Natural Gas Development in Low-Carbon Energy Transition

The Commonwealth

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Contents

Acronyms and Abbreviations

CNG	compressed natural gas
CO2	carbon dioxide
GDP	gross domestic product
GHG	Greenhouse gas
GJ	Gigajoules
GWh	gigawatt hour
HDI	Human Development Index
IEA	International Energy Agency
LCOE	levelised cost of energy
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MJ	megajoules
MtCO2e	metric tonnes of carbon dioxide equivalent
NDCs	Nationally Determined Contributions
MW	Megawatt
MWh	megawatt hour
PV	(solar) photovoltaic
R/P ratio	reserves-to-production ratio
SDG	Sustainable Development Goal
TWh	terawatt hour

1. Introduction

1.1 Background and objective

Commonwealth member countries rich in natural gas face complex policy choices and trade-offs regarding their need to generate maximum benefits from their natural gas resources while transitioning to low-carbon economies. However, a lack of holistic guidance to inform such policy choices and trade-offs means that diverse and conflicting views may hamper sound policy decision-making and clear policy direction in steering their low-carbon energy transition pathways to achieve their development and climate change goals. This paper offers some contribution to the discussion, as a policy guide to help inform policy choices and actions.

The prospects of natural gas development in an energy transition raise several policy issues that will influence Commonwealth member countries' options and choices for low-carbon transition pathways. A selection of these issues, highlighted in Table 1.1, is the focus of this paper.

Table 1.1 Issues for policy considerations in low-carbon energy transition

Issues	Consideration
Geopolitics and energy	The energy transition will herald a shift of geopolitical influence from fossil fuel countries to countries that invest in and take advantage of opportunities created by renewable energy technologies.
Energy security	Exogenous shocks such as the Russian invasion of Ukraine and the impact of the global response to the COVID-19 pandemic have raised concerns over energy security and the strategic importance of natural gas in the energy transition.
Natural gas in the global energy mix	The global outlook for natural gas provides critical insights for policy makers on opportunities and uncertainties that may impact exploitation of their natural gas resources.
The value of natural gas to the energy transition	While natural gas is argued to play an important role in the energy transition on account of such factors as low-carbon content compared to other fossil fuels, its drilling, extraction and transportation often result in fugitive emissions such as methane. This is a much more potent gas than CO_2 – though in the short term – in causing global warming.
A dilemma for resource-rich Commonwealth member countries	A significant number of developing Commonwealth member countries rely on their ongoing production of, or yet-to-be-developed, gas resources for the revenues they provide or could provide. They may find that the energy transition offers more challenges, which could result in the realisation of such risks as reduced investments, stranded assets and ageing infrastructure.
Nationally Determined Contributions (NDCs) and their implications for natural gas development	In meeting commitments to submit voluntary NDCs to the UN Framework Convention on Climate Change (UNFCCC) secretariat, member countries are presented with complex policy choices in determining their NDCs in ways that could constrain their ability to exploit their natural gas resources.
Fair and equitable energy transition, particularly for fossil fuel-dependent developing countries	The social and economic impacts of energy transition have implications for the priorities, choices and, hence, policies pertaining to how gas-rich developing countries address their energy poverty and energy access gaps as they strive for economic development.

Gas-rich countries, including Commonwealth member countries, have made pledges to reduce CO_2 emissions in their various Nationally Determined Contributions (NDCs) as part of their commitments under the Paris Agreement. As a result, they are faced with complex policy choices and trade-offs in how to maximise the benefits from their natural gas development while transitioning to a low-carbon economy.

For gas-rich developing countries, which include countries in sub-Saharan Africa, several of them Commonwealth members, an added complexity is achieving the right pace in the transition away from fossil fuels.

> *'Africa must have natural gas to complement its renewable energy … Even if Africa were to triple its production of natural gas from current levels, its contribution to global emissions would only rise by 0.67%.'*
>
> Akinwumi Adesina, President of the African Development Bank[1]

> *'If we make a list of the top 500 things we need to do to be in line with our climate targets, what Africa does with its natural gas does not make that list.'*
>
> Fatih Birol, Executive Director of the International Energy Agency (IEA)[2]

With significant gas reserves, a resource-rich country would face such complexity as it navigates the impact and cost implications of, as well as the necessary mitigating actions for, the transition to a low-carbon world. This happens against the backdrop of the need to enhance the sustainability of energy systems, in keeping with the global shift away from fossil fuels as a fundamental component of strategies to combat global warming. With the development of gas resources including infrastructure involving large financial outlay, in particular foreign direct investment in developing countries, this shift has involved the capital markets, where competition for risk capital for investment in gas development is increasingly stiff. This is proving particularly difficult for the energy transition journey of countries reliant on gas development for foreign exchange revenue and for potential gas-based power sector development. As a result, public finances have come under pressure to fund gas infrastructure projects.

1.2 Gas producer member countries

In developing policy considerations to frame possible pathways for a low-carbon transition, an analysis is presented in this section of the risks, challenges and opportunities for gas development in a low-carbon context, drawing on existing reserves and production data in a selection of Commonwealth countries. In this analysis, 16 Commonwealth member countries with significant proven natural gas reserves, recent commercial discoveries and for which publicly available production data are available, have been selected, across different stages of development, and with different gas resource profiles. These countries are: Australia, Bangladesh, Brunei Darussalam, Canada, Ghana, Guyana, India, Malaysia, Mozambique, Namibia, Nigeria, Pakistan, South Africa, Tanzania, Trinidad and Tobago, and the United Kingdom. They cover the spectrum of countries by income status (see Table 1.2).

1 Reuters (2022), 'Africa deserves right to use natural gas reserves – AfDB chief', 16 November, available at: www.reuters.com/business/cop/africa-deserves-right-use-natural-gas-reserves-afdb-chief-2022-11-15/

2 World Economic Forum (2022), 'Africa must act quickly on its gas reserves, IEA report' , 23 June, available at: www.weforum.org/agenda/2022/06/gas-energy-africa-iea/)

Table 1.2 Selected Commonwealth gas-producing countries

Low-income economies	Lower middle-income economies	Upper middle-income economies	High-income economies
Mozambique	Bangladesh	Guyana	Australia
	Ghana	Malaysia	Brunei Darussalam
	India	Namibia	Canada
	Nigeria	South Africa	Trinidad & Tobago
	Pakistan		United Kingdom
	Tanzania		

Source: Adapted from World Bank (no date)[3]

Except where specified otherwise, the time horizon considered in the analysis is up to 2030, where data are available.

3 World Bank (no date), 'World Bank Country and Lending Groups', available at: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

2. The Resource Base

2.1 Implications of gas reserves life for low-carbon energy transition

An important metric for understanding the life of an oil or gas reserve is the reserves-to-production ratio (R/P ratio). The R/P ratio, measured in years, gives a sense of how long, typically expressed in years, it would take to produce the commercially extractible gas volumes or reserves before reaching the end of their economic life. This is an important metric, particularly for the Commonwealth gas-producing countries in the lower middle- and lower-income categories, which may not have viable alternative clean energy supply sources. For several of these countries, the R/P ratios suggest natural gas production may continue beyond 2050.[4]

In the oil and gas industry, 'proved reserves' are generally defined as having a 90 per cent or greater likelihood of being economically viable to extract in the prevailing market conditions. Such volumes can be analysed in several ways, for different purposes. These purposes range from determining the economic value of the proved reserves to the length of time it would take to reasonably extract those reserves under given rates of extraction and other conditions.

Each of the selected countries for this paper is at a different stage of natural gas production lifetime, measured – for example – using the reserves-to-production (R/P) ratio. If all their proved gas reserves were produced and no further discoveries were made, such that no further proved reserves were added, Mozambique, Nigeria, India and Tanzania could continue producing gas beyond 2050 and into the next century – with R/P ratios of approximately 121, 111 and 147 years respectively. Ghana, Brunei Darussalam, Australia, Canada, Malaysia and Pakistan could continue producing beyond 2030 but may cease production before 2040 based on existing reserves; Trinidad and Tobago could continue producing beyond 2025 but before 2030; and the UK and Bangladesh may exhaust their reserves by or not long after 2025.[5]

According to Climate Watch data on global historical emissions,[6] except for Australia, Canada, Trinidad and Tobago, and the UK, the other countries in this cohort currently account for 17 per cent of global greenhouse gas (GHG) emissions (around 6 per cent if India is excluded). If all their gas reserves were produced, and the current trajectory of emissions in the respective countries was maintained, by 2030 their emissions could exceed the emissions committed to in their respective NDCs by about 3,500 metric tonnes of carbon dioxide equivalent (MtCO2e). Excluding Australia, Canada, Trinidad and Tobago, and the UK, the emissions could exceed the NDC targets by about 2,800MtCO2e.

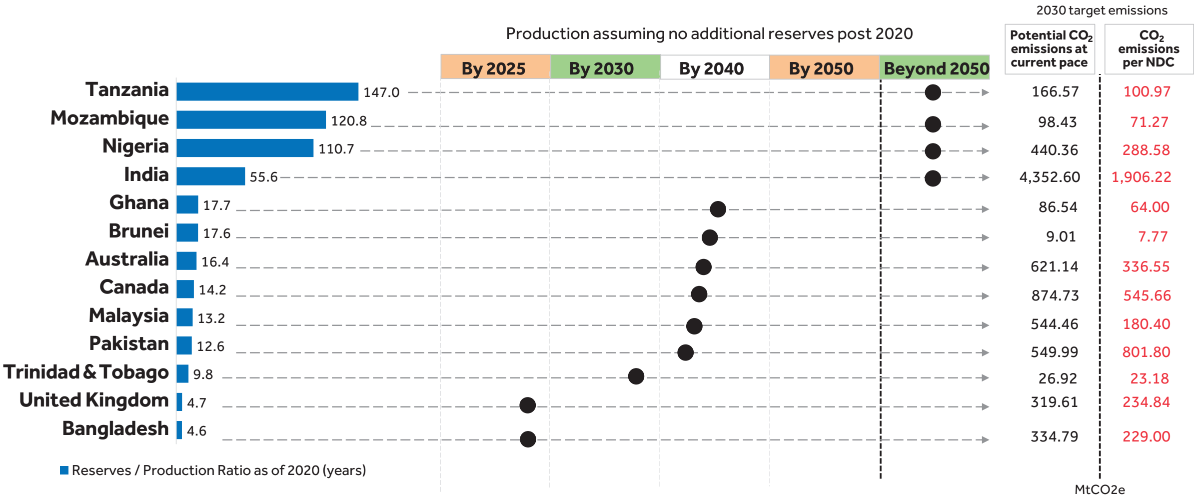
As is shown in Figure 2.1, individually, Mozambique could potentially overshoot its 2030 NDC target by 38 per cent and Nigeria by 53 per cent; similarly, India could exceed its target by 128 per cent and Ghana by 35 per cent. The observable exception is Pakistan, where the forecast emissions based on current data could be less than its target for 2030. However, that these observations and forecasts are based on current circumstances that exclude potential new discoveries, depletion of reserves and changes to government policy, particularly regarding climate change. They also consider total GHG emissions, and not emissions isolated to natural gas production alone.

4 The R/P ratios can vary because of a number of factors, for example: prevailing geological conditions which, given available technology and financial resources, could increase or reduce the pace of extraction; and government policy, which could similarly affect the pace of extraction. However, it remains a useful metric to consider, given the typical tendency of companies involved in the deployment of risk capital for such extraction to seek a rate of extraction that optimises the risks and benefits.

5 BP (no date), *Annual Statistical Review of World Energy*, available at: www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html

6 Climate Watch (no date), 'Historical GHG Emissions', available at: www.climatewatchdata.org/ghg-emissions?end_year=2019&gases=all-ghg&start_year=1990

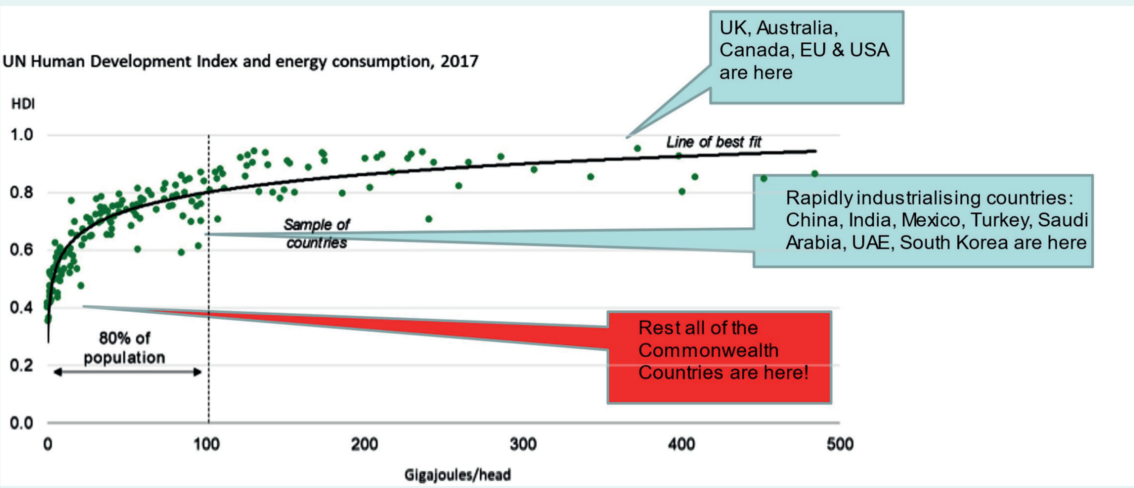
Figure 2.1 Gas R/P ratios and GHG emissions targets for selected Commonwealth countries



Sources: BP (various years), *Annual Statistical Review of World Energy* (for R/P ratios and CO2 emissions); UN (no date), NDC Registry, https://unfccc.int/NDCREG (for CO2 emissions per NDC); author's forecast (for potential CO2 emissions at current pace, using BP CO2 emissions data).

Low-income countries with low Human Development Index (HDI) scores tend to have low per capita energy consumption levels. No country with an HDI of above 0.95 (typical for upper middle-income economies and above) has a per capita energy consumption level of 146 gigajoules (GJ) per annum (Shastri 2022). In most Commonwealth countries, per capita energy consumption is below 25GJ (Figure 2.2).

Figure 2.2 UN Human Development Index and energy consumption



Source: reproduced from Shastri, A (2022), 'Energy Transition in The Commonwealth: Walking the thin line of De-carbonisation and Growth', Institute of Commonwealth Studies, School of Advanced Study, University of London, November, available at: https://commonwealth.sas.ac.uk/blog/energy-transition-commonwealth-walking-thin-line-de-carbonisation-and-growth

2.2 Implications of equity considerations in low-carbon energy transition

R/P ratio considerations have implications for the carbon emission targets made by resource-rich developing countries under the Paris Agreement. These countries typically are low carbon dioxide (CO_2) emitters, have comparatively low levels of electricity access, use significant proportions of gasoline and heavy fuel oil for off-grid electricity generation, and have relatively low access to clean fuels and technologies for cooking.

Commonwealth member countries account for about 9 per cent of global total proved gas reserves, with Nigeria and Mozambique having the largest proved reserves in the cohort, at 193 and 100 trillion cubic feet (Tcf) respectively.[7] The selected countries for this analysis account for nearly all the gas reserves among the Commonwealth member countries, holding over 96 per cent.

The comparatively modest levels of emissions from some low-income and lower middle-income economies – with high R/P ratios and pressing developmental needs such as poverty eradication or closing the energy access gap – can justify policy approaches that allow for continued gas development alongside sustainable measures for curbing carbon emissions.

This policy note suggests one of several policy options that gas-producing countries with comparatively low Human Development Index (HDI) scores, corresponding low energy consumption levels and low emissions can pursue is an energy mix pathway. This would involve a mitigation strategy comprising using natural gas as a lower-carbon fuel (excluding heavier emitters such as fuel oil), increasing energy efficiency and improving energy access to a variety of use cases, including clean cooking.

Other targeted policy considerations include, but are not limited to, economic and technological measures such as:

- diversifying the energy mix by increasing investment in renewable energy technologies, including using export revenues generated from natural gas extraction and development to invest in renewable energy sources, such as solar and wind power, as well as energy storage technologies;[8]
- offering fiscal incentives for investment in projects such as development of carbon capture and storage (CCS) technologies, as well as renewable energy technologies;
- promoting the use of such renewable technologies as biomethane, produced from the breakdown of organic matter, alongside the development of conventional natural gas;
- replacing the use of diesel and heavy fuel oil in the energy mix with natural gas as a lower carbon transition fuel;
- providing fiscal incentives for, and using export revenues generated from natural gas extraction and development to invest in, promoting and enhancing energy efficiency in various sectors, such as buildings, transportation and industry; and
- implementing carbon pricing mechanisms such as a carbon tax or a cap-and-trade system.

These measures, as highlighted later, will vary from country to country, depending on their relevant economic and technology comparative advantages.

2.3 Risks, challenges and opportunities for natural gas development in a low-carbon context

2.3.1 Risks and policy considerations

For countries reliant on their significant gas reserves, including natural gas development in the energy transition faces several risks. Prominent among these are:

7 BP (no date), *Annual Statistical Review of World Energy*, op. cit. note 2; Worldometer, 'Natural Gas Reserves by Country', available at: www.worldometers.info/gas/gas-reserves-by-country/

8 This would depend on various considerations, chief among which is the extent to which the country intends to deal with potential trade-offs by using public finance for competing development interests.

- **Stranded assets:**[9] This pertains to the risk of assets not being developed to the end of their economic life due to changes in the commerciality of the project. The main contributing factors to this risk are changing market conditions that result in further gas production being no longer commercially viable, as well as increasing divestments from gas development projects.[10]
- **Divestments:** The increasing divestment of capital away from upstream petroleum projects, as well as asset write-downs by oil companies, will either require countries reliant on natural gas export to find alternative investment sources for the continued development of their stranded assets and exploration for new discoveries or for them to find new markets for their gas in the transition period. Furthermore, many such divestments would likely be to operators with less experience and operating capital, so leading potentially to practices that have less regard for reducing emissions during operation. In this instance, such assets are not necessarily stranded but now risk being produced with potentially weakened environmental standards.
- **Revenue shock:** This pertains to the risk of stranded assets being realised by gas-dependent producers because of a drastic drop in gas export revenues causing a revenue shock to the country. This may be particularly pronounced in countries such as Brunei Darussalam and Nigeria, which rely on oil and gas exports for over 80 per cent of their export revenue and more than half of total government revenue. The realisation of this risk is typically manifest in the inability of the government to honour its financial obligations, such as capital and recurrent expenditures and debt servicing.
- **Missed emissions targets:** Nearly all the countries selected for this analysis – particularly the countries in the low-income and lower middle-income categories – carry the risk of not being able to attain their net zero targets or emissions reduction targets as committed to in their NDCs. This is due to several factors, which include an evidently slow build-up of required funding for climate resilience and sustainability projects, as well as the reality surrounding the difficulties currently being experienced by nearly all of these countries in diversifying away from government revenue dependence on fossil fuel export revenues.
- **Supply shock:** Countries with a higher reliance on oil and gas imports or exports face the risk of supply shocks arising from the energy transition due to a number of factors. One such factor is a possibility that asset divestments and write-downs could lead to a reduction in the rate of gas supply, such that it is far outpaced by growth in gas demand. In addition, exogenous events such as wars could further exacerbate the risk, as has been demonstrated in the wake of Russia's invasion of Ukraine. In the Commonwealth, this risk is elevated in countries most reliant on oil and gas exports, such as Brunei Darussalam and Nigeria.

These risks have different implications for different countries and their mitigating actions depend on each country's circumstances and stage of development. In the case of stranded assets, countries with high R/P ratios and a long gas production life for their gas reserves, may need to consider a long-term roadmap for low-carbon development of their resource potential. Countries that are highly dependent on gas export revenue are more likely to be negatively impacted by the revenue shock risk. Countries that are heavily reliant on gas imports also face the potential risk of stranded fossil fuel-based assets, including power plants and other infrastructures. They would therefore need to consider a long-term roadmap for orderly transition to a cleaner energy system in a manner that supports the country's economic and social development objectives. In addition, they would be most affected by a supply shock and so need to consider policy measures to increase energy security, including diversifying their supply sources and scaling up deployment of renewable

9 The International Energy Agency (IEA) defines stranded assets as 'those investments which are made but which, at some time prior to the end of their economic life (as assumed at the investment decision point), are no longer able to generate an economic return, as a result of changes in the market and regulatory environment'.

10 A comprehensive discussion on this risk and policy implications is provided by Lahn, G and S Bradley (2016), 'Left Stranded? Extractives-led Growth in a Carbon-Constrained World', Chatham House, available at: www.chathamhouse.org/sites/default/files/publications/research/2016-06-17-left-stranded-extractives-bradley-lahn-final.pdf

energy sources. The nature and magnitude of the adjustment needed after a price or supply shock depends on several factors, which include the policy framework, existing buffers and the expected duration of the shock.

2.3.2 Challenges

Of the challenges faced by developing countries among the gas producers in the Commonwealth, in so far as energy in general and the energy transition in particular are concerned, four groupings are prominent from observing several development indicators:

- low or limited energy access;
- affordability regarding modern energy services;
- commercially viable markets; and
- funding constraints.

Energy access

A major challenge, particularly for low-income and low middle-income countries to overcome in the transition, is to reduce energy poverty. For this note, 'energy poverty' refers to the lack of access to reliable and affordable sources of energy for heating, lighting and powering household appliances and devices. It also refers to the inability to afford the cost of using energy efficiently, such as by using energy-efficient appliances or building materials. It is often linked to other forms of poverty, such as lack of access to clean water, sanitation and healthcare. Many people living in energy poverty typically rely on traditional, fossil fuel-based sources of energy.

Lower-income countries tend to have lower energy access than higher-income countries and are striving to make improvements as part of their Sustainable Development Goal (SDG)7 goals. Compared to higher-income countries with legacy energy infrastructure, lower-income countries may have the advantage of relying on renewable energy sources to increase energy access, so increasing their chances of 'leapfrogging' the hydrocarbon energy reliance stage.

Despite the advantages lower-income countries may have in potentially increasing energy access without necessarily having to install traditional energy supply infrastructure, many countries – including Commonwealth member countries – are likely to miss the SDG7 target of universal energy access by a wide margin.[11]

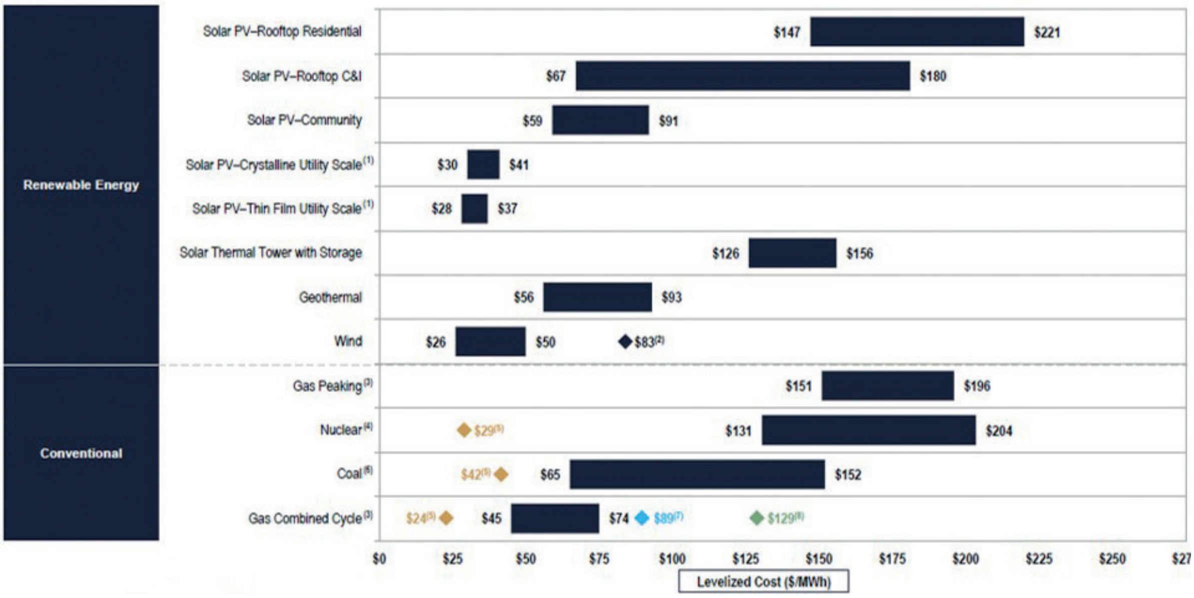
Efforts to address energy poverty often involve the provision of cleaner, more efficient and more affordable energy sources, such as renewable energy technologies. Significant progress has been made regarding lowering costs of renewable technologies such as wind and solar, and there is a opportunity for large-scale rollout of mini and off-grid systems based on renewable energy technologies to boost access to electricity.

However, the scale of the challenge in countries with lower access to electricity becomes more pronounced, particularly with regard to providing infrastructure for grid connectivity at large scale. In general, renewable energy technologies have become more competitive than traditional technologies and this may depend on such factors as location, scale and policy interventions that include availability of subsidies for renewable energy technology providers. For larger-scale access, or for grid-connected baseload connectivity, such cost competitiveness is not clearly evident. Larger-scale economies improve the cost competitiveness of renewable energy technologies. Meanwhile, recent changes in market conditions, including surging gas prices, have seen renewable power generation in places like Europe and elsewhere becoming more cost competitive compared to gas-based baseload generation. However, the intermittency of solar and wind technologies, for example, means that increasing share of renewable energy sources in the energy mix comes with added cost to ensure reliability and stability of power supply, which impacts on their competitiveness.

In examining the competitiveness across different energy technologies of both fossil fuel-based and renewable energy technologies, a review of a technology's levelised cost of energy (LCOE) is undertaken drawing on Lazard's published Levelized

11 Commonwealth Secretariat (2022), The Commonwealth Sustainable Energy Transition: Pathways and Progress Report, June, available at: www.thecommonwealth-ilibrary.org/index.php/comsec/catalog/book/979

Figure 2.3 Levelised cost of energy comparison



Source: reproduced from Lazard (2021), 'Lazard's Levelized Cost of Energy Analysis – Version 15.0', October', available at: www.lazard.com/media/sptlfats/lazards-levelized-cost-of-energy-version-150-vf.pdf

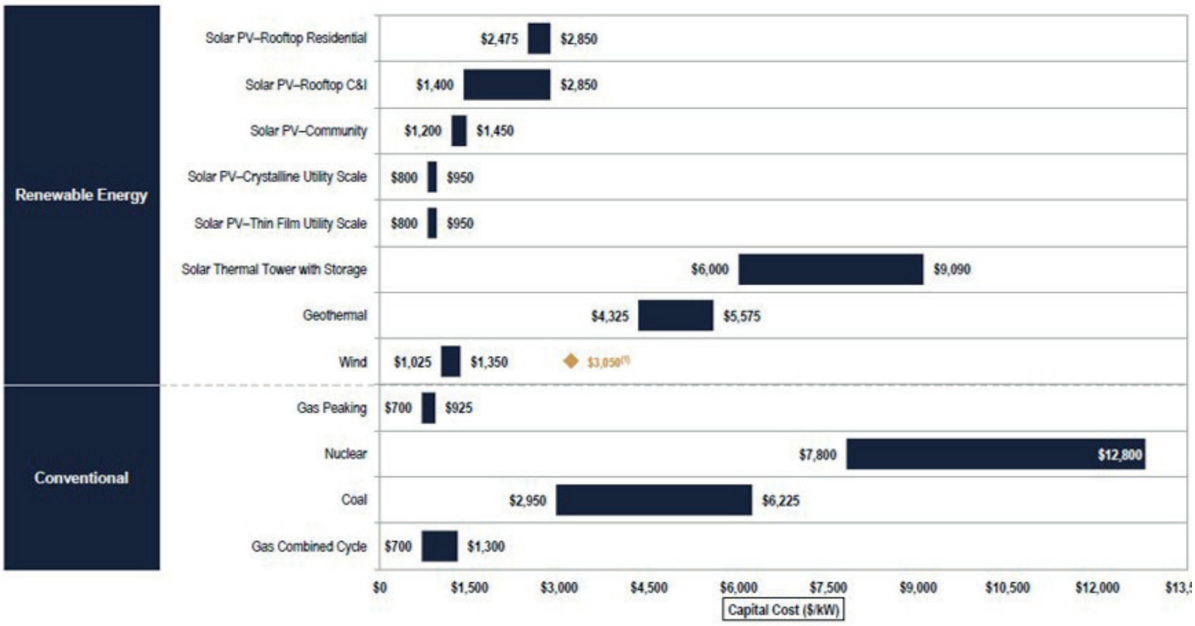
Cost of Energy (LCOE) Analysis (see Figure 2.3).[12] This analysis seeks to understand which renewable energy technologies may be cost competitive with conventional generation technologies, either now or in the future, and under various operating assumptions. It compares the marginal costs of a selection of power generation technologies under subsidised and unsubsidised conditions. The findings of the analysis illustrate the LCOE range for each technology, underscoring the relative nature of the competitiveness of the respective technologies' LCOE. For example, looking at a range of LCOE, combined cycle gas power generation can be relatively cheaper under certain conditions, such as fuel cost, scale and location, while wind technology and utility-scale solar PV (photovoltaic) also offer cost competitiveness under varying conditions.

Renewable energy from wind and solar is intermittent and not always available. This can make it difficult to provide a constant, reliable and competitive source of power. Variable renewable energy sources such as solar and wind are dependent on weather conditions. For example, solar panels can only generate electricity when the sun is shining, and wind turbines, only when the wind is blowing. This means that the amounts of electricity they generate vary unpredictably over time. In contrast, traditional baseload power plants are designed to operate consistently at a high capacity and generate a steady stream of electricity. There are ways to address the intermittent nature of renewable energy, such as using energy storage systems or pairing renewable energy sources with other types of power plants. However, these solutions can be expensive and may not always be practical. As Figure 2.5 shows, the only non-hydro renewable energy technology currently capable of providing baseload power is geothermal energy.

Energy access can impact on the energy transition pathway regarding policy options and choices, so affecting the choice of energy technology. Considering energy access in the context of gas producers, R/P ratios have been examined against energy access indicators such as access to electricity and to clean cooking fuels technology (Figure 2.6).

12 The methodology used in Lazard's (2021) analysis consists of creating a power plant representative of an illustrative project that results in a levered internal rate of return (IRR) equal to the assumed cost of equity. Some of the key assumptions used include engineering, procurement and construction (EPC) costs, fixed operations and maintenance (O&M) costs, plant life, heat rate, and financial considerations, such as cost of capital.

Figure 2.4 Capital cost comparison of power generation technologies



Source: reproduced from Lazard, (2021)

As illustrated in Figures 2.6a and 2.6b, countries in the top half of both graphs have better access to power and are arguably better placed to transition with increasing share of renewable energy through such approaches as either pairing with storage systems such as batteries or pumped hydroelectric storage or pairing with other types of power plants such as natural gas plants. The low gas R/P ratios (which show a shorter gas reserves life) of these countries could mean that, combined with other

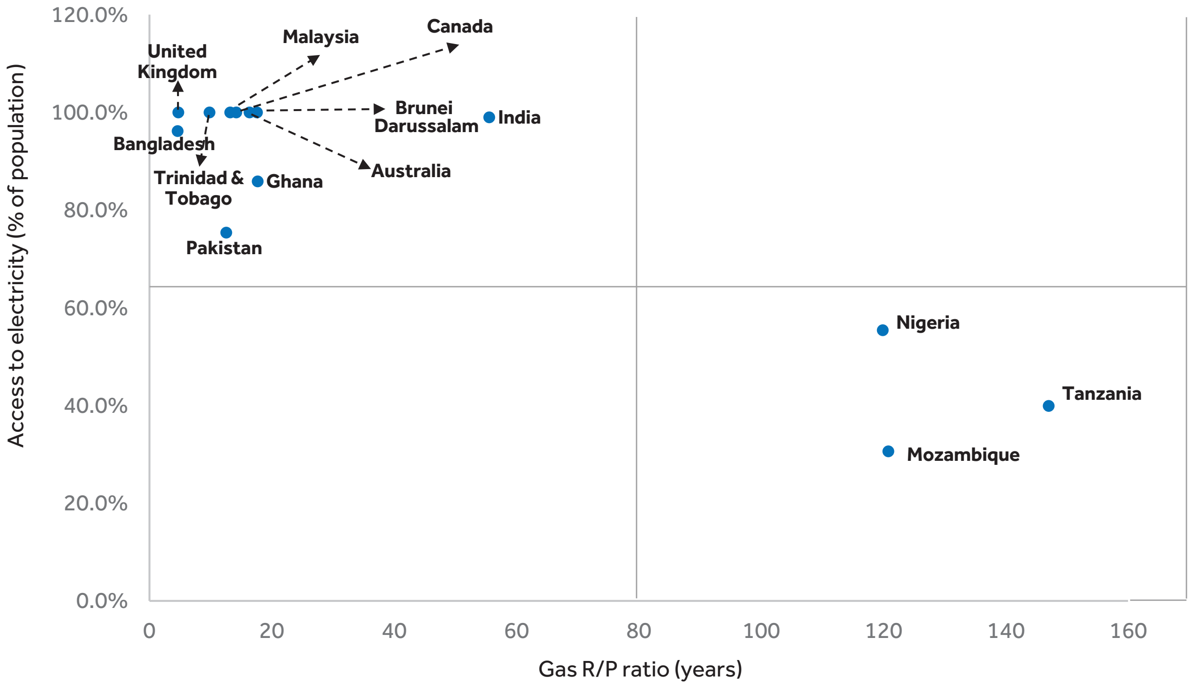
Figure 2.5 Matrix of energy resource applications*

		Carbon Neutral/ REC Potential	Location			Dispatch			
			Distributed	Centralized	Geography	Intermittent	Peaking	Load-Following	Baseload
Renewable Energy	Solar PV[1]	✓	✓	✓	Universal[2]	✓	✓		
	Solar Thermal	✓		✓	Rural	✓	✓	✓	
	Geothermal	✓		✓	Varies				✓
	Onshore Wind	✓		✓	Rural	✓			
Conventional	Gas Peaking	✗	✓	✓	Universal		✓	✓	
	Nuclear	✓		✓	Rural				✓
	Coal	✗		✓	Co-located or rural				✓
	Gas Combined Cycle	✗		✓	Universal			✓	✓

Source: reproduced from Lazard, (2021)

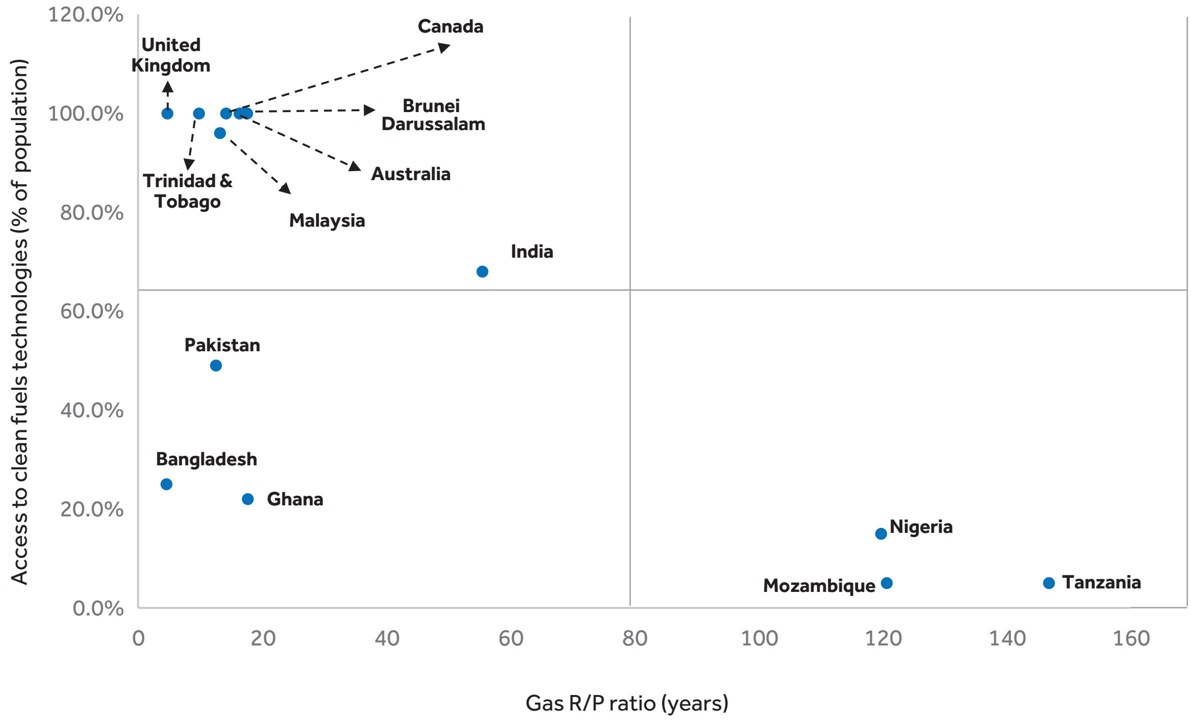
*Note: The analysis displayed in the table does not take account of potential social and environmental externalities, nor reliability-related considerations.

Figure 2.6a Access to electricity as a percentage of the population



Sources: BP (various years), *Annual Statistical Review of World Energy* (for R/P ratios); World Bank (no date). Open Data, https://data.worldbank.org/ (for access to electricity)

Figure 2.6b Access to clean fuels as a percentage of the population



Sources: BP (various years), *Annual Statistical Review of World Energy* (for R/P ratios); World Bank (no date). Open Data, https://data.worldbank.org (for access to clean fuels technologies) factors, concern for energy security and the climate change imperative provide a comparatively higher incentive to transition faster away from fossil fuel dependency. Furthermore, with relatively higher levels of gross domestic product (GDP) per capita, many of the governments and/or citizens of these countries can afford the cost of deploying renewable energy projects such as rooftop solar photovoltaic (PV) installations and developing geothermal resources. In terms of policy choices and subject to political will, they are therefore able to pursue faster decarbonisation pathways than countries in the bottom halves of Figures 2.6a and 2.6b.

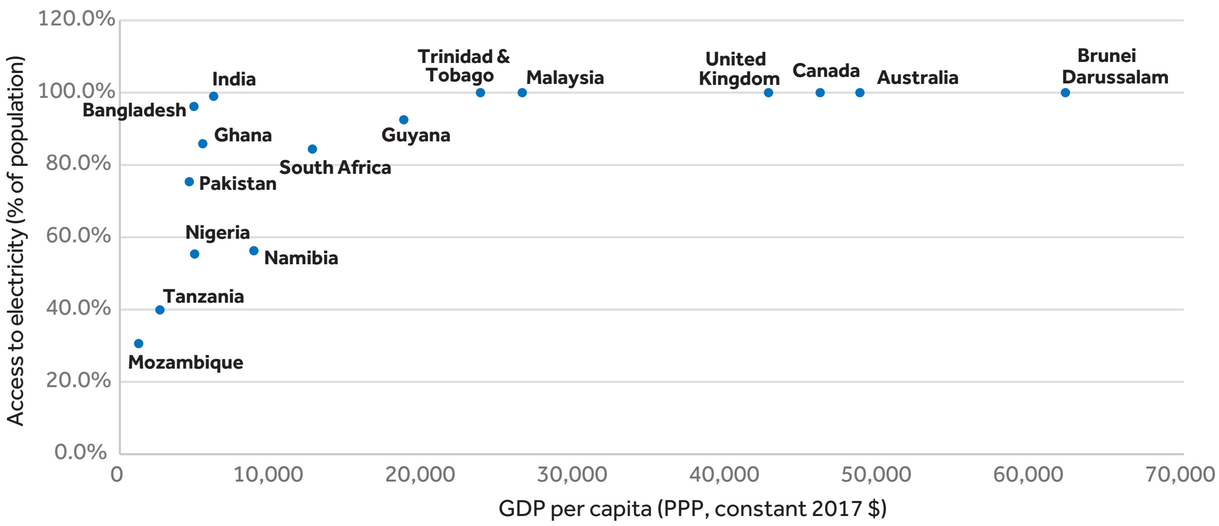
Countries in the bottom half have a greater need for electricity access, whether grid connected on a large scale or through smaller decentralised systems, to close the energy access gap – particularly in the last mile. They would therefore be presented with policy considerations that include some combination of producing their relatively short-life gas reserves (high R/P ratios) for domestic gas utilisation (such as combined cycle gas turbines [CCGT] for power generation) with clean energy solutions at the off-grid level through decentralised energy resources such as wind and solar. The extent of combination of these technologies will depend, to a large extent, on country-specific factors – ranging from renewable energy resource endowment, grid infrastructure and population density to affordability as well as the commercial viability of the domestic market.

Affordability

Affordability of energy poses an energy transition challenge, particularly for low-income countries. While renewable energy can be a cost-effective and sustainable way to meet energy needs for many countries, there are several affordability considerations that low-income countries may face when transitioning to a low-carbon economy. One such consideration is the initial cost of building renewable energy infrastructure, such as wind farms, solar PV farms or hydroelectric dams.

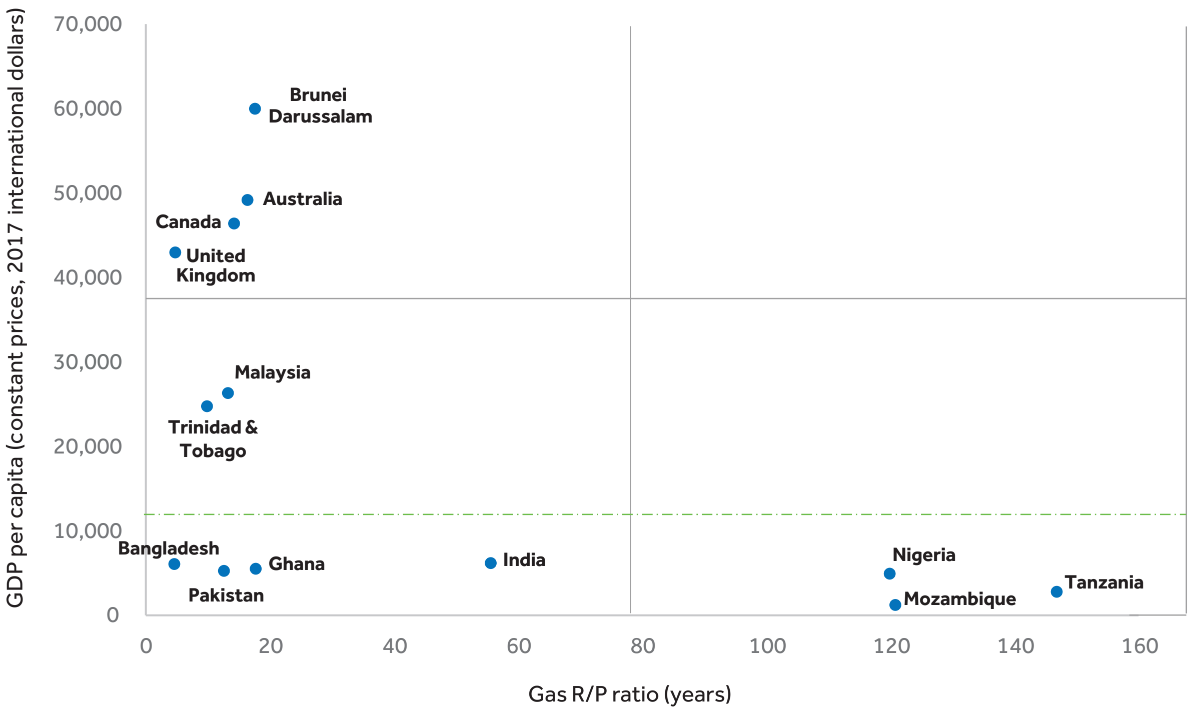
These projects can require significant upfront investments and it may be difficult for low-income countries to secure sufficient financing to implement them. In addition, the technical expertise or infrastructure required to support the development and deployment of renewable energy projects can present further challenges, such as a lack of trained personnel, specialised equipment or a reliable grid to which renewable energy systems can be connected. Such lack of technical expertise and ancillary technology is not necessarily unique to low-income countries. However, it is typically more prevalent in low-income countries, such that there is limited absorptive capacity for fast-paced development in this regard.

Figure 2.7 Electricity access vs GDP per capita in the selected countries



Sources: World Bank (no date), Open Data, https://data.worldbank.org/

Figure 2.8 GDP per capita and gas development prospects



Sources: BP (various years), *Annual Statistical Review of World Energy* (for R/P ratios); World Bank (no date), Open Data, https://data.worldbank.org/ (GDP per capita)

Countries with low HDI scores tend to also score low in terms of energy consumption per capita (Figure 2.2). This shows in GDP per capita also, where countries with lower electricity access tend to have comparatively lower GDP per capita (Figure 2.7).

Countries below the dotted line in Figure 2.8 make an even stronger case for cheaper energy, particularly when their energy use per capita and HDI (Figure 2.2) scores are taken into consideration. More feasible and potentially scalable pathways would include development of all energy sources and applying affordability as a critical criterion for prioritising policy interventions to encourage private sector investment in generating affordable energy. This may include investment incentives through such avenues as the permitting and licensing process, access to land, and fiscal measures.

More specifically, a range of policy options could include, but not be limited to:

- leveraging international support through funding and technical assistance from international organisations such as the World Bank, UN Development Programme (UNDP) and the Commonwealth Secretariat;
- actively promoting decentralised renewable energy systems, so helping to improve access to affordable and reliable electricity and other clean energy services – particularly in rural areas;
- implementing targeted energy efficiency measures in key sectors, such as in buildings and in transportation;
- actively promoting the use of affordable clean cooking technologies; and
- building local capacity in renewable energy to develop the skills and expertise needed to support clean energy transition, through such means as training programmes, research and development, and educational initiatives.

These measures – and indeed other measures in the energy transition highlighted earlier – would likely produce policy options and trade-offs. These trade-offs will vary depending on the specific context and policy options being considered and may include:

- **Economic costs:** Transitioning to a low-carbon economy may require significant upfront investments in clean energy technologies and infrastructure, which could have high short-term cost implications. However, these investments can also lead to long-term economic benefits, such as the creation of new jobs and the development of new industries supported by clean energy systems.
- **Political challenges:** Implementing policy changes to support an energy transition may face vested interests that are opposed to the changes. Governments may need to navigate these challenges and build consensus among stakeholders for a successful energy transition.
- **Technological challenges:** Transitioning may require the development and deployment of new technologies, which may include overcoming technical barriers or developing new technologies that are not yet in the market. Cultural challenges may also arise towards adoption of new technologies such as modern cooking stoves. These cooking stoves may not be well received, as they may be deemed to be inconsistent with traditional ways of cooking or incapable of producing the same taste for cooked food as traditional stoves.
- **Social and environmental impacts:** There could be social and environmental impacts that need to be carefully considered. For example, the deployment of renewable energy projects such as wind farms or solar PV farms may impact local communities and ecosystems. These impacts may need to be mitigated through careful planning and stakeholder engagement.

Market viability

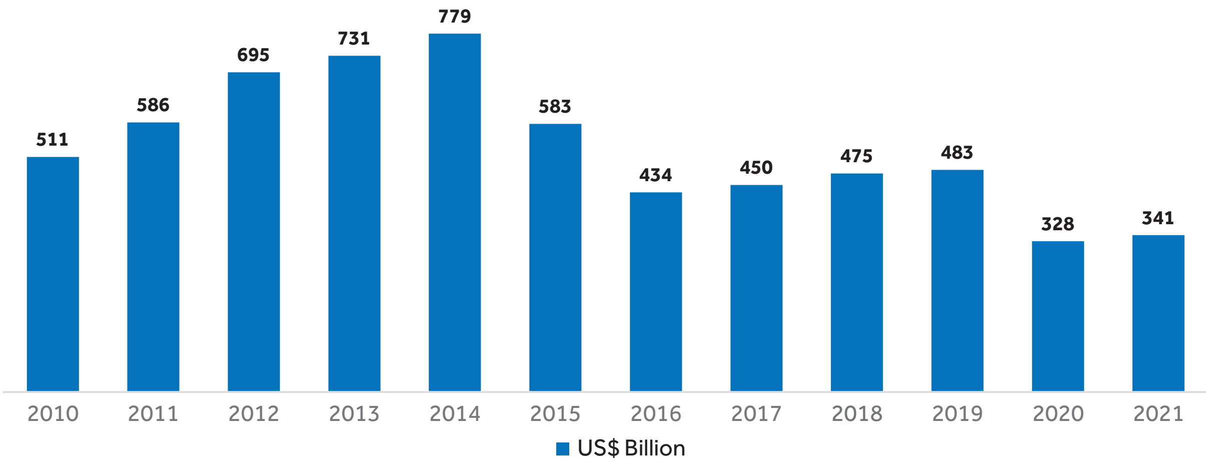
In many countries (including Commonwealth developing member countries), the relatively insufficient absorptive capacity of firms in their markets is a barrier to the ramping up of domestic gas utilisation initiatives. This is due to a wide range of factors, chief of which are:

- **Economic:** These may include low GDP per capita, a high poverty rate, competition with cheaper and more readily available energy sources such as biomass, and a lack of financing to develop relevant infrastructure such as pipelines and distribution infrastructure to connect gas production to gas markets.
- **Commercial:** These factors may include limited market demand due to low levels of economic development and limited access to electricity, and an inability of consumers to pay market-based prices.
- **Regulatory:** Here the implication could be of policy or regulatory disincentives for investment.
- **Infrastructural:** Such factors may include, for example, inadequate pipeline networks, insufficient processing facilities, and lack of small and large-scale power generating equipment such as gas turbines.

These factors, in contributing to limiting the absorptive capacity of the market, could result in the creation of a commercial environment that is unconducive for investment. Policy measures for consideration in addressing this challenge include, but are not limited to:

- Fiscal and commercial incentives to attract private sector investment in projects. These could include investment tax credits or other tax relief measures, and/or government guarantees to support project finance structures.
- Legislative and regulatory support. These could include, for example, mandating and/or incentivising the use of clean fuel in cooking, to move away from the use of unsustainable biomass which may be preferred due to affordability.
- Supporting investment in infrastructure such as pipelines, storage facilities and power plants to help improve domestic market utilisation.
- Encouraging alternative uses for natural gas, such as feedstock to produce hydrogen or other chemicals.

Figure 2.9 Global oil and gas capital spending, 2010–2021



Sources: International Energy Agency (2022), *Global oil and gas upstream spending 2014-2019*; SP Global (2022)

It is important that these measures discourage market decisions that would either otherwise not be made or would be difficult to sustain in the long run without continued government intervention, such as through subsidies.

Funding constraints

A low-carbon transition pathway for gas producers would inevitably require funding for measures to reduce carbon footprint in the gas transition, as well as investment in the emerging new clean energy industry. Recent trends have seen considerable change in capital expenditure for investment in gas development when compared with developments in renewable energy capital expenditure. The level of capital investment in upstream oil and gas projects is not only significantly lower than previous peaks – such as in 2014, when total global capital expenditure in oil and gas projects was approximately US$780 billion – but also competing unfavourably with renewable energy capital expenditure. For example, in 2021, global energy capital spending on renewable energy was US$315 billion compared with US$341 billion in oil and gas[13] (Figure 2.9). Spending for renewable energy between 2021 and 2025 is predicted to increase by US$367 billion,[14] while over the same period the increase will be US$209 billion for oil and gas operations.

There are, however, several gas exploration and developments either at final investment decision (FID) stage, announcement stage, at various stages of expansion. For example, Chevron has continued its drilling of wells in the Bibiyana gas field, one of its operated fields in Bangladesh. The Bibiyana onshore gas field currently produces around 1,200 million cubic feet per day (mmcf/d) of gas, constituting around 85 per cent of Chevron's gas production in Bangladesh. In the UK, Harbour Energy projected spending about US$1.3 billion in 2022, some of which was envisaged for gas development. For example, the Tolmount field began production in April 2022 and is expected to increase UK gas production by more than 5 per cent.[15] Table 2.1 highlights some of the gas processing projects underway or forthcoming in the Commonwealth.

While capital investment levels are not expected to reach 2019 levels before 2023, it is notable that there is an increase in upstream oil and gas capital spending following a sharp decline in 2015.[16] However, the increase in spending is coming in a period of increased competition for available capital with renewable energy projects. This leaves gas-

13 SP Global (2022), 'Global Energy Sector Capex Poised for a Strong Rebound', March, available at: www.spglobal.com/commodityinsights/en/ci/research-analysis/global-energy-sector-capex-strong-rebound.html#:~:text=Fossil%20fuel%20capex%20is%20projected,36%25%20in%202021%2D2025.

14 Ibid.

15 Harbour Energy (2022), 'Trading Update', 11 May, available at: www.harbourenergy.com/news-and-media/latest-news/2022/trading-update/

16 Ibid.

Table 2.1 Gas liquefaction projects in the Commonwealth

Country	Liquefaction plant train	Infrastructure start year	Liquefaction capacity (million tonnes per annum)	Owners
Australia	Pluto LNG T2 (Expansion)	2026	5.00	Woodside* (51%); Global Infrastructure Partners (GIP) (49%)
Canada	LNG Canada T1-T2	2025	14.00	Shell; Petronas; Mitsubishi Corp; PetroChina; Korea Gas
Mozambique	Coral-Sul Floating Liquified Natural Gas (FLNG)	2022	3.40	Eni (operator); ExxonMobil; CNPC; ENH (Mozambique); Galp Energia SA; Korea Gas
	Mozambique LNG (Area 1) T1-T2	2025	12.88	Total (operator); Mitsui; ONGC (India); ENH (Mozambique); Bharat Petroleum Corp (BPCL); PTTEP (Thailand); Oil India
Nigeria	NLNG T7	2024	8.00	NNPC (Nigeria); Shell; TotalEnergies; Eni

Source: International Gas Union (2022), World LNG Report, https://www.igu.org/resources/world-lng-report-2022/

rich and gas-dependent countries with a number of risks and challenges in attracting required capital for gas investments.

In this situation, an important policy consideration for these countries will be creating and sustaining an enabling environment to enhance the attractiveness for investment in low-carbon transition pathways. Such considerations would include legislative and regulatory reforms, institutional adaptation, fiscal and commercial incentives, and infrastructure investment. It would thus be useful for these countries to reconsider existing gas sector plans and policy positions to take advantage of available opportunities for investment in a low-carbon transition pathway for natural gas development.

2.3.3 Opportunities

Despite the risks and challenges involved, there are several opportunities for Commonwealth member countries with high gas R/P ratios to pursue a transition pathway to low carbon with gas resource as an important source of primary energy (Table 2.2). They can pursue an array of policy choices, as well as leveraging partnerships and platforms to aid in significantly reducing gas emissions from gas development and production operations and in the course of implementing other carbon reduction initiatives. Table 2.2 briefly outlines some of these opportunities and strategies for countries to consider, and the sectors where such opportunities can be explored for implementation.

Table 2.2 A selection of opportunities for gas development in a low-carbon context

Sector	Opportunity
Power	Faster phase-out of coal, diesel and heavy fuel oil in the energy mix
	Ramping up gas-fired embedded generation
	Utilising flared gas from upstream petroleum operations for power generation
Transportation	Implementing gas use in heavy-duty vehicles
	Facilitating growth in ride-sharing systems
	Increasing the share of fuel-efficient vehicles in the fleet
	Removing transport fuel subsidies
Upstream gas development	• Deploying renewable energy technologies in and around offshore development facilities. These could include technologies for recovery, telecommunication systems, pumping systems, instrumentation and control, air conditioning and space heating, and other energy efficient practices such as waste-to-energy. • Measures to reduce GHG emissions in gas development and production operations, through numerous initiatives such as: – the UK North Sea Transition Deal (NSTD) between the oil and gas sector and UK government, with emissions reduction targets of 10% by 2025 and 25% by 2027;[17] – the Nigerian Gas Flare Commercialisation Programme (NGFCP), whose main objective is to eliminate routine gas flaring from upstream oil and gas operations with a commercial framework that enables the purchase and sale of gas volumes that would otherwise be flared;[18] – the World Bank Global Gas Flaring Reduction Partnership (GGFR), a multi-donor trust fund comprising governments, oil companies and multilateral organisations, which develops country-specific flaring reduction programmes, shares research and best practices, secures commitments to end gas flaring, and advises on gas flare measurements and reporting;[19] – the Global Methane Initiative (GMI), which provides technical support to deploy methane-to-energy projects that enable countries to launch methane recovery and use projects;[20] – the Climate and Clean Air Coalition's (CCAC) 'Mineral Methane' Initiative, whose aim is to achieve 45% emissions reductions over estimated 2015 levels by 2025, and by 60%–75% by 2030;[21] and – the Oil and Gas Methane Partnership 2.0, a multistakeholder initiative launched by the United Nations Environmental Programme (UNEP) and CCAC, which is a comprehensive framework for enhancing accuracy and transparency regarding measuring and reporting methane emissions from oil and gas operations.[22]
Midstream gas processing	Increasing the use of natural gas liquids (NGLs) in the production of petrochemical feedstock, such as ethane for ethylene plants or butane in chemical plants

17 Government of the UK, Department for Energy Security and Net Zero and Department for Business, Energy & Industrial Strategy (2021), 'North Sea Transition Deal: one year on', Policy paper, available at: www.gov.uk/government/publications/north-sea-transition-deal

18 Nigerian Gas Flare Commercialisation Programme, available at: https://ngfcp.nuprc.gov.ng/

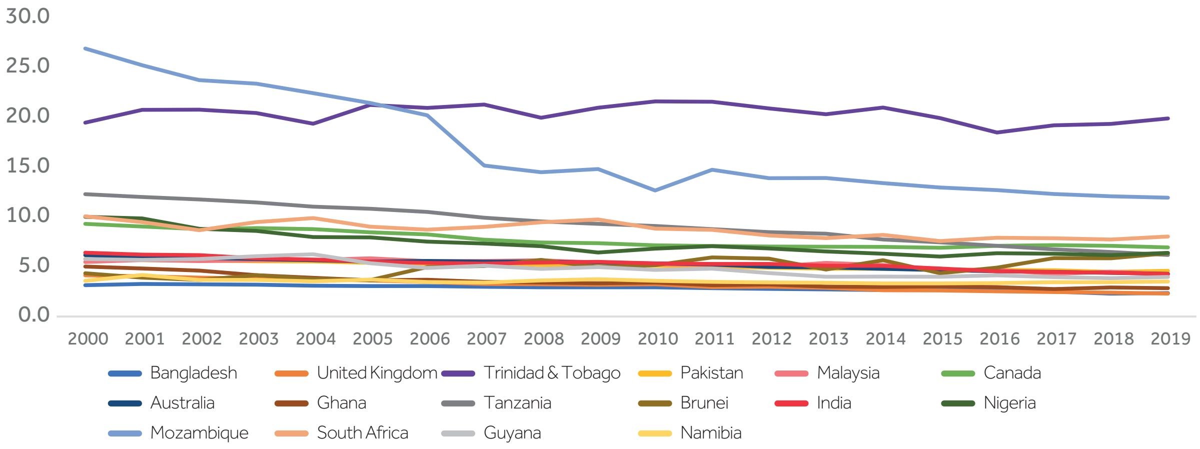
19 World Bank, Global Gas Flaring Reduction Partnership, available at: www.worldbank.org/en/programs/gasflaringreduction/about

20 Global Methane Initiative, available at: www.globalmethane.org/

21 Climate & Clean Air Coalition, Fossil Fuels Hub, available at: www.ccacoalition.org/en/initiatives/oil-gas

22 UN Environment Program (no date), The Oil & Gas Methane Partnership 2.0, available at: www.ogmpartnership.com/

Figure 2.10 Energy intensity in the selected countries (MJ/GDP)*



Sources: UN Statistics Division (no date), SDG Indicators Database

*Note: Energy intensity is defined as the energy supplied to the economy per unit value of economic output (megajoules per constant 2017 US$ purchasing power parity GDP).

Opportunities for natural gas development in the low-carbon context of the energy transition will vary from country to country. An important distinguishing factor for each of the countries is the pace of deployment of gas technologies to replace other higher-emitting conventional energy sources. The countries will be at different stages, with different capabilities and different market structures, and will have different approaches to enhance emissions reduction practices in gas development and processing. While the technologies to be deployed for these gas-related opportunities are not necessarily new, several practices that could be deployed in a low-carbon pathway for natural gas development will require innovative solutions. Such practices will include forms of carbon capture, utilisation and storage (CCUS), 'blue hydrogen',[23] or the tracking and reduction of fugitive methane emissions during operations.

2.4 Changes in energy consumption

Increasing energy efficiency is an important aspect of a transition to low carbon, particularly for lower-income countries as their economies expand and their energy access and – by implication – consumption, increases. This is also critical for higher-income countries, especially in the context of the significant savings that would be realised from efficiency improvements given their high-energy use in industries and households. Increased energy efficiency will help reduce the pace of growth in energy use, if not reduce energy demand itself.

Commonwealth developing countries in general, and the selected gas-producing countries in particular, have been experiencing a relatively consistent decline in energy intensity (expressed as units of energy in megajoules [MJ] per unit of GDP).[24] This implies that they are requiring less energy to produce a unit of economic output, and hence improvements in energy efficiency. Figure 2.10 demonstrates this improvement in the selected countries.

23 That is, the splitting of natural gas into hydrogen and CO_2, with the CO_2 captured and then stored.

24 Commonwealth Secretariat (2022), *The Commonwealth Sustainable Energy Transition: Pathways and Progress Report*, June, available at: www.thecommonwealth-ilibrary.org/index.php/comsec/catalog/book/979

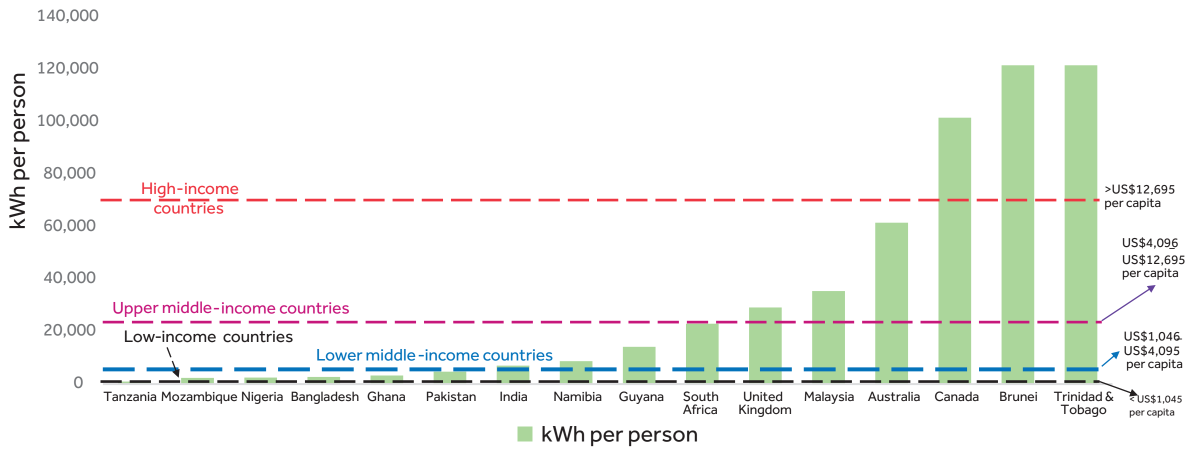
However, considering such improvements in the context of average levels of energy consumption consistent with certain levels of income and development, there are two main policy challenges.

- **The need to further improve energy efficiency in some countries:**[25] Trinidad and Tobago stands out in the cohort, with 2019 energy intensity levels at more than three times the average for the cohort of countries in the same year. The same can be said of Brunei Darussalam and Canada, which are twice and 1.8 times the global average respectively.
- **Reminder of the energy and developmental needs of developing countries:** A number of low- and lower middle-income countries have energy consumption per capita levels that are significantly below those typically observed for the upper middle-income and higher-income countries to which they aspire. Among the selected gas-rich Commonwealth member countries, Bangladesh, Ghana, Mozambique, Nigeria, Pakistan and Tanzania belong to this category (see Figure 2.11).

The following figures illustrate these policy issues further.

Another consideration in the changing dynamics of energy consumption in developing countries is rapid urbanisation and the need to meet the energy needs of such growth. Combined with growing economic output in Commonwealth developing countries, rapid changes in urbanisation often result in changes in energy appliance stock, such as in refrigeration, transportation, air conditioning and petrochemicals products (from fabric to pharmaceutical products). When considered in the context of energy consumption at different income levels, the countries with the more rapid urbanisation rates are typically the countries with lower-than-average energy access, clean fuels access, and energy use per capita, while they are not as energy efficient as higher-income countries.

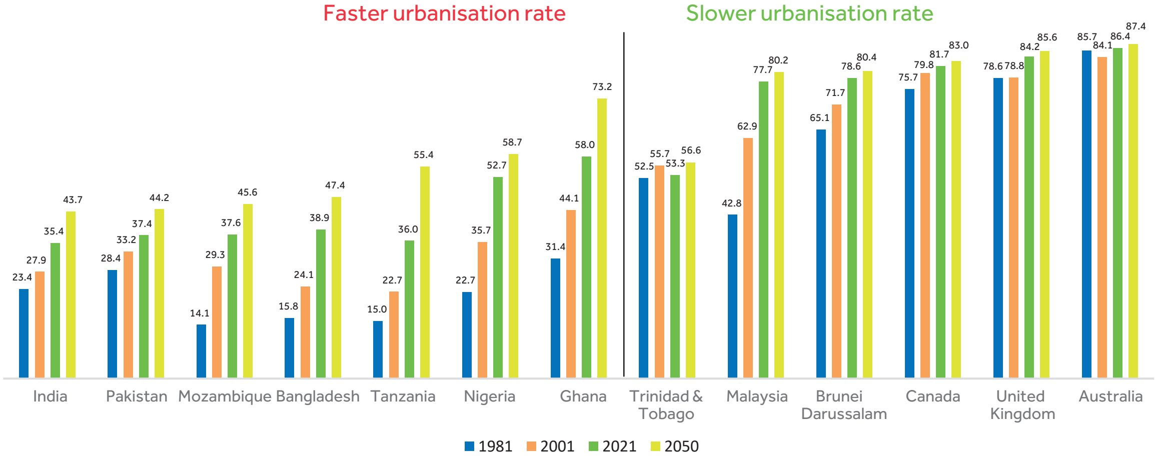
Figure 2.11 Energy consumption per capita and income levels



Sources: World Bank (no date), Open Data, https://data.worldbank.org/; Global Change Data Lab (no date), Our World in Data, https://ourworldindata.org/

25 Taking into consideration that declines in energy intensity, *ceteris paribus*, can be a proxy for efficiency improvements.

Figure 2.12 Urban population as a percentage of total population in selected Commonwealth member countries



Sources: Adapted from World Bankv (no date) Human Development Indicators, https://databank.worldbank.org/Human-development-index/id/363d401b; UN (2022) *World Urbanisation Prospects*: *Summary of Results*, https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022_summary_of_results.pdf

3. Just Transition Pathways

A just transition is of significant importance for gas-rich countries, particularly in ensuring that their transition to a low-carbon, renewable energy system is fair and equitable for all stakeholders, including workers and communities that may be disproportionately impacted by the transition. Several reasons underpin this importance. They include, but are not limited to the following three factors.

- **Economic justice:** This helps to ensure that the costs and benefits of the energy transition are distributed fairly among different groups of people, including those who may be negatively impacted by the transition. This can include workers in fossil fuel industries who may lose their jobs because of the transition to renewables, as well as communities that may be affected by the closure of fossil fuel facilities.
- **Social justice:** This recognises the importance of ensuring that marginalised groups are not disproportionately affected by the transition and are able to fully participate in and benefit from the transition.

South Africa's Just Energy Transition Investment Plan (JET IP)[26]

South Africa's JET IP is a proposal to shift the country's energy generation from fossil fuels to renewable sources, such as wind, solar and hydro power. The plan also includes measures to support communities and workers affected by the transition, as well as plans to increase energy efficiency and decrease demand. The goal of the plan is to create a sustainable and just energy system for all South Africans, while also addressing climate change and creating new economic opportunities.

Some key features of South Africa's Just Energy Transition Investment Plan include the following.

- **A shift towards renewable energy sources:** The plan calls for increasing the proportion of renewable energy in the country's energy mix, with a goal of reaching at least 50 per cent of total power generation from renewable sources by 2030.
- **Support for affected communities and workers:** The plan includes measures to support communities and workers who may be impacted by the transition, such as retraining programmes for workers in the fossil fuel industry and investments in infrastructure for communities that rely on coal mining.
- **Energy efficiency and demand-side management:** The plan aims to increase energy efficiency and decrease demand for energy through measures such as retrofitting buildings and promoting energy-efficient appliances.
- **Economic development:** The plan also aims to create new economic opportunities through the development of a renewable energy industry, such as the manufacturing of components for wind and solar power plants.
- **Carbon pricing:** The plan proposes to implement a carbon pricing mechanism to help internalise the external costs of carbon emissions and create incentives to reduce emissions. *Energy access:* The plan aims to ensure that all South Africans have access to reliable, affordable energy, particularly in rural and low-income communities.
- **Energy access:** The plan aims to ensure that all South Africans have access to reliable, affordable energy, particularly in rural and low-income communities.

26 Further information: The Government of the UK (2022), 'South Africa Just Energy Transition Investment Plan: joint statement', Press release, available at: www.gov.uk/government/news/joint-statement-south-africa-just-energy-transition-investment-plan#:~:text=A%20'Just'%20approach%20underpins%20the,Africa's%2020%20year%20energy%20transition., https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_22_6664

- **Environmental justice:** This ensures that the transition to a low-carbon, renewable energy system is done in a way that is environmentally sustainable and addresses the impacts of climate change on vulnerable communities.

There are several variations to the above considerations, but they essentially seek to answer the practical questions of how the climate mitigation measures will be funded and the pace of transition a gas resource-rich country can pursue. The latter question is discussed in the following section of this paper. The suggestion is that a more 'just' pathway for the low- and low middle-income gas-rich countries to follow is one that allows for a simultaneous and orderly development of gas and renewable energy resources. The emphasis, in this regard, is on ensuring that the economic growth prospects of such countries are not stifled as they try to achieve these energy use characteristics with significant baseload on-grid energy access.

Several of the selected countries have clearly stated the need for external financial support to execute the conditional commitments included in their NDCs. While such funding has so far failed to meet expectations set by the various pledges that have been made at previous climate summit meetings, there are examples of external commitment to supporting countries as they transition away from such fossil fuels as coal. For example, at the recently concluded Conference of the Parties (COP)27, South Africa provided details of a US$84 billion investment plan to transition from coal to clean energy. There was also a pledge of about US$20 billion to Indonesia to support the country in retiring its coal plants and scaling up renewable energy capacity.

Most importantly, and in line with the question of the pace of transition for gas-rich developing countries, 'just and equitable energy transition' must be based on national development priorities and include social protection and solidarity measures. These would include the provision of retraining programmes and support for workers adversely affected by the transition.

4. Framing the Pathways for a Low-Carbon Transition

4.1 A sequential approach

There are numerous ways to frame, from a policy standpoint, the pathways for a low-carbon transition of gas-rich developing countries. The preceding discussion has reviewed a range of policy considerations that focus primarily on timing and sequencing. It is useful to consider that countries are at different stages of the transition, different stages of development, different levels of energy access and consumption, and therefore policy measures for low-carbon transition should be country specific. There is no hard and fast rule to apply in these situations, primarily due to country specificity. However, it would be useful to present several possible country-agnostic policy instruments that can be applied, but whose application would of course vary depending on the country's specific circumstance.

The timing and sequencing of the transition for gas-producing countries are critical. As discussed earlier, diversifying too quickly from natural gas could realise the risks and associated challenges, while diversifying too slowly could exacerbate the carbon emissions contribution of these countries. What is clear, however, is a need to reflect the realities each country faces in navigating these pathways.

While the pace of transition will vary from country to country, there are possible policy instruments that can be used to help accelerate the transition. These would in turn depend on other wider policy considerations and trade-offs that the respective government faces. For example, the use of a legislative mandate can be a powerful tool in the transition. It could be deployed for the prohibition of certain activities, such as the use of wood fuel for cooking. Depending on the country's profile of factors, including gas resource potential (R/P ratios), the extent of energy access, and challenges and opportunities in developing alternative clean energy sources, this tool of legislative mandate could be deployed only where it can achieve its intended objectives. The same considerations could apply to such other policy tools as the deployment of fiscal incentives, the use of subsidies and funding of infrastructure.

There are several ways to measure the pace of energy transition, such as through renewable energy penetration, carbon intensity, energy productivity, energy access and composite indexes that aim to measure the progress of energy transition in a comprehensive way. No single metric can fully capture the complexity of energy transition, and multiple metrics should be used to obtain a comprehensive picture of progress. Additionally, measuring the pace of energy transition requires a long-term perspective, as it may take decades for the energy system to fully transition to a low-carbon, sustainable state.

4.2 Comparison of energy transition pathways

Table 4.1 compares the low-carbon pathways, as identified in the NDCs and other relevant policy positions, submitted by the selected countries. It is a non-exhaustive selection of policies and strategies adopted by the countries, as stated in their NDCs or relevant policy document. A qualitative colour coding is used to highlight the possible implications of the policies and strategies on the pace of transition pathway that the country could follow, as well as the impact it could have on prospects for further natural gas development. Green indicates a positive impact on gas development and production, such that the introduction of renewable energy technologies does not necessarily result in a reduction of pace in gas development. Amber indicates neutral impact, such that there is a likelihood that an increase in renewable energy effort would likely come at the expense of, or at a faster pace than, the pace of gas development and production. Red indicates that the impact on gas development could be negative, in the sense that an increase in climate change mitigation efforts will more likely be at the expense and in replacement of gas development.

Table 4.1 Energy transition pathways for gas-producing Commonwealth countries

	Policy / strategy, as extracted from most recently published NDC or other government policy document	Potential impact on gas development[27]
Australia	• Invest 20 billion Australian dollars (A$) in Australia's electricity grid to unlock greater penetration of renewable energy and accelerate decarbonisation of the grid • Invest up to A$3 billion from the new National Reconstruction Fund to support renewables manufacturing and the deployment of low emissions technologies • Introduce declining emissions baselines for Australia's major emitters • Accelerate the uptake of electric vehicles • Commit to reduce the emissions of government agencies to net zero by 2030	
Bangladesh	• Grid-connected Solar-581 megawatt (MW), Wind-149MW, Biomass-20MW, Biogas-5MW, New Hydro-100MW, Solar Mini-grid-56.8MW by 2030 • Install new combined cycle gas-based power plant (3208MW) by 2030 • Improve efficiency of existing gas turbine power plant (570MW) by 2030 • Improve road traffic congestion (5% improvement in fuel efficiency) • Achieve 10% energy efficiency in the industry sub-sector through measures according to the Energy Efficiency and Conservation Master Plan (EECMP) • Use energy-efficient appliances in household and commercial buildings (achieve 5% and 12% reduction in emissions respectively) • Establish waste-to-energy plant in Dhaka	
Brunei	• Achieve zero-routine flaring and reduce other industrial emissions through reduction of fugitive emissions within oil and gas facilities • Increase carbon sink through afforestation and reforestation • Increase total share of electric vehicles (EV) to 60% of the total annual vehicle sales by 2035 • Increase total share of renewable energy to at least 30% of total capacity in the power generation mix by 2035 • Reduce GHG emissions by at least 10% through better supply and demand management of electricity consumption by 2035 • Impose price on carbon emissions for industrial sector • Mandatory monthly and annual reporting of carbon inventory	

27 Author's assessment, based on policy direction regarding decarbonisation.

	Policy / strategy, as extracted from most recently published NDC or other government policy document	Potential impact on gas development[27]
Canada	• Reduce emissions and energy costs of homes by creating a C$2.6 billion Canada Greener Homes Grant initiative and providing up to C$4.4 billion in loans for homes and commercial buildings retrofitting • Require 100% of new light-duty vehicle and passenger trucks sold in Canada to be zero emissions by 2035 • Invest $964 million in smart renewable energy and grid modernisation projects • Commit to powering rural, remote, northern and Indigenous communities that currently rely on diesel with clean, reliable energy by 2030 • Introduce an investment tax credit for capital invested in carbon capture, utilisation and storage projects, with the goal of reducing emissions by at least 15Mt of CO2 annually • Invest more than $3 billion over ten years to plant two billion trees	
Ghana	• Early warning and disaster risk management • Promote energy efficiency in homes, industry and commerce • Low-carbon electricity generation • Expand the adoption of market-based cleaner cooking solutions • Promote sustainable charcoal production • Scale up renewable energy penetration by 10% by 2030 • Decarbonise oil and gas production	
Guyana	• Improve ongoing work to realise sustainable forest management, by ensuring compliance with the various codes of practice that govern the timber industry using local resources • Improve added-value activities locally to assist in creating higher potential for carbon storage in long-use wood products • Strengthen support for indigenous communities as they continue stewardship of their lands, including support to better manage their transition to more market-based means of social and cultural well-being • Continue to avoid emissions in the amount of 48.7MtCO2e annually, subject to adequate conditional incentives • Conserve an additional 2 million hectares through the National Protected Area System • Reduce emissions by 13.5% through reduced impact logging, and reducing incidental and collateral damage during tree felling by about 10%	

	Policy / strategy, as extracted from most recently published NDC or other government policy document	Potential impact on gas development[27]
India	• Reduce emissions intensity of GDP by 45% by 2030, from 2005 level • Achieve about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030 • Create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover	
Malaysia	• Achieve economy-wide carbon intensity reduction (against GDP) of 45% by 2030 compared to 2005 level	
Mozambique	• Strengthen climate risk preparedness and response capacity • Increase the resilience of agriculture and livestock and fisheries • Develop low-carbon agricultural practices • Increase water resources management capacity • Rehabilitate deforested areas for pasture creation, agriculture practice, forest resources exploitation	
Namibia	• 30% reduction equivalent in the quantity (2.668TWh) of electricity imported in 2018, which would result in 0.8TWh (800GWh) in new renewable energy generation of 330 MW of Solar PV per annum until 2030 • Reduce deforestation rate by 75% • Reforest of 20,000 hectares per year • Promote passenger vehicle fuel efficiency standards • 10,000 electric vehicles – replacing gasoline • Renewable Energy Feed-in Tariff (REFIT) 70MW PV – replacing imports • Solar rooftop systems (45MW PV) – replacing imports • Embedded generation – 13MW PV replacing imports • Replace 23% clinker in cement production	

	Policy / strategy, as extracted from most recently published NDC or other government policy document	Potential impact on gas development[27]
Nigeria	• Increase switch to clean fuels for cooking by 2030 (48% of population using LPG and 13% using improved cookstoves) • Elimination of kerosene lighting • 100,000 extra public transport buses • 25% of trucks and buses to convert to compressed natural gas (CNG) • All vehicles to meet EURO IV emission limits by 2030 • 30% of on-grid electricity from renewables (mostly hydro, with solar and wind) • Reduce grid transmission and distribution losses to 8% of final consumption of electricity • Replace 100% of diesel and gasoline power generators with combined cycle gas generators • Achieve zero gas flaring in oil and gas operations by 2030 • Reduce fugitive methane emissions by 60% by 2031	
Pakistan	• Achieve a target of 30% and 90% share in sale of electric passenger vehicles and heavy-duty trucks by 2030 and 2040 • Implement result-based financing (RBF) pilot projects to encourage private sector investment for off-grid solutions • Implement bus rapid transit systems • Achieve at least 20% renewable energy generation by 2025 and at least 30% by 2030 • Complete ban on open burning of rice stubble, solid waste and other hazardous materials • Encourage turning animal waste (cow dung) to methane for use as fuel for rural household and urban transportation projects	

	Policy / strategy, as extracted from most recently published NDC or other government policy document	Potential impact on gas development[27]
Tanzania	• Promote clean technologies for power generation and diverse renewable sources such as geothermal, wind, hydro, solar and bioenergy • Expand the use of natural gas 15 for power production, cooking, transportation and thermal services through improvement of natural gas supply systems throughout the country • Reduce the consumption of charcoal in urban and rural areas by promoting affordable alternative energy sources through a regulation policy for charcoal production and use • Promote low-emission transport systems through deployment of mass rapid transport systems and investments in rail, maritime and road infrastructures, including high-quality transport systems and expansion/scaling up of bus rapid transit (BRT) infrastructures • Promote nationwide forest landscape restoration programmes and initiatives • Promote waste-to-energy technologies	
Trinidad and Tobago	• 30% reduction in GHG emissions by 31 December 2030 in the public transportation sector compared to a 'business as usual' scenario • Feed-in Tariff (FIT) Policy for the integration of renewable energy into the national grid • Large-scale renewable energy installation (10% utility-scale solar) • Acquisition of new high-efficiency single-cycle generators in Tobago • Light Bulb Replacement Programme • Conduct carbon capture and storage studies • Improve use of energy and heat in industrial processes • Implement more efficient technologies in the oil and natural gas sector to reduce fuel consumption in the production process • Promote a fuel switch in public transportation to CNG • Upgrade and replace aircraft • Introduce alternative fuels to the marine navigation sector • Establish a national waste recycling programme	

	Policy / strategy, as extracted from most recently published NDC or other government policy document	Potential impact on gas development[27]
United Kingdom	• Invest substantially in clean energy, committing up to £1.7 billion to increase the UK's nuclear energy production and over £1.6 billion to advance offshore wind capacity to meet the UK's 50GW target by 2050 • Publish the first three in a series of investor roadmaps for automotive, hydrogen and carbon capture, usage and storage (CCUS) • Launch the £240 million Net Zero Hydrogen Fund • Commit to phase out unabated coal power by 2024 and to fully decarbonise the power system by 2035 • Commit to ending government's direct support for the fossil fuel energy sector overseas • Commit to ending the sale of new petrol and diesel vehicles by 2030, and for all new cars and vans to be fully zero emission at the tailpipe by 2035	

Key to Table 4.1 Impact of clean energy technology strategies included in NDCs on natural gas development			
Levels	Lowest	Medium	Highest
Criteria	Positive impact on the pace of gas development and production	Neutral impact on the pace of gas development and production	Negative impact on the pace of gas development and production

The pace of the energy transition is not solely determined by policy and cost. Factors such as infrastructure, public perception and availability of financing also play a role. Lack of infrastructure for renewable energy can slow the transition, as can resistance from the public or a lack of financing for clean energy projects.

Overall, the pace of energy transition pathways is complex and multifaceted. While government policy, cost and other factors play a role, there is no 'one-size-fits-all' approach. A combination of approaches, including policy and regulations, technological advancements, public engagement, and financing, will likely be adopted in different forms across countries.

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