following development of Germany's Climate Action Plan 2050. Regular consultations will be held to review progress in implementation.

In Mexico experts and stakeholders identified possible climate impacts as part of the climate change adaptation process.

2.2.2 Leveraging International Cooperation

Early and open exchanges between countries while developing long-term strategies (and similar initiatives) can assist in the sharing of lessons and discussion of common challenges. Such exchanges can help identify opportunities for collaborating on policy alignment, linking financial or technical cooperation, and harmonizing the analysis of cross-border elements of scenarios used in the development of long-term strategies.³ Working on climate action with other countries can also accelerate innovation in clean technologies and avoid emissions leakage.

Canada, Mexico, and the United States⁴ worked together in developing their long-term strategies, which facilitated open exchanges and the sharing of information. All three countries highlighted the benefits of working together collaboratively (Government of Canada 2016).

2.2.3 Capacity

Long-term strategies can identify resource requirements for implementation and additional capacity-building needs.

Retaining expertise and institutional memory to design and implement a long-term strategy may be a challenge for many countries. The Capacity Building Initiative for Transparency (CBIT) seeks to address this issue. A CBIT project in South Africa supports education programs at universities and research centers in an effort to address the problem of high personnel turnover (GEF 2017). A project in Argentina will train a range of staff within the different ministries in the National Climate Change Cabinet to ensure the continuity and robustness of long-term planning.

Initial consideration of resource and capacity needs should take account of linkages across development areas (Ould-Dada 2018). Having a long-term vision can help ensure that resource and capacity needs are addressed sustainably across a variety of areas. The process of developing a long-term strategy can also help answer questions about a country's future needs, such as whether changes in the workforce are needed or how quickly new technology need to be incorporated (Garcia 2018). Answering these questions can help determine what types of training, extension programs, or advancements in research and development (R&D) may be necessary; countries may choose to include these types of resource and capacity needs in their long-term strategies as action points or milestones to overcome.

2.2.4 Finance

Putting in place the right investments, incentives, signals, and systems to finance the transition to a sustainable future is critical to achieving a country's long-term vision. Government actions promoting forward-looking climate financing include the following (Ballesteros 2018, Buchner 2018, and Robins 2018):

- initiating market-transformation mechanisms to reduce emissions (e.g., removing fossil fuel subsidies)

³ The 2050 Pathways Platform (<https://www.2050pathways.org>) was established to facilitate and support these exchanges.

⁴ In the United States, the previous Administration submitted a Mid-Century Strategy in 2016 that included modeling scenarios with technology and implications for policy through mid-century, and communicated this product to the UNFCCC. This submission does not reflect current United States policy.

- incentivizing investments of asset owners/managers, banks, insurance companies, and funds in clean energy companies and technology
- adopting policies that reduce gaps in returns between business-as-usual and climate compatible investments (through feed-in tariffs, guarantees, tax incentives, concessional loans, and green bonds)
- ensuring that financial institutions have credible data, tools, and frameworks to allow them to prioritize and focus on high-impact investments
- establishing institutions to efficiently access climate finance (e.g., a direct access facility)

Germany's long-term strategy describes a host of national-level climate financing mechanisms. One is a commitment to eliminating environmentally harmful subsidies. The German government has pledged to work at the domestic, European, and international levels to advocate for the elimination of these subsidies, while keeping in mind the interests of all stakeholders and the global economy (Government of Germany 2016).

2.2.5 Building on Existing Plans and Policies

Building on (and where necessary adjusting) existing development or other relevant plans and policies—particularly ones that stem from robust analytical and engagement processes at the domestic level—can offer numerous benefits, including optimizing resources, ensuring policy coherence, and building buy-in by key institutions. A review of relevant plans and policies can be a useful starting point. It helps ensure that long-term strategies are integrated into major economic or development plans rather than developed separately.

Many countries have experience in planning over the medium term (through 2030) with processes that established the initial NDCs and Low Emissions Development Strategies (LEDS). If long-term strategies are developed based on shorter-term approaches, however, policymakers may need to reconsider certain assumptions and pathways, in order to avoid the lock-in of carbon-intensive or non-climate-resilient infrastructure.

Many countries engage in long-term planning that can provide insight into and facilitate scenario planning for countries' mid- to long-range development and growth. These bottom-up long-term planning approaches can help accelerate the commercialization and deployment of advanced and innovative technologies. They can be updated frequently to reflect changing technology and market conditions.

The United Kingdom's long-term strategy (the Clean Growth Strategy) builds on preexisting domestic plans and ideas in a multitude of areas. Both the 2009 Foundations in UK Low Carbon Transition Plan and the 2011 Foundations in UK Carbon Plan committed to demonstrate international leadership in carbon capture usage and storage by collaborating with partners and allocating investment funds.

The United States engages in planning activities in specific programmatic contexts and around specific technologies, which allows for engagement in both near- and long-term technology and modeling scenarios through a bottom-up process.⁵

3. Scope and Elements of Long-Term Strategies

Various elements can be included in long-term strategies. They can include a long-term vision, development considerations, mitigation elements, adaptation elements, sectoral strategies, implementation approaches, and monitoring plans and revisions processes. Consideration of each element at the outset can help ensure strategic use of resources.

Ideally, the depth and scope of a country's long-term strategy will be in line with national priorities. In the end, however, the scope and depth of the strategy depends on the level of preparation, capability, and available resources.

The invitation to communicate long-term strategies is in accordance with Article 4 of the Paris Agreement, which states that parties are to take into account "common but differentiated responsibilities and respective capabilities, in the light of different national circumstances." Although the assumption is that strategies focus on mitigation, countries may add additional elements or considerations. There is no one-size-fits all approach; long-term strategies should be tailored to national circumstances and priorities.

3.1 A LONG-TERM VISION

A long-term vision is essential to guide decisions, identify policy priorities, and generate political support. It should include social and economic development while safeguarding natural resources and services. This vision could encompass the following elements:

- a timeframe for the strategy
- a long-term quantified outcome for reductions in greenhouse gas emissions

⁵ In the United States, the previous Administration submitted a Mid-Century Strategy in 2016 that included modeling scenarios with technology and implications for policy through mid-century, and communicated this product to the UNFCCC. This submission does not reflect current United States policy.

- goals for sustained and inclusive development, a just transition for workers, creation of decent work and quality jobs, and poverty reduction
- goals for human and environmental well-being
- a long-term outcome for climate adaptation and resiliency
- consideration of the interactions between development and mitigation and adaptation responses
- a trajectory toward the long-term vision

The long-term visions communicated in the long-term strategies of G20 countries are diverse. Common themes appear, however, including transitioning to low-greenhouse gas emissions societies, strengthening climate resilience, creating rewarding and well-paying jobs, and maintaining thriving economies (Ross and Fransen 2017).

3.2 DEVELOPMENT CONSIDERATIONS

Long-term strategies can identify and integrate national development considerations, including environmental, social, and economic objectives, supporting the country's long-term vision.

Integrating development objectives into long-term strategies can provide a foundation to ensure that the strategy delivers on a range of goals and provides for a just transition. Quantifying the development gains associated with low-greenhouse gas emissions and climate-resilient development can be a useful way to rally political support across sectors and levels of government and ensure integration of the strategy across sectors. Modeling exercises can reveal the different greenhouse gas emissions pathways toward achieving long-term development objectives and potential trade-offs that may need to be managed to accommodate the transition. Development gains can be quantified in terms of health, decent jobs, economic growth, poverty reduction, access to clean energy, and/or reduced inequality.

G20 countries that have communicated official long-term strategies assert that economic growth and climate action are mutually beneficial objectives and indicate their strategies' potential to catalyze sustainable economic transformation. The narratives that frame the strategies refer to job creation, new investments, planning, and sustainable development (Ross and Fransen 2017).

3.3 MITIGATION ELEMENTS

Achieving global mitigation goals will require ambitious national contributions. Mitigation will be a central component of G20 long-term strategies.

One common element of long-term strategies communicated as of June 2018 is a quantitative, long-term emissions reduction outcome or target to guide the design of the strategy and transformation

at the sectoral level and various levels of government. The long-term strategy exercise provides an opportunity to explore ambitious emission outcomes and to backcast from these outcomes to identify milestones and barriers (Williams and Waisman 2017).⁶

The Paris Agreement states that long-term strategies should be mindful of Article 2, which includes the long-term goal of limiting warming to well below 2°C above preindustrial levels and pursuing efforts to limit the temperature increase to 1.5°C above preindustrial levels. Article 2 has a complementary global long-term goal of achieving “a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty.” This concept is akin to net zero greenhouse gas emissions: Anthropogenic greenhouse gas emissions are reduced as much as possible; enhanced removals make up the remainder to achieve net zero emissions.

One critical question is how to translate this global goal to the national level. To align their long-term targets with the Paris Agreement’s temperature goals, countries should keep in mind the following issues:

- *When their emissions will peak:* The scenarios in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) with a likely chance of limiting warming to 2°C in a cost-effective manner feature a peak in world emissions by 2020. The sooner emissions peak, the lower the required rate of reducing emissions each year. Meeting the target will be less expensive and the transition smoother than it will be if emissions rise more and for a longer time.
- *When they will phase out net greenhouse gas emissions:* According to the *Emissions Gap Report* prepared by the United Nations Environment Programme (UNEP), to have a likely chance of keeping warming to below 2°C, global net carbon dioxide emissions drop to zero between 2060 and 2075 on average (with net greenhouse gas emissions declining to zero between 2080 and 2090). To have a likely chance of limiting warming to below 1.5°C, global net carbon dioxide emissions drop to zero between 2045 and 2050 (with net greenhouse gas emissions declining to zero between 2060 and 2080) (UNEP 2016, table ES.1). There is no expectation that all countries reach net zero emissions at the same time, but these scientific guideposts indicate the scale of transformation required.
- *How to ensure a realistic rate of reducing emissions, so that the annual rate of emissions decline and any increase in carbon removal is feasible:* The feasibility of emission reductions can depend upon the mitigation potential in key sectors, the co-benefits to be achieved through mitigation, any tradeoffs with other development and policy goals, the low-carbon energy potential, the financing capacity, technological advances, cost, and other national circumstances.

Article 2 of the Paris Agreement references a balance between anthropogenic emissions and removals. Some countries, including Bhutan, Mali, and Sweden, have set net zero emissions targets. Others, such as Canada and Mexico, have identified emissions reduction goals for midcentury (e.g., 80 percent reduction from 2005 emissions levels by 2050). Another option is setting both a net zero emissions target and another target (e.g., when 80 or 90 percent of reductions should occur), which can help guide the emissions trajectory. Targets that cover all greenhouse gases and sectors will better capture the entirety of a country’s emissions and mitigation objectives than those that cover only some greenhouse gases or sectors.

⁶ Backcasting starts with a vision of the future and then explores scenarios to achieve it. Forecasting looks at past trends and extrapolates them into the future.

If a long-term target is set, it can be helpful to set short-term emissions reduction milestones, to assess the country's projected cumulative emissions and guide an emissions reduction trajectory (i.e., consider the pathway to the long-term outcome rather than only the endpoint). These milestones can also inform future NDCs. Temperature increase is directly related to the total amount of emissions in the atmosphere rather than emissions in a given year. It is therefore important to consider the implications of the trajectory of a country's cumulative emissions.

All G20 countries that have submitted their long-term strategies to the UNFCCC include economy-wide quantitative visions for emissions reductions in 2050:

- Canada examines an emissions abatement pathway consistent with net greenhouse gas emissions falling by 80 percent in 2050 relative to 2005 levels.
- France's strategy includes a target to reduce greenhouse gas emissions by 75 percent by 2050 relative to 1990 levels.
- Germany sets a general objective to reduce greenhouse gas emissions by 80–95 percent by 2050 relative to 1990 levels (the strategy is also guided by the principle of “extensive greenhouse gas neutrality in Germany by the middle of the century”).
- Mexico aims to reduce greenhouse gas emissions by 50 percent by 2050 relative to 2000 levels.
- The United Kingdom's Climate Change Act commits the country to reducing greenhouse gas emissions by at least 80 percent by 2050 relative to 1990 levels, through a process of legally binding five-year caps on emissions.
- The United States' long-term strategy envisions economy-wide net greenhouse gas emissions reductions of 80 percent or more below 2005 levels by 2050.⁷

These countries also provide detailed descriptions of how they considered the long-term temperature goals of the Paris Agreement, citing various studies to demonstrate how their vision for emission reductions contributes to the global goals (Ross and Fransen 2017).

⁷ In the United States, the previous Administration submitted a Mid-Century Strategy in 2016 that included modeling scenarios with technology and implications for policy through mid-century, and communicated this product to the UNFCCC. This submission does not reflect current United States policy.

3.4 ADAPTATION ELEMENTS

Including adaptation elements in a long-term strategy offers an opportunity to integrate climate resiliency planning with mitigation and development priorities.

Article 4 of the Paris Agreement invites countries to communicate their long-term strategies. The assumption is that the strategies are mitigation focused, but countries may add additional elements or considerations. The Paris Agreement also encourages countries to develop their strategies mindful of Article 2, which includes goals to increase the “ability to adapt to the adverse impacts of climate change and foster climate resilience” (UNFCCC 2015).

Some countries may choose to include adaptation elements in their long-term strategy. Possible entry points to incorporating adaptation in a long-term strategy include the following:

- goals to enhance adaptive capacity, strengthen resilience, and reduce vulnerability
- assessment of the impacts of future changes in climate on long-lived infrastructure, land use planning, ecosystem services, and/or social change
- description of the risks of inaction for environmental, social, human, and economic outcomes
- identification of vulnerable groups and sectors
- links to national adaptation plans
- consideration of the synergies between mitigation and adaptation responses
- co-benefits of mitigation actions for adaptation/resilience and vice versa
- consideration of how to strengthen the resilience of mitigation actions in the long-term strategy
- explicit treatment of the uncertainty associated with future climate risks
- links to a social development agenda and efforts to reduce poverty

Countries have various options for adaptation planning, including National Adaptation Programmes of Action (NAPAs), National Adaptation Plans (NAPs), broader national climate legislation, climate-sensitive development plans, sector plans, plans for implementing the Sustainable Development Goals (SDGs), and long-term strategies. Any one of them—or a combination of more than one—can provide a good basis for adaptation planning if well-resourced, inclusive, iterative, transparent, and well positioned for implementation. National governments should also consider linkages among plans, in order to prevent duplication, build legitimacy, and foster efficient achievement of the country’s climate and development objectives (McGray 2018). It may also be helpful to coordinate with the country’s disaster risk reduction agency.

Canada, France, Germany, the United Kingdom, and the United States⁸ touch lightly on adaptation in their long-term strategies, referring to other national adaptation planning documents. All of the strategies recognize the inherent linkages between long-term adaptation and mitigation pathways.

Mexico's strategy provides a more comprehensive treatment of adaptation. Its strategy is rooted in the vision of building a climate-resilient society while transitioning toward a low-emissions economy. The adaptation section of the strategy is drawn from the National Climate Change Strategy: 10-20-40 Vision, released in 2013. It contains a vulnerability assessment, which led to the identification of three strategic focus areas, with associated lines of action: reducing vulnerability and building social resilience, ecosystem-based adaptation, and protecting strategic infrastructure and production systems. Mexico presents six cross-cutting elements that set the foundation of climate policy for both adaptation and mitigation: interinstitutional collaboration; market-based instruments; innovation, R&D, and technology adoption; building a climate culture; social participation; measurement, reporting, and verification and monitoring and evaluation; and international leadership (Ross and Fransen 2017).

3.5 SECTORAL PATHWAYS

Sectoral strategies can play an important role in the design and implementation of a long-term strategy, by informing how the overall objectives of the strategy can be realized. The long-term strategy can also lead to the formulation of sectoral strategies.

3.5.1 The Role of Sectoral Policies and Planning in Long-Term Strategies

Many decisions are made at the sectoral level. Sectoral policies and plans help dictate investments and technology choices. They also guide behavioral changes at the local, corporate, and individual levels. A comprehensive long-term strategy will inform all stages of the sectoral policy cycle: policy formulation, planning, resource allocation, and programming (OECD 2009). It is important to prioritize the sectors that contribute most to the national greenhouse gas inventory and/or are expected to contribute most in the future.

Articulating a sector-specific component or strategy within a long-term strategy can help ensure that policies and investments are designed in a way that is consistent with future pathways and do not lead to stranded assets and costly choices that may be difficult or impossible to reverse. Long-term strategies can help guide investments at the sectoral level and help define sectoral targets and actions. An integrated analysis of sectoral plans can ensure consistency with the long-term strategy.

Box 1 describes considerations for the land sector in long-term strategies. Section 3.6 explores the role of energy planning in long-term strategies.

⁸ In the United States, the previous Administration submitted a Mid-Century Strategy in 2016 that included modeling scenarios with technology and implications for policy through mid-century, and communicated this product to the UNFCCC. This submission does not reflect current United States policy.

Box 1. Long-term planning for transitions in the land sector

Emissions from the land sector account for nearly a quarter of all human-caused emissions (Searchinger, 2013), 55 percent of which occur in G20 countries (Climate Watch 2018). By 2050 the land sector could consume 70 percent of the total allowable “budget” of greenhouse gas emissions consistent with the Paris Agreement goal (Searchinger 2013).

At the same time, forests act as critical carbon sinks, soaking up one-third of fossil fuel emissions every year, with the potential to absorb even more (Pan 2011). Transforming agriculture, forestry, and other land uses (collectively, the “land sector”) will be critical to meeting global climate goals.

The land sector can be both decarbonized (to reduce emissions) and recarbonized (to pull carbon out of the atmosphere and back into forests and landscapes). Emissions reductions can occur by implementing demand-side mitigation options (such as reducing food loss and waste) and/or supply-side options (such as protecting and restoring forests and other ecosystems) (Searchinger 2013). These options may interact with one another and support both mitigation and adaptation. Demand-side options include slowing growth in food demand, reducing food loss and waste, shifting to healthier and less resource-intensive diets (particularly in medium- and high-income countries), avoiding bioenergy competition for food crops and land, and reducing demand for wood products. Supply-side options include protecting and restoring forests and other natural ecosystems, boosting crop yields (on existing cropland), boosting meat and milk yields (on existing pastureland), reducing emissions from agricultural production, and increasing sequestration on agricultural lands.

Policies and practices that will be particularly important in implementing land sector solutions including the following (Searchinger et al. forthcoming):

- *Linking yield gains with forest protection (“produce and protect”):* Increases in crop and livestock yields are necessary to avoid expansion of agricultural land, but yield gains alone will not prevent expansion. Measures to help link yield gains and land protection include, but are not limited to, developing and updating land use plans to prioritize investment, mitigating agricultural emissions, limiting agricultural land expansion, directing national and international financing efforts to support these plans, and strengthening and enforcing laws governing the clearing of forests and other native landscapes.
- *Supporting the creation and implementation of REDD+ policies in developing countries:* REDD+ (reducing emissions from deforestation and forest degradation and fostering conservation, sustainable management of forests, and enhancement of forest carbon stocks) provides a framework that creates incentives for forest protection, sustainable forest management, and forest restoration while supporting financial flows to rural areas; encouraging land tenure reform; and improving social inclusion, human health, and well-being.
- *Using incentives or regulation to advance technologies that mitigate emissions from agricultural production and encourage increased CO₂ removals by forests:* Most options to mitigate agricultural production emissions involve additional costs (at least initially), but they appear to be cost-effective relative to other climate change mitigation strategies and may eventually pay for themselves. Their development and deployment will require strong incentives and/or regulations.
- *Changing behavior through demand-side strategies:* Demand-side strategies involve significant behavior changes by many actors across food supply chains. In high-income countries, where levels of meat consumption and consumer food waste are high, influencing decisions by consumers and food providers is important. Changes in policy—including policies governing food procurement, dietary guidelines, food labeling, food marketing, and taxation and subsidies—can support shifts toward healthier and more sustainable dietary patterns.

3.5.2 Elements of Sectoral Strategies in Long-Term Strategies

A sectoral strategy could include the following:

- *A desired outcome:* A country could commit to a certain outcome or result, such as reducing sectoral emissions to a specific level (a greenhouse gas outcome) or generating a certain percentage of renewable energy or increasing energy efficiency to a certain level (non-greenhouse gas outcomes with mitigation benefits).
- *Specific policies, means, or actions:* A country could commit to implementing specific sectoral actions that are aligned with long-term strategies, such as adopting a feed-in tariff.
- *Milestones to be achieved:* A SMART (specific, measurable, achievable, realistic, and time-bound) indicator design for milestones can help hold decision-makers accountable for meeting the long-term goals, enhance the credibility of the process, scale up political buy-in, enhance vertical integration and collaboration from policymakers to data collectors, and draw attention to innovative local climate action, among other benefits.
- *Elaboration of how the transition will be managed:* Sectoral planning for just transitions may include stakeholder processes that solicit inputs from affected communities; references to the distributional effects, including effects on employment and income and the means to mitigate such effects; the definition of a successful transition, given the inevitability of both winners and losers in any major economic transition; and policies and measures.
- *Opportunities for innovation and R&D:* Innovation and R&D can help guide investments in both the public and private sectors.
- *Capacities, resources, and investment strategies:* Countries may identify the capacities and resources required to implement the sectoral strategy.
- *Consideration of other sectors:* A consideration of other sectors might include a description or analysis of cross-sectoral linkages, tradeoffs, and prioritization.

3.5.3 Overview of Sectoral Strategies in Existing Long-Term Strategies

Countries include certain sectors in their long-term strategies for a variety of reasons, including their contribution to greenhouse gas emissions, their potential for emissions reductions, whether sectoral targets were already in place, and/or their relevance to the economy or development objectives.

In its long-term strategy, Germany describes the ways in which preexisting sectoral policies—such as the Energiewende, which lays out Germany’s energy transition—affected the strategy’s development. The strategy draws on targets in the construction sector from the Energy Concept as well as the Climate Action Program 2020 (Government of Germany 2016).

Mexico included the agriculture and livestock sectors, which are key for food security but contribute significantly to greenhouse gas emissions (Government of Mexico 2016).

Table 1 identifies the sectors that existing strategies cover. All of countries in table 1 cover human settlements, buildings, and infrastructure; agriculture and rural development; forests; and energy production/electricity. Most of them also cover transport/mobility, industry and business, and waste.

Table 1: Sectors included in countries' long-term strategies

Country	Transport and Mobility	Human Settlements, Buildings, Infrastructure	Agriculture and Rural Development	Forests	Industry and business	Energy production, electricity	Waste	Health	Water	Wetlands
Benin		x	x	x		x		x	x	
Canada	x	x	x	x	x	x	x			
France	x	x	x	x	x	x	x			
Germany	x	x	x	x	x	x				
Mexico	x	x	x	x	x	x	x			
United Kingdom	x	x	x	x	x	x	x			x
United States ^a	x	x	x	x	x	x				x

Note: a. In the United States, the previous Administration submitted a Mid-Century Strategy in 2016 that included modeling scenarios with technology and implications for policy through mid-century, and communicated this product to the UNFCCC. This submission does not reflect current United States policy.

3.6 THE ROLE OF THE ENERGY SECTOR IN LONG-TERM STRATEGIES

The energy sector plays a unique and central role in the success of long-term strategies. Energy production and use account for the bulk of current greenhouse gas emissions and potential reductions. The sector is also the potential source of deep greenhouse gas reductions for other energy uses via decarbonized electrification strategies. Energy planning that accounts for the long lifetimes of energy assets increases the likelihood of avoiding technology “lock-in” and stranding assets.

Current NDC pledges for energy and other sectors are not ambitious enough to achieve the 1.5°–2°C targets set in the Paris Agreement. Achieving these targets will require significant investments and new policy mechanisms in energy efficiency and conservation; decarbonization of electric power combined with electrification; optimized use of fossil fuels; and carbon capture and storage (CCS).

Energy production and use account for about two-thirds of global greenhouse gas emissions. The G20 countries account for more than 80 percent of global energy-related CO₂ emissions (IEA and IRENA 2017). The sector thus plays an outsized role in efforts by G20 countries and the wider international community to develop and implement long-term strategies.

Because investment cycles for energy infrastructure are long, decisions made today have long-term implications for both climate and development goals. Energy planning that accounts for the extended lifetimes of energy assets increases the likelihood of meeting climate goals and avoiding technology “lock-in,” which can result in substantial stranded assets and act as a drag on economic

growth.⁹ UNEP's estimate of viable energy pathways for limiting warming to 2°C would involve stranding about 1,500 GW of coal and natural gas power plants globally after 2030 (UNEP 2017). Failing to significantly reduce emissions from energy production and use increases the need for future investments, by some estimates, potentially doubling the amount of stranded assets (DDPP 2015).

3.6.1 Energy Sector Dynamics and the 1.5°–2°C Goal

The energy sector is key to reaching the 1.5°–2°C target. Assuming a 66 percent chance of meeting the 2°C target, the International Energy Agency (IEA) and International Renewable Energy Agency (IRENA) estimate that the energy sector accounts for 90 percent of the carbon budget for 2015–2100 (about 790 Gt CO₂ out of a total carbon budget of 880 Gt CO₂) (IEA and IRENA 2017). Continuing business as usual with the existing energy system and levels of carbon intensity would likely lead to warming of more than 4°C by the end of the century (ETC 2017).

Rapid action to increase the ambition of efforts is therefore critical. Aggressive improvements in energy efficiency are needed, specifically, an increase in the historical rate of improvement in energy efficiency from 1.7 percent up to 2.5–3 percent a year (ETC 2017).¹⁰ Energy-related CO₂ emissions need to peak before 2020 (IPCC, 2014) and fall by more than 70 percent by 2050. At the same time, some combination of low- and zero-carbon energy technologies needs to more than triple from current levels to meet roughly 70 percent of energy demand by 2050 (IEA and IRENA 2017). Renewable energy, energy efficiency, nuclear energy, and CCS could all feature prominently in the 2050 energy portfolio, in ways that reflect individual country goals and preferences.

Virtually all analyses of long-term strategies consistent with a 2°C limit show that fossil fuels will likely play a small role in a world optimized for low greenhouse gas emissions by 2050. Most scenario-based studies show that early retirement of a large portion of existing coal-fired capacity and avoidance of construction of new coal-fired assets are essential for meeting climate goals. Similarly, upstream (i.e., for extraction or production) fossil fuel resources cannot be exploited to their full extent.¹¹

At the country level, clean energy strategies should reflect nationally appropriate low-greenhouse gas technologies that reflect each country's technical potential, policies, level of development, and technology priorities. Long-term energy plans should address specific and pressing development needs in tandem with climate goals, which go hand in hand with sustainable development. The wide differences in economic prosperity across the globe arise in part from wide country-level and regional disparities in energy use and accessibility. In India, South Africa, and other developing countries, energy investments will need to explicitly support economic growth and reduce energy poverty; in developed G20 economies, the transition will focus more on replacing aging energy capital.

⁹ In this context, stranded assets refer to energy capital that needs to be retired prematurely or is underutilized because of climate policies (e.g., a carbon tax) or competition with lower-cost clean technologies and fossil fuels that cannot be burned if a greenhouse gas target is to be reached (UNEP 2017).

¹⁰ Energy intensity refers to the amount of energy required to produce a given unit of output (e.g., units of energy per U.S. dollar of GDP). A reduction in energy intensity generally means that an economy is using energy more efficiently to produce goods and services.

¹¹ UNEP (2017) estimates that 80–90 percent of the world's coal reserves need to remain unburned in order to meet climate targets (the figures are 35 percent for oil reserves and 50 percent for natural gas reserves).

3.6.2 Solutions and Milestones for the Energy Sector

Numerous modeling and analytic efforts have explored a range of long-term pathways for the energy sector consistent with the 1.5°–2°C target, based on various assumptions about economic and population growth, the costs and deployment of technology, consumer and business behavior, and other factors. They yield a fairly consistent set of core, often related solutions critical to a successful energy system transition. These solutions need to be pursued simultaneously and immediately.

Increasing energy efficiency and conservation

By deploying currently available efficient energy technologies and techniques, some economies could be two to four times more energy efficient in 2050 than in 2010, according to DDPP (2015), with a decline in energy intensity of 65 percent.¹² Efficiency strategies can reduce costs and increase energy security for consumers and businesses. They can foster economic development by freeing up resources for more productive investment, particularly in countries that rely heavily on imported fossil fuels.

Decarbonizing electric power and electrifying other energy demand

Decarbonizing the electric power sector is essential for reducing emissions by the power sector. Efforts will require increased use of clean sources of energy (renewables, hydropower, biomass, and baseload power from nuclear and CCS) as well as reduced demand for energy use through higher energy efficiency in buildings, appliances, and industry.

Shifting other energy demand onto a decarbonized electric grid amplifies opportunities for a rapid scale-up of the pace and magnitude of greenhouse gas emission reductions. For example, petroleum use in the light-duty vehicle sector is a major source of energy demand that is potentially ready to be electrified immediately. Barriers to the deployment of electric vehicles include battery costs, the need for charging infrastructure, and the relatively slow turnover of the stock of light-duty vehicles. Policies need to incentivize a faster transition in this sector.

Decarbonizing needs to extend beyond the power and automobile sectors, to aviation, shipping, industry, and heavy-duty road vehicles. Technologies such as hydrogen fuel cell vehicles and alternative low-carbon fuels may be critical in doing so.

Optimizing the use of fossil fuels within the remaining carbon budget

Total use of fossil fuels need to be roughly one-third of current levels by 2050. The role of coal will likely decline the most. Although the 2050 carbon budget allows room for natural gas, some expert analyses project natural gas use declining or at most staying level (or close to it) beyond 2020. Concerns about gas use include the high level of uncertainty about the greenhouse gas benefits of fuel switching given current levels of fugitive methane emissions from gas distribution systems and the prospect of path dependency if investments in long-lived gas plants and infrastructure occur.

Oil use will likely decline as it is replaced by electricity in certain applications (e.g., light-duty transport) and less carbon-intensive substitutes in others. Fossil fuel-based generation with CCS will likely play some role in power and industry. CCS is important for reaching possible long-term pathways with

¹² DDPP's analysis focused on 15 G20 countries (Australia, Brazil, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, South Africa, South Korea, the United Kingdom, and the United States), representing 74 percent of global CO₂ emissions from energy.

deep decarbonization. Technology for CCS is available and ready for deployment; the challenges are to reach large-scale deployment and increase market penetration.¹³

Scaling up energy access

Globally, 1.1 billion people still lack access to electricity, and another 2.8 billion are without access to clean cooking facilities (IEA 2017). Within the G20, energy demand per capita varies by a factor of 12; access to affordable, reliable energy remains a major challenge in India, Indonesia, and South Africa (IEA and IRENA 2017).

Long-term planning for many G20 and other countries needs to address increased access to clean, affordable energy. Expanding conventional metrics for evaluating energy costs and benefits to account for socioeconomic impacts (e.g., changes in air quality and public health) will provide a fuller accounting of repercussions of energy choices on all members of society. Electricity and liquified petroleum gas can increase access to clean cooking in urban areas. Advanced biomass cookstoves may be a better solution in rural areas.

3.6.3 Policies and Practices

In conjunction with a diverse portfolio of clean energy practices and technologies, a smooth energy transition will require significant policy changes. A price on carbon emissions that is sustained and gradually increasing over time can help achieve the long-term goal in a cost-effective manner. A price signal on carbon—accompanied by other complementary policies to ensure the availability of substitutes and consideration of demand elasticity—bolsters the market viability of all zero- and low-greenhouse gas options. A carbon price provides higher profitability and returns to investors in clean energy infrastructure and technologies, which often have high up-front capital costs but lower operating costs and greenhouse gas impacts.

Carbon pricing is an important policy option, but it will not be sufficient to induce the necessary level of investments, new technologies, and changes in practices. Complementary policies need to address specific gaps. Design changes and reforms of energy markets are needed to induce high levels of variable renewable energy into power systems while maintaining system flexibility and reliability.

Also needed is the elimination of subsidies for fossil fuel exploration, development, and use, which encourage wasteful consumption and reinforce inequalities by favoring high-income groups. The G20 has committed to phase out fossil fuel subsidies over the medium term (see the 2009 and subsequent declarations). Innovative policy and financing instruments for energy efficiency are needed to significantly scale up investments in energy efficiency.

Performance standards and related regulations, such as appliance and vehicle fuel efficiency standards, can spur innovations in efficiency technologies, which also have positive spillover effects. Sustainable transportation systems and urban planning and designs should enable economic growth while reducing growth in energy demand. Integrated energy system planning should be coordinated across sectors, especially as additional load is added to the power grid via electrification (ETC 2017).

¹³ CCS features prominently in many modeling scenarios given their reliance upon bioenergy combined with CCS.

3.6.4 Managing for a Just Transition and Consequences

Strategies and policies designed for a transition to a clean energy future will be durable and politically viable only if they also deliver affordable and reliable energy service to all members of society (including the poorest, women, indigenous groups, and people most vulnerable to climate impacts) and enable economic growth across income groups and social strata.

Workers and businesses in upstream fossil fuel industries stand to experience losses in employment, revenues, and long-term viability in a carbon-constrained future unless complementary plans and policies are put in place to guide a fair transition. New business models for scaling access to members of society often excluded by new energy development (such as pay-as-you-go finance and microfinance) are delivering affordable electricity access to millions of people through off-grid solar home systems and community level mini-grids. In East Africa, for example, the number of households using pay-as-you-go solar systems reached almost 500,000 households in 2015 and 800,000 in 2016. (GSMA 2017; REN21 2017).

Current accounting practices, which focus only on the financial outcomes of energy investments, pose a barrier to the equitable distribution of energy services. Accounting that includes the socioeconomic and environmental impacts of energy development provides a much fuller picture of the impacts on populations and constituencies.

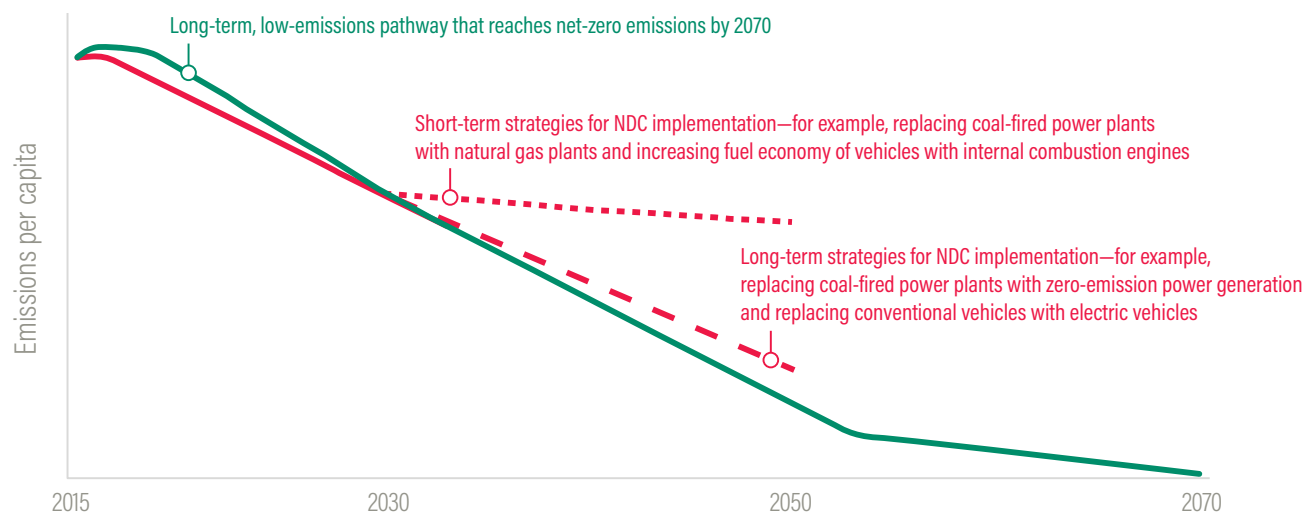
3.6.5 Opportunities for Innovation and the Need for Research, Development, and Demonstration (RD&D)

Innovation is needed to develop new technologies to complement existing clean energy options. A strong carbon price signal would help incentivize private investment in low-greenhouse gas technology, but a significant gap remains in government support of research, development, and demonstration (RD&D) of early-stage clean technologies. Innovative approaches to shifting consumer and business choices toward best practices can increase energy productivity beyond what can be achieved through technology alone.

3.7 IMPLEMENTATION APPROACHES

Although long-term strategies are not typically formulated as implementation plans, they can guide near- and medium-term implementation processes. The extent to which a short- or medium-term goal aligns with long-term decarbonization goals will depend on the types of policies, plans, and investments taken to achieve it (Sachs et al. 2016) (figure 1). The level of emissions reductions achieved will not be sufficient for assessing progress toward long-term transitions. In each sector, how emissions reductions are obtained will play a critical role in aligning short-term efforts with longer-term decarbonization and development objectives (Fay et al. 2015; Vogt-Schilb and Hallegatte 2017). It is important not to overlook small changes in policy settings and calibrations that build up over time to result in meaningful, durable change (Levin et al. 2012).

Figure 1: The role of 2050 planning in informing pathways for near- and medium-term goals



Note: All strategies achieve the same 2030 emissions, but only the long-term strategies set the course for long-term emissions neutrality in the second half of the century.

Source: Adapted from Sachs et al. 2016.

Countries may consider addressing the following issues in developing an implementation strategy:

- how the long-term vision will guide short- and medium-term sectoral and cross-sectoral decision-making, including decisions related to near- and medium-term goals or milestones (e.g., NDCs, SDGs, sectoral plans and policies)
- coherence with existing policies and planning efforts, infrastructure plans, and investment plans and how the long-term strategy will be integrated into medium- or long-term economic or development plans for countries that produce them
- priority measures for implementing the strategy, such as investing in long-lasting infrastructure now to avoid longer-term emissions (e.g., reinforcing the grid to allow variable renewable energy integration in the future) instead of focusing on low-cost but nondurable solutions (Hallegatte et al. 2017)
- institutional arrangements and legal frameworks for implementation of the strategy
- stakeholder consultation plans during implementation
- efforts to manage the transition in a just manner
- capacities and resources required for implementation
- the role of nonstate and subnational actors in implementation

Alternatively, countries may wish to specify when and how an implementation plan will be developed, including the envisioned legislative steps.

Several G20 countries have experience using long-term plans or visions to inform near- and medium-term decisions. At the 19th National Congress of the Communist Party, China announced a two-stage plan to become a “great modern socialist country” by 2050, in two development periods (2020–35 and 2035–50). This long-term vision will inform short-term policy decisions, by, for example, renewing efforts to reduce poverty by 2020 (Chan 2017).

The European Union’s 2050 low-carbon economy roadmap, published in 2011, exemplifies another mechanism for establishing near- and medium-term stepping-stones that build toward a long-term vision. The ultimate goal is to reduce emissions by 80 percent between 1990 and 2050. The roadmap sets out cost-effective plans for 40 percent cuts by 2030 and 60 percent cuts by 2040 (The European Commission 2011).

India translated a longer-term (15-year) vision into a 7-year strategy document and associated sectoral plans (Hindu Business Line 2016).

The six G20 countries that have submitted their long-term strategies to the UNFCCC take a variety of approaches to reflecting near- and medium-term decision-making in their strategies (Ross and Fransen 2017):

- Canada notes that midcentury objectives will be realized through concrete, short-term action linked to the Pan-Canadian Framework on Clean Growth and Climate Change (a 2030 plan).
- France establishes successive four-year periods, with indicative emission reduction targets by sector.
- Germany sets 2030 sectoral targets and milestones and actions and notes that programs and measures will be laid out by 2018 to achieve these targets (see Hoven 2018).
- Mexico defines milestones for the next 10, 20, and 40 years for society and population, ecosystems, energy, emissions, productive systems, private sector, and mobility.
- The United Kingdom sets out plans to meet its carbon budgets out to 2032, with a view to meeting the long-term 2050 target set in the Climate Change Act.
- The United States outlined a scenario approach that explores how low greenhouse gas pathways consistent with the long-term vision depend upon strategic investments.^a

Most of these long-term strategies also explicitly discuss lock-in risks in the context of long-lived infrastructure (e.g., power generation facilities, distributional infrastructure such as pipelines, buildings).

Note: a. In the United States, the previous Administration submitted a Mid-Century Strategy in 2016 that included modeling scenarios with technology and implications for policy through mid-century, and communicated this product to the UNFCCC. This submission does not reflect current United States policy.

3.8 MONITORING PLANS AND REVISION PROCESSES

Including monitoring plans and revision processes in the long-term strategy can establish how such processes will be carried out during implementation. During strategy development, it is useful to develop a plan for monitoring progress. Institutional responsibilities and processes should be defined that specify the “what,” “when,” “who,” and “how” of monitoring. Sectoral indicators can be established to assess whether efforts are having the desired effects at the sectoral level and key indicators are moving in the right direction.

Progress should be evaluated regularly, using a consistent approach. A monitoring plan could detail the following information:

- institutional roles, including the institutions responsible for collecting and compiling data
- data or indicators to be tracked over time, as well as sources of data
- duration and frequency of monitoring
- measurement or data collection methods (e.g., surveys, censuses)

Review and revision based on the results from the monitoring is important to ensure that the strategy keeps pace with innovation, shifting priorities and capacity, and R&D. Modeling assumptions can change in the space of a few years (e.g., based on new information and costs of new technologies). Data availability may increase and modeling techniques improve, which could uncover untapped areas of mitigation potential. The review and revision process can also provide additional opportunities to engage stakeholders and accelerate support for climate action.

The long-term strategy could lay out the framework for review and revision processes, including (UNDP 2009):

- the objectives or principles guiding the review, with a description of which elements get reviewed
- the ministries or agencies responsible for the review process
- the frequency of review
- the methods for review
- the resources required for the review and revision process and where they are committed
- alignment of the review process with other domestic or international processes

G20 countries that have communicated long-term strategies plan to review their strategies at regular intervals of 5–10 years. Germany plans to revise its strategy in line with the five-year cycle of review under the provisions of the Paris Agreement, better aligning near-term policy, planning, and targets with the long-term goals (Ross and Fransen 2017).

3.9 CONSIDERATIONS AND TRADE-OFFS IN DEFINING SCOPE AND ELEMENTS

Countries need to contend with several trade-offs when defining the scope and elements of their long-term strategies:

- *Trade-offs between what is comprehensive and what is manageable.* It is reasonable to assume that the depth and scope of a country’s long-term strategy will be in line with national priorities

as well as the level of preparation, capability, and resources. Consideration of each element (see sections 3.1–3.7) can help ensure strategic use of resources at the outset (Ross and Fransen 2017).

- *Tradeoffs between which elements are best addressed in the context of a long-term strategy and which are best addressed through other vehicles.* For example, including adaptation elements could help policymakers assess the impacts on resilience of long-term low-greenhouse gas emission development. But countries may instead focus their limited resources on developing separate adaptation plans for 2050 and beyond rather than integrating adaptation fully into their long-term strategies. Consideration of the long-term vision, along with the intended use of the strategy, can help define the scope at the outset.
- *Tradeoffs between the urgency of developing the strategy and the need to involve and mobilize a broad range of stakeholders.* Under the Paris Agreement, countries are invited to communicate their long-term strategies by 2020. Some countries have already done so, and a few others plan to do so in 2018, which may limit the time available to conduct widespread stakeholder engagement. Piggybacking on other ongoing and relevant domestic policy processes can be an effective way to garner support in a limited time, as the Canadian government did in developing its climate change plan.

4. Inputs to a Long-Term Strategy

Various inputs are required to develop a long-term strategy. They may include data, modeling and scenarios, and complementary qualitative approaches.

4.1 DATA INPUTS

Depending on the extent of long-term planning that has taken place in a country, existing information may be sufficient or new data may need to be collected. Data collection can help inform long-term goal setting, as well as the identification and prioritization of short- and medium-term policies. Some of the types of information that can assist in developing NDCs may also be useful for developing a long-term strategy (Levin et al. 2015).

Data inputs include (but are not limited to) the following:

- a statement of long-term goals or vision, which can either be the starting point of the development of a long-term strategy or the outcome of the exercise
- national objectives and priorities
- any relevant internationally commitments
- current and future greenhouse gas emissions profiles of the country
- current mitigation and adaptation activities
- projected future emissions under a business-as-usual (and/or other) scenario
- assessment of mitigation potential
- relationship to global 1.5°–2°C goals
- plans for securing resources
- climate change trends, impacts, and vulnerabilities
- socioeconomic trends

- assessments of development gaps
- summary of technical, financial, and capacity-building support
- statement of gaps, barriers, and needs
- monitoring plans
- results of modeling exercises
- cost-benefit analyses
- expert assessment

To inform the design of their long-term strategies, countries have engaged with sectoral experts, gathered data from relevant ministries, considered affected communities, and integrated other international processes.

In crafting its agriculture sectoral strategy, for example, Benin drew on relevant targets from international development processes, including the Millennium Development Goals (MDGs) and the SDGs as well as domestic plans in the sector (Government of Benin 2016).

Canada considered indigenous communities' reliance on diesel infrastructure and highlighted a number of renewable energy initiatives and power projects developed in partnership with the communities (Government of Canada 2016).

Data from the transport interdependence forecast for 2030 of the Federal Ministry of Transport and Digital Infrastructure's informed the milestones for Germany's transport sector. Projections of the increase in vehicle kilometers and passenger kilometers contextualized sector-specific milestones (Government of Germany 2016).

4.2 MODELING AND SCENARIOS

Modeling and scenarios, ideally based on sectoral details and socioeconomic indicators, inform decision-makers about the implications of various objectives and provide anchor points for discussions with stakeholders.

Modelling can help stakeholders evaluate options in a range of possible futures. For example, alternative scenarios might contrast a future with a large share of renewables and a future with a large share of natural gas, a future in which cost-effective carbon capture and storage are available and a future in which they are not, or a future in which a country strives to achieve an ambitious medium-term greenhouse gas reduction target with a future in which it sticks to business as usual. Modeling these scenarios shows how key indicators, such as GDP, employment, and emissions, evolve given varying assumptions. Sensitivity analysis can determine the extent to which particular assumptions affect such variables. Once a long-term vision has been developed, modeling can help decision-makers assess the means of achieving that future.¹⁴

¹⁴ The *2050 Pathways Platform Handbook* (Williams and Waisman 2017) presents a methodology for integrating the quantification approach and the elaboration of the pathways with a view to ensure their clarity, practicality, relevance, and credibility, including interactions with stakeholders throughout the quantification of the scenarios.

Modeling is subject to limitations, however. Experts caution against relying exclusively on models in developing strategy or interpreting results as predictions of the future. Modeling scenarios can also suffer from:

- limited input data and information
- reliance on assumptions that may rapidly become outdated (Awafo 2018)—a particularly serious problem for long-term planning and cost assumptions
- outdated models
- modeler bias (Awafo 2018)
- false precision (Zenghelis 2018)
- inability to address unpredictable events (Zenghelis 2018)

It is also important to consider the types of constraints that might be placed on models (e.g., limits on certain types of energy or land-use changes or assumptions about the speed of adoption of different technologies).

With these caveats in mind, the following considerations may guide modeling and scenario development in the context of long-term strategies:

- Promoting robust stakeholder engagement (Hultman and Edmonds 2018) during the design process for validation of scenarios and assumptions, among other aspects, as well as in communication of outputs (Williams and Waisman 2017; Waisman 2018).
- Designing scenarios that are fit for purpose (i.e., ensuring that they address the main areas of transformation) (Waisman 2018). Some planning initiatives have found it helpful to take a backcasting approach from established benchmarks (Awafo 2018) (Waisman 2018) and to develop multiple scenarios to support the development of robust strategies under high uncertainty (Hultman and Edmonds 2018).
- Identifying a robust model or set of models appropriate for the task at hand, including considerations of scientific robustness and the ability to represent a national scale in the global context (Hultman and Edmonds 2018). In some cases, it may be appropriate to use multiple models in order to address a range of questions (Awafo 2018) (Hultman and Edmonds 2018).
- Analyzing a wide range of scenarios or pathways, in order to identify cost-effective options and support policy neutrality.
- Embracing a process in which results and assumptions are questioned and refined with stakeholders.

The 2014 Greenhouse Gas Protocol Mitigation Goal Standard notes that the choice of model typically reflects a tradeoff among several factors, including available resources (financial resources and technical expertise); data; model performance (with considerations of the level of sophistication and suitability for jurisdiction (e.g., national/subnational/sector level); software costs; alignment with other models being used; and the expected use of the model outputs.¹⁵ For many midcentury strategies, multiple models are used to conduct economy-wide analysis that includes a full range of variables. As outlined in the Greenhouse Gas Protocol (2014), options include the following:

- *Top-down, bottom-up, and hybrid models:* Top-down models project overall economic output and emissions intensity based on projections of intersectoral relationships, considering the impact on

¹⁵ The 2014 Greenhouse Gas Protocol Mitigation Goal Standard is available at https://ghgprotocol.org/sites/default/files/standards/Mitigation_Goal_Standard.pdf.

- GDP, consumption, and investment. Bottom-up models project energy use by type and sector, based on disaggregated data on specific technologies. Bottom-up accounting models work from external assumptions regarding structural and policy developments in each sector; bottom-up optimization models reflect a least-cost allocation of technology choices. Hybrid models combine the two approaches. Top-down models include ENV-Linkages and second-generation model (SGM). Bottom-up models include the Long-Range Energy Alternatives Planning (LEAP) system, the Model for Analysis of Energy Demand (MAED), Market Allocation (MARKAL), the Model for Long-Term Energy Demand Evaluation (MEDEE), and the Prospective Outlook on Long-Term Energy Systems (POLES). Hybrid models include MARKAL-MACRO and the National Energy Modeling System (NEMS).
- *Jurisdiction-driven and generic models:* Jurisdiction-driven models—such as the U.S. NEMS model, Canada’s Energy-Economy Environment Model for Canada (E3MC) model, and the United Kingdom’s Dynamic Dispatch Model (DDM)—are developed by countries or other individual jurisdictions to reflect their unique circumstances. They are tailored to capture the complexities of the jurisdiction’s economic and energy systems. Generic models—such as the LEAP and the MARKAL model—are designed to meet the needs of multiple users. They can be customized to fit users’ specific needs. For users with limited capacity, generic models can provide a more convenient solution than jurisdiction-driven models for common sectors such as electricity generation, cement, and iron and steel. However, for uncommon or diverse sectors (e.g., transport), a jurisdiction-driven or customized generic model may be required, as generic models are not typically available for these types of sectors.

Box 2 provides information about the scenarios used for the six G20 long-term strategies that have been communicated to date.

Qualitative approaches can complement modeling, providing deeper and richer insights for long-term planning. They can also generate innovative thinking, which can be constrained by model-based scenarios. Qualitative approaches can be used to examine employment or community transition issues and the fiscal sustainability of a strategy. They can also help define the objectives, scope, and scenarios to be analyzed. Qualitative approaches also help decision-makers interpret model outcomes and consequences. Focus groups with government officials at different ministries can help establish a long-term qualitative vision. Interviews with key stakeholders can identify policy-relevant information and considerations, which traditional quantitative data and metrics may overlook.

Box 2. Scenarios used for the six G20 long-term strategies

All six G20 countries that have submitted long-term strategies deployed modeling and scenario development in crafting strategies (box table 2.1). Some countries, such as Canada, used several scenarios to explore possible futures under high technological uncertainty (e.g., the extent to which carbon capture and storage will be available and cost-effective), in order to examine trade-offs and identify trends under a range of possible futures. France and Mexico designed scenarios to examine the effect of medium-term goals and policies on their long-term pathways. Germany modeled scenarios to determine the feasibility of its greenhouse gas reduction target under existing technologies.

Box table 2.1: Scenarios included in G20 countries' long-term strategies

Country	Mitigation scenarios
Canada	<p>Canada draws on six scenarios:</p> <ul style="list-style-type: none"> • High Ambition (Deep Decarbonization Pathways Project) scenario, which achieves 89 percent greenhouse gas emission reductions below projections in 2050 (excluding agriculture) • Current Tech scenario (from the Trottier Energy Futures Project), which achieves a 60 percent reduction in energy sector greenhouse gas emissions relative to 1990 levels • New Tech scenario (from the Trottier Energy Futures Project), which also achieves a 60 percent reduction in energy sector greenhouse gas emissions relative to 1990 levels • Nonemitting Electricity scenarios: <ul style="list-style-type: none"> – High Nuclear scenario, which is heavily dependent on nuclear electricity production – High Hydro scenario, which relies on a mix of hydro and wind to produce most electricity • High Demand Response scenario, which achieves a net 80 percent greenhouse gas emission reduction by 2050 relative to 2005 levels <p>Unlike the other countries that use scenarios in their long-term strategies, Canada does not include a benchmark scenario.</p>
France	<p>France includes two scenarios in its strategy:</p> <ul style="list-style-type: none"> • Trend-Based (with Existing Measures) scenario, which is based on policies and measures implemented before January 1, 2014 • Reference (with Additional Measures) scenario, which includes all measures included in the Green Growth and Energy Transition Law
Germany	<p>Scenario results are not included in the strategy, although scenarios did inform the development of the strategy.</p>
Mexico	<p>Mexico develops three scenarios to advance the understanding of its mitigation options:</p> <ul style="list-style-type: none"> • Baseline scenario, which estimates the emissions trajectory without imposing climate or energy policy constraints • NDC Policy scenario, which achieves a 22 percent reduction in greenhouse gas emissions by 2030 (in line with Mexico's unconditional NDC target) and 50 percent by 2050, both relative to 2000 levels • NDC More Ambition scenario, which achieves a 36 percent reduction in greenhouse gas emissions by 2030 (in line with Mexico's conditional NDC target) and 50 percent by 2050, both relative to 2000 levels

Country	Mitigation scenarios
United Kingdom	<p>The United Kingdom's Clean Growth Strategy presents three illustrative pathways to 2050 to help identify "low-regret" actions that are likely to be needed for all 2050 scenarios and that highlight key risks and uncertainties:</p> <ul style="list-style-type: none"> • Electricity Pathway, in which transport and heating are fueled primarily by electricity, virtually all of which is from clean sources • Hydrogen Pathway, in which hydrogen is used to heat homes and buildings, fuel vehicles, and power industry • Emissions Removal Pathway, in which biomass power stations are used in parallel with carbon capture, utilization, and storage (CCUS), allowing more time for decarbonization in other sectors
United States^a	<p>The United States modeled seven scenarios, reflecting the "uncertainties surrounding the evolution of technologies, economic conditions, and social dynamics over the coming decades":</p> <ul style="list-style-type: none"> • Benchmark scenario (a starting point for the analysis) • No CO₂ Removal Technology scenario, which assumes that engineered CO₂ removal technologies like bioenergy with carbon capture and storage (BECCS) are unavailable • Limited Sink scenario, which assumes not only limited availability of CO₂ removal technologies but also limited success in maintaining and enhancing the land sink • No CCUS scenario, which achieves 80 percent reductions by 2050 without the use of CCUS, relative to 1990 levels • Smart Growth scenario, which portrays a different pathway to reducing emissions in the transportation and building sectors • Limited Biomass scenario, which explores an alternative to the midcentury strategy (MCS benchmark scenario with lower bioenergy consumption and no deployment of BECCS) • Beyond 80 scenario, which assumes stronger global action to reduce emissions and more rapid advances in low-emissions technologies

Source: Ross and Fransen 2017.

Note: a. In the United States, the previous Administration submitted a Mid-Century Strategy in 2016 that included modeling scenarios with technology and implications for policy through mid-century, and communicated this product to the UNFCCC. This submission does not reflect current United States policy.

5. Transparent Communication

Communicating the elements of the long-term strategy to a variety of stakeholders is critical. Transparency—communicating information so that concepts are unambiguously conveyed and clearly understood—has many benefits, including the following:

- *Guiding domestic decision-making:* Providing information to maintain awareness of the long-term vision, plans, and actions can steer actions by the private sector, sectoral decision-makers, local governments, and civil society.
- *Promoting understanding:* Detailing assumptions and methodologies underpinning the long-term strategy can help promote a better understanding of the strategy and the rationale for the design of its elements, which can help build trust and confidence.
- *Providing context:* Providing information that tells the country's story promotes understanding of challenges, national circumstances, and development priorities.
- *Sharing needs and identifying areas where international cooperation may be useful.*
- *Assessing global emissions:* Providing information to other countries, businesses, and stakeholders enables global analysis of future global emissions.

Appendix A lists information that can be provided to communicate long-term strategies.

6. Conclusion

Rather than an end themselves, long-term strategies present a roadmap to be updated and improved as national circumstances change and new learning takes place. These strategies are living documents that can be improved over time to inform the preparation of successive NDCs. The strategies can help institutionalize action on climate change across the country and assess the sensitivity of the economy to climate change, highlighting opportunities and constraints.

Integrating a long-term perspective into national policy and planning processes is a process. To achieve national development goals, along with the goals of the Paris Agreement and the 2030 Agenda, countries need to get started right away. If designed correctly, long-term strategies can enable countries to fundamentally change the way decisions are made. Moving to a strategic and transformational approach that is guided by a shared vision can allow countries to reap the benefits of the transition.

Appendix A. Information Needed for Transparent Communication of a Long-Term Strategy

Information that can be considered for communication of long-term strategies includes the following:

- *Description of the long-term vision*
- *Development objectives of the long-term vision, which may include the following:*
 - goals for sustained and inclusive development and a just transition for workers, creation of decent work and quality jobs, and poverty reduction (described qualitatively or quantitatively)
 - goals for human and environmental well-being
- *Mitigation elements, which may include the following:*
 - a long-term quantified outcome for greenhouse gas emissions reductions, including information on the following:
 - base year/period of greenhouse gas and non-greenhouse gas targets and base year/period emissions
 - timeframe for the strategy and target year of any greenhouse gas or non-greenhouse gas targets
 - expected national emissions/non-greenhouse gas outcomes in the target year/period
 - intended peaking year and peaking emissions level implied by the trajectory
 - implied annual rate of emissions reductions and/or expected emissions trajectory
 - implied deviation from business-as-usual emissions
 - description of how the vision will limit cumulative emissions over time
 - relevant definitions (such as “carbon neutrality,” if applicable)
 - sectors covered (e.g., all IPCC sectors covered in national greenhouse gas inventory or all economic sectors as defined by national sector classification)
 - greenhouse gases covered
 - assumptions and methodological approaches, including for estimating and accounting for anthropogenic greenhouse gas emissions and, as appropriate, removals
 - assumed IPCC inventory methodologies and global warming potential values
 - modeling that underpins the mitigation vision, including a description of the methodology used to project the baseline scenario, including the projection method (e.g., name and type of models); the cut-off year for policies included in the baseline scenario and any significant policies excluded from the baseline scenario; the emissions drivers included and assumptions and data sources for key drivers; and assumptions about negative emissions
 - description of qualitative approaches used to develop the mitigation vision
 - description of how the long-term strategy is aligned with the Paris Agreement’s temperature goals
- *Adaptation elements, which may include:*
 - long-term outcomes for climate adaptation and resiliency

- description of the risks of inaction, with consequences for environmental, social, human, and economic outcomes
 - goals to enhance adaptive capacity, strengthen resilience, and reduce vulnerability
 - assessment of the impacts of changes in climate on long-lived infrastructure, land-use planning, ecosystem services, and/or social change
 - identification of vulnerable groups and sectors within the country
 - links to national adaptation plans
 - co-benefits of mitigation actions for adaptation/resilience and vice versa
 - consideration of how to strengthen the resilience of mitigation actions proposed in the long-term strategy
 - description of synergies between development gains and mitigation and adaptation responses
- *Intermediate targets to support the long-term vision*
 - *Sectoral strategies to achieve the long-term vision, which could include:*
 - any sectoral greenhouse gas or non-greenhouse gas targets
 - description of prioritized actions and measures
 - description of how the transition will be managed to ensure that it is just for affected populations
 - opportunities for innovation and research, development, and demonstration
 - description of how the long-term strategy will be mainstreamed into sectoral policies and plans
 - additional context, including importance of the sector to the economy, vulnerability to climate change, sectoral potential, trends and projections, innovation opportunities, among others
 - development process for preparation of the long-term strategy (such as stakeholder engagement and public consultation; process, data, and analysis for developing the long-term vision; and decision-making processes)
 - *Implementation approaches for the strategy, including:*
 - description of how the long-term vision will guide short- and medium-term sectoral and cross-sectoral decision-making
 - capacities and resources required for implementation
 - coherence with existing planning efforts
 - priority measures for implementation of the strategy
 - institutional arrangements and legal frameworks for implementation of the strategy
 - stakeholder consultation plans during implementation
 - efforts to manage the transition in a just manner
 - *Monitoring plans, including:*
 - institutional roles, including the entities or institutions responsible for collecting and compiling data
 - data or indicators to be tracked, as well as sources of data
 - duration and frequency of monitoring
 - measurement or data collection methods (e.g., surveys, censuses)

- *Review and revision process, including:*
 - frequency and process for stakeholder engagement
 - objectives or principles guiding the review, with a description of which elements get reviewed
 - ministries/agencies responsible for the review process
 - alignment of the review process with other domestic or international processes

- *Other relevant information, including:*
 - emissions (e.g., past, current, or projected emissions, emissions per capita, emissions intensity, or emissions as a percentage of global emissions)
 - economic and development indicators (e.g., GDP, GDP per capita, indicators related to health, energy access, energy prices, education, housing, etc.)
 - vulnerability and capacity to adapt to climate change impacts
 - costs or relative costs of action
 - mitigation potential (e.g., renewable energy potential)
 - benefits of action (e.g., co-benefits) or other factors
 - projected business-as-usual emissions
 - recent historical emission trends
 - benchmarks for annual rate of emissions reductions or other factors
 - priority sectors
 - other information on national circumstances.

Depending on the strategy's scope and objectives, elements may be more or less relevant to a given country's long-term strategy.

Source: Based on Levin et al. 2015.

Appendix B. Resources to Support the Development of Long-Term Strategies

Table B.1 identifies some of the resources countries can draw on in developing long-term strategies.

Table B1: Resources to support the development of long-term strategies

Organization	Title	Description
2050 Pathways Platform	2050 Pathways: A Handbook (https://www.2050pathways.org/resources/)	Suggests criteria, principles, and building blocks for development of pathways, along with select illustrations
	Why Develop 2050 Pathways? (https://www.2050pathways.org/resources/)	Presents possible motivations for countries, regions, cities, and other entities to develop long-term strategies
Deep Decarbonization Pathways Project	Pathways to Deep Decarbonization: 2015 Synthesis Report (http://deepdecarbonization.org/wp-content/uploads/2016/03/DDPP_2015_REPORT.pdf)	Shows how 16 countries can achieve deep long-term decarbonization of their economies while accommodating the energy services needed to meet their economic growth targets and social priorities
Institute for Sustainable Development and International Relations (IDDRI)	Developing 2050 Decarbonization Strategies in the EU: Insights on Good Practice from National Experiences (http://www.iddri.org/Publications/Developing-2050-decarbonization-strategies-in-the-EU-Insights-on-good-practice-from-national-experiences)	Reviews long-term strategies from several countries in the European Union and highlights good practice examples
Organisation for Economic Co-operation and Development (OECD)	Low Emissions Development Strategies: Technical, Institutional and Policy Lessons (http://www.oecd.org/env/cc/46553489.pdf)	Explores potential purposes of long-term strategies and identifies good practice examples for long-term strategies. Although framed in the context of UNFCCC low-emission development strategies, the report provides useful lessons that can be applied in developing midcentury strategies
World Bank Group	Decarbonizing Development: Three Steps to a Zero-Carbon Future (http://www.worldbank.org/content/dam/Worldbank/document/Climate/dd/decarbonizing-development-report.pdf)	Examines how countries can manage the transition of their political economies to align with a 2100 goal of zero emissions. Discusses how planning mechanisms can lay the foundation for a stable climate and economic development
World Resources Institute	Early Insights on Long-Term Climate Strategies (http://www.wri.org/publication/early-insights)	Reviews long-term strategies that have been officially communicated to UNFCCC, to identify key considerations for countries that are about to embark on this exercise
World Resources Institute (WRI) and United Nations Development Programme (UNDP)	Expert perspectives, case studies, and a series of papers on long-term strategies (http://www.longtermstrategies.org)	WRI and UNDP, in cooperation with the UNFCCC Secretariat, are developing a set of resources that all countries can use to develop long-term strategies. Resources are a contribution to the 2050 Pathways Platform and NDC Partnership
World Wildlife Fund (WWF) Maximiser Project	Planning to Succeed: How to Build Strong 2050 Climate and Energy Development Strategies (http://www.maximiser.eu/publications/)	Identifies essential elements for long-term strategies, based on review of the strategies of European Union member countries

Acronyms

BECCS	Bioenergy with Carbon Capture and Storage
C3	Mexico's Climate Change Council
CBIT	Capacity Building Initiative for Transparency
CCS	Carbon Capture and Storage
CCUS	Carbon Capture, Utilization, and Storage
CICC	Mexico's Interministerial Commission on Climate Change
CO₂	Carbon dioxide
CSWG	Climate Sustainability Working Group
DDM	United Kingdom's Dynamic Dispatch Model
DDPP	Deep Decarbonization Pathways Project
E3MC	Canada's Energy-Economy Environment Model for Canada
ETC	Energy Transitions Commission
GDP	Gross Domestic Product
GEF	Global Environment Facility
IDDRI	Institute for Sustainable Development and International Relations
IEA	International Energy Agency
INECC	Mexico's National Institute for Ecology and Climate Change
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
LEAP	Long-Range Energy Alternatives Planning
LEDS	Low Emissions Development Strategies
MAED	Model for Analysis of Energy Demand
MARKAL	Market Allocation
MCS	Midcentury Strategy
MDG	Millennium Development Goal
MEDEE	Model for Long-Term Energy Demand Evaluation
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
NDCs	Nationally Determined Contributions
NEMS	National Energy Modeling System
NGOs	Non-Governmental Organizations
OECD	Organisation for Economic Co-operation and Development
POLES	Prospective Outlook on Long-Term Energy Systems
R&D	Research and Development
RD&D	Research, Development, and Demonstration
REDD+	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
SDG	Sustainable Development Goal
SGM	Second-Generation Model
SMART	Specific, Measurable, Achievable, Realistic and Timebound
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WRI	World Resources Institute
WWF	World Wildlife Fund

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