Natural Resource Governance Institute

Framework for Countries Evaluating Gas-to-Power Pathways

Goal 1: Navigating the Energy Transition and Climate Crisis

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When do gas-to-power projects make sense for developing fossil fuel-producing countries?

Many developing countries with gas reserves have ambitious plans to use more of their gas domestically. The reason could be that they face power shortages, high energy costs, or the risk of losing out in the global energy transition. With such problems, some countries see extracting and burning more gas as the best—or even the only—option, at least in the short term. Different countries also have different starting positions: A middle-income, industrialized nation that sees gas mainly as a substitute for coal will not feel the same pressures and constraints as a low-income, fossil fuel-dependent country that wants to use gas to expand energy access and build a diversified economy for its young, fast-growing population.

But betting big on gas comes with serious risks and tradeoffs, especially as the world moves away from fossil fuels. Hasty, ill-informed decisions today could carry hidden costs for a country's development prospects, energy costs and security, and climate, especially if it ends up locked into a dirty, outdated and high-priced domestic energy system. There are also opportunity costs to weigh: What else could be accomplished with the money, time and political capital spent on gas?

Given these high stakes, the Natural Resource Governance Institute (NRGI) is developing an analytical framework to help government officials, researchers, activists, campaigners, other civil society actors, and journalists in gas-producing, developing countries ask: How well will producing and burning more gas to generate electricity serve a particular country's goals for its domestic energy sector?

The content is organized around five goals, each with a short module:

GOAL 1
Navigating the energy transition and climate crisis

GOAL 2
Providing electricity to those who need it

GOAL 3
Attracting foreign investment and finance

GOAL 4
Making electricity cheaper

GOAL 5
Growing and diversifying the economy

These five modules will be released one at a time.

Each contains information, questions and considerations to help stakeholders challenge common narratives and claims made by gas advocates.

A few notes on what this framework does and does not do:

- It does not tell countries that they must stop producing or burning gas now because of the climate crisis, though there is a section on climate considerations (see Common Claim 1.3). Of course, NRGI believes the world urgently needs to extract and burn far fewer fossil fuels to avoid the worst-case climate change scenarios. We also see many countries planning gas projects that look incompatible with a 1.5-degree scenario or net zero by 2050. But we also know that countries bear unequal responsibility for the crisis and that hard-line messages on climate may not resonate in some places, especially when they come from an international NGO. Instead, we think that more people at the forefront of the debate in gas-producing countries should be asking the question, "Is it really in our interest, or even realistic, to invest more in gas?"

- This framework is not a standalone "tool," model or methodology that can conclude whether a particular gas-to-power project is bankable, cost-effective, or Paris-aligned. Reaching such conclusions can involve work by a range of experts using all sorts of tools and methods, many of which are discussed in the different modules. The goal, instead, is to help non-expert, interested actors ask hard questions about governments' gas-to-power ambitions.

- In what follows, "gas-to-power" includes electricity generation projects in which the gas comes from a linked gas extraction project in the host country or deliveries of imported gas through pipelines or liquified natural gas (LNG). Although projects are the main unit of focus, much of the information and questions presented could also help stakeholders assess the gas-related parts of domestic energy plans and policies, as well as other types of projects that use gas for fuel—cement, fertilizer, or petrochemical plants, for instance.

NRGI staff are already using this framework in country-specific engagements, and hope it will help others make better energy sector decisions for better futures.

Navigating the energy transition and climate crisis

GOAL

1

Key messages

- Gas will play and important role in the energy transitions of some developing countries. Producing and burning more of it could help backstop renewables and replace dirtier fuels. It could also shield countries from some of the worst effects of the global energy transition—for example, volatile prices for imported fuels.
- Over the longer term, however, investing big in gas-to-power projects could leave countries with domestic energy mixes that cost more, hold back development, and undermine global climate goals.
- Stakeholders should weigh the trade-offs carefully—especially since the future is hard to predict and politics often discounts the future. In particular, they should ask if other, less risky investments and pathways could achieve the same goals.

This document, the first module in a series of five, provides stakeholders with information and options for interrogating three common claims about the role of gas in domestic energy transitions:

Common claim 1.1

"Gas will be a 'transition fuel,' a short-term 'bridge' to renewable electricity."

Background

Realistically, many developing countries will need decades to switch to 100 percent renewable electricity. This is partly because of the steep challenges they face—consider this short list of more common ones:

- **Technical:** Power sector infrastructure needs significant changes and additions for renewables to work; the sector lacks the know-how and access to clean technology; solar and wind intermittency may destabilize the grid (see Common claim 1.2).
- **Commercial:** The electricity supply chain is financially unsound or based on business models that do not allow new projects to make attractive returns; the country cannot spend or borrow enough for the big investments needed.
- **Political:** The regulatory and institutional frameworks for power are unfinished or dysfunctional; key decision-makers in government do not devote attention or support to renewables; popular narratives create false or inflated expectations around gas; vested interests block change.

Issues like these lie behind many of the arguments about whether poorer countries can "leapfrog" over gas to renewables and whether planning for 100 percent renewable power systems is even realistic. Such arguments may hold important truths about the challenges lower-income countries are facing. But they can also be overly simplistic, especially when they frame investing in gas and renewables as an either-or choice.

At the same time, claims about the limits of renewables, or the urgent need to add gas to the grid, can also distract attention from an important risk: that investing too much in gas now can "crowd out" renewables over time, "locking in" a country to a domestic energy mix that relies heavily on fossil fuels long after renewables would better meet its needs and goals.

All sorts of factors and dynamics could put a country on a path to long-term gas dependence. For example:

- To attract investors and recoup costs, the government has to sign contracts and loans that last decades and prioritize gas in the electricity mix.
- To achieve its plans, the country must build lots of new gas infrastructure, which remains in service for decades.
- The choice to develop gas-fired power before renewables gives further new gas projects a cost advantage, at least initially.
- Over-investment in gas creates a power surplus, killing the demand for renewables.
- Heavy investments in gas mean less public or private financing for renewable energy projects.
- The electricity sector develops expertise in gas-fired power rather than renewables.
- Politicking and contracting around gas projects creates vested interests.

There can be many variations on these, and not all necessarily lead to lock-in. Since many developing countries are still early in their transitions away from fossil fuels, good case studies of what measures lead to and prevent lock-in are limited; some lessons are inferred from earlier transitions in wealthier countries—e.g., the move away from coal. With these caveats in mind, this section offers an overview of the latest and best thinking on how countries can make lock-in less inevitable.

Considerations and questions

Energy sector plans should clearly describe the changing role of gas over time, and how gas and renewables would work together.

The details could be found in a range of official documents: grid expansion or integration studies, least-cost generation plans, sector master plans, development plans, energy market assessments, or the long-term strategies required under the Paris Agreement. Some countries may not adhere to their own plans, of course, but reference to plans can be a useful way to focus public debate and hold decision-makers accountable. And without a plan, the fossil fuel-based status quo is more likely to survive. Here stakeholders could ask:

- Are the government's supply and demand projections for gas and electricity credible?
- What power projects are listed as planned or commissioned?
- What grid improvements are planned, and what is the associated model for future electricity generation? Is there an intention to build most new transmission and distribution lines around one or a few large urban gas plants, or to connect smaller solar or wind farms in different areas to the grid?
- Do the plans use modeling or scenario-based analysis to show how the role of gas in the electricity mix will change over time? The main types of services power plants can provide are:
  - **Base load:** The plant runs continuously for long periods, providing a stable flow of electricity that meets a large portion of daily demand.
  - **Peak load or mid-merit:** The plant runs for shorter periods—often minutes or hours—to meet daily peaks in demand.
  - **Ancillary services:** The plant runs at lower levels to provide stable power to consumers, such as regulating voltage and frequency on the grid or responding to unplanned outages.

In developing countries, gas plants may be less likely to displace renewables if they can shift more to the latter two kinds of services over time, to support solar and wind energy rather than compete with them for customers.

- What capacity factors do the plans use? Power system modeling assumes every gas-fired power plant or solar/wind farm will operate at a certain "capacity factor"—that is, a level of actual electricity output that is a percentage of the maximum power the plant could generate over time. If the plans show gas plants operating at higher capacity factors—over 40 or 50 percent, say—without major drops over time, this could suggest gas will remain a baseload power source throughout the plant's useful life.
- Do the plans set dates for decommissioning or retiring gas plants? Timelines for this may have climate policy implications as well (see Common claim 1.3, below).
- Do different official documents share the same vision?
- Who supports and opposes the plans, and why?
- When and why were the plans announced? For instance, were they developed after a process of study and consultation, or rolled out quickly around a major political event like a scandal, economic crisis, or election?
- Do the plans clearly articulate why gas is the best fuel for electricity generation—e.g., due to cost, ability to meet rising demand? Or do they start with the premise that the country has reserves and they should be harnessed for power generation?

It is also worth checking whether the country's international climate commitments describe pathways for weaning electricity suppliers and consumers off gas over time.

In a country where energy policy and planning are siloed, plans developed by energy sector gatekeepers may present a very different vision of the future than the country's nationally defined contribution (NDC) or long-term strategy (LTS) required by the Paris Agreement. The different documents may also enjoy different levels of political support and relevance for decision-making. Stronger linkages between climate commitments and domestic energy plans could help ensure that hard questions around the suitability of gas-fired power are asked, and that vested interests cannot capture planning processes unchallenged. It might also help attract climate finance, as shown by South Africa's Just Energy Transition Partnership (JETP). Energy transition advocates should also see the commitments in NDCs and LTSs as additional promises for which the government can be held accountable.

The choice of gas plant technology also deserves careful consideration.

When developing countries build new gas power plants, or convert existing power plants to gas, they usually install either large closed-cycle gas turbines (CCGTs) or smaller open-cycle or "simple" gas turbines (OCGTs). Each has pros and cons, for instance:

	PROS	CONS
CCGT	- (generally) cheaper to run per kWh - lower emissions per kWh	- costs more to build - lack of flexibility: needs to run for many hours to turn a profit
OCGT	- cost less to build - greater flexibility: can turn a profit after running for fewer hours	- (generally) more expensive to run per-kWh - higher emissions per kWh

These differences, in turn, raise at least the following questions about which technology will best help a country avoid lock-in and meet its other energy sector goals:

- Is the technology the best fit for the intended goal? If the country is adding gas to the grid mainly to close a large electricity supply gap, CCGTs generally will do that more quickly and efficiently. If the goal is to lower costs, CCGTs can cost less to run per MWh than OCGTs—though governments should remember the important caveat in the next bullet.
- Is the technology right for the operating environment? In dysfunctional operating environments--those with regular grid failures or fuel shortages, for example--CCGT plants can struggle to run enough hours to recoup their high capital costs. In worst cases, this can leave the government subsidizing their operations, or paying for power or capacity it can't use. One study concluded that in a typical lower-income country, OCGTs will likely be the least-cost technology except at capacity factors above 80 percent, which are rarely seen anywhere.
- Is the technology more likely to help or hinder a shift to renewables? Because OCGTs cost less to build, they can more easily turn a profit while running mainly as a back-up to renewables—for instance, operating in peak or balancing/ancillary modes. They may also be able to be retired earlier, depending on the debts and contracts attached to them. By contrast, CCGTs' design and high capital costs mean they need to run a lot, and thus are less appropriate for back-up generation, where they would need to sit idle most of the time. This could make them more likely to compete with solar and wind, not complement.
- Could other, smaller pieces of technology get the job done for less cost and risk? On this point, see Section 1.2's discussion of other technologies that can help manage variability.

Contracts for individual gas projects need terms that allow a plant's role to shift as more renewables come on stream.

Ideally, from a cost and risk perspective, public utilities should be able to buy power from the plants able to supply it when needed in ways that best serve the country's energy sector needs and goals. In reality, though, outside investors in developing country gas-to-power projects can demand contract terms that force the country to keep buying power from their plants even when it is not the best option. In many countries, the negotiation and signing of the relevant types of contracts—especially power purchase agreements (PPAs) and fuel supply and transport deals—are subject to very little public scrutiny; terms frequently are not publicly available. Governments may not have the bargaining power or favorable investment environments needed to avoid all contract terms that risk lock-in. But interested stakeholders should ask whether the public utilities, ministries or other bodies handling the negotiations are doing all they can to minimize the risks. Relevant questions here include:

- Does the PPA include a flexible operating regime for the plant that allows it to perform different services and run less over time? Answering this question can take some analysis and modeling, as PPAs tend not to have provisions saying things like "This plant will only run in baseload mode." Instead, the operating regime is implied by details scattered across many of the contract's clauses—for example, those on the power plant's minimum functional specifications, capacity minimums and definitions, rules for dispatch and over- and under-generation, net energy output requirements and outages.

- How are capacity payments calculated in the PPA? Many PPAs in developing countries require the offtaker to compensate the owner for certain amounts of plant downtime. These are called "capacity payments," and they come on top of amounts owed for the electricity the plant generates when up and running (often called "energy payments"). Capacity payments can be useful for weaning a country off gas-fired power, allowing investors to recoup their investments while the state-owned utility gets more electricity from renewable sources. But if a PPA requires a utility to buy too much capacity at too high of a price, it may become too expensive to idle the gas plant. This could especially be true if the utility is already in financial distress, as is the case in many developing countries. In extreme cases, high-capacity payments could even endanger a country's financial health.

- How are take-or-pay obligations structured in the PPA? In a PPA, a take-or-pay (TOP) clause requires the buyer to purchase a certain amount of power or pay a fee for any part of this amount that it does not take. These clauses have become standard in developing country PPAs, mainly because third-party debt financiers insist on them. They can help safeguard investor returns, but they can also leave power purchasers stuck with crippling debts and force governments to keep using existing power plants, as happened in Ghana, for instance. Given these risks, there are different ways to structure TOP arrangements that can balance buyer and seller risks more fairly. In terms of contract language, the government can ask for a wider range of deductions and exemptions from the TOP amounts it must pay, or negotiate to pay lower prices for the power it doesn't take. Caps on overall TOP liability and "make-up rights" that let the buyer purchase some of the power later can also offer some protection against crushing TOP debts. Another option is to explore using take-and-pay or take-or-cancel provisions instead, though these have their own risks and tradeoffs.

- How long do the contracts last? Are there provisions for renegotiation and renewal, or early retirement and decommissioning? It could also be worth asking whether the agreements would last longer than the period needed for investors to achieve a fair return on investment.

- If contract terms are not made public, why not?

Common claim 1.2

"More gas-fired power is needed to manage the variability of renewables."

Background

The basic job of an electrical grid operator is to supply enough power to meet demand throughout the day in ways that don't cause the grid to fail (sometimes called "meeting load"). The more sources of power are feeding the grid, and the more supply from them fluctuates, the trickier this job can be. The operator also must account for the fact that demand is changing minute-by-minute.

Large solar or wind farms can make it harder to keep a grid stable. Unless they come equipped with batteries or other storage technology, the electricity they produce generally isn't dispatchable—that is, it cannot be generated on command when needed. Instead, it flows onto the grid whenever it is available, i.e., when the sun is shining or the wind is blowing. In moments when supply from renewables is bigger or smaller than demand, the grid can malfunction if the grid operator or someone else in the power supply chain doesn't do something to compensate. Unplanned grid failures like brownouts and blackouts can occur, and these can be costly for households and businesses.

When power supply overtakes demand, plants may also have to curtail generation in ways that undermine their economics and cause wear and tear.

These issues tend to increase as renewables' share of total generation goes up, and developing countries can face distinct challenges. Unlike rich economies, where electricity demand tends to be flat and infrastructure is built up, they often have inadequate infrastructure and fast-rising demand. Some will also have to build entirely new, more complex regulatory structures and markets as they transition to new technologies.

Adding gas-fired power to the grid is one way to manage renewables' variability, though by no means the only one. Countries may have cheaper, more sustainable options for achieving the more flexible generation and markets that help renewables succeed. Most will not be magic bullets, and grid management is a niche, highly technical area that we cannot cover in detail here. The goal of this section is to give an overview of the issues and the full range of responses.

Considerations and questions

More efficient ways of managing supply and demand could offer cheaper, more permanent responses to variability than gas.

Sinking money into new infrastructure is not the only way to plan for and respond to power fluctuations. Other options can be as simple—and cost-effective—as using new software or training people to do their jobs differently. Here stakeholders could ask questions like:

- Has the grid operator tried more advanced, short-term load forecasting or weather forecasting?
- Would new ways of managing grid power reserves help?
- Could power be distributed over a wider area? For instance, using grid interconnections, extensions, regional markets and power pools.
- Are the country's grid codes designed to make integrating renewables easier?
- Has the country looked at its options for demand management? For instance, through time-of-use tariffs, incentives payments or other energy efficiency initiatives.

Countries should also explore other, lower-cost technologies to help balance the grid before settling on large gas plants.

These more modest fixes might serve other goals less well than gas turbines, of course, especially closing power supply gaps. Nonetheless, it is worth asking:

- Would smaller gas-fired equipment be enough to solve the problem of intermittency? Some solar and wind farms use networks of gas-powered internal combustion engines—reciprocating engines or aero-derivative turbines, for instance—that ramp up as sun or wind levels go down. These devices can be cheaper alternatives to CCGTs and OCGTs.

- Has anyone looked into when battery storage for solar and wind plants will be affordable for the country, or hydrogen as a storage option? Some modeling has found that on-grid wind- or solar-plus-battery systems are already cheaper than gas peaker plants in many countries. In some countries, gas power may be better understood as a bridge to storage than to renewables, and so the sooner storage is viable, the less gas may be needed.
- Could mini-grids provide power to the main grid to help keep it balanced?
- Can solar and wind help balance one another? For instance, if they tend to peak at different times of the day or are distributed across the country in ways that don't overload the grid.
- Could the country use any other technologies to help stabilize the grid? Examples include synchronous condensers, large hydro and pumped hydro storage.

Addressing renewables variability should start with a clear, shared understanding of the actual problems more solar or wind will cause, including when and how.

Without this, countries will be more likely to choose less effective responses, and it could be easier for pro-gas voices to exaggerate the problem. The challenges will also vary from time to time and place to place—consider this simplified, non-exhaustive list based on issues that different weather patterns can cause:

Challenge	Possible response
Solar/wind generation regularly exceeds demand at parts of the day	- Try using time-of-day tariffs or other demand management tools to shift demand - Transmit and distribute power over larger areas, e.g., through grid extensions or loops - Determine whether storage is economical
Peak solar/wind generation does not correspond to peak demand, leaving a supply gap at peak times	- Use weather and demand forecasting to identify the problem times - If possible, dispatch more power from other existing sources at those times - If solar and wind peak at different times, see whether they can help balance one another - Explore storage options
Sunshine/wind speeds fluctuate rapidly and dramatically throughout the day	- Use better forecasting to anticipate changes in real-time - Explore new reserve management techniques and storage options - Analyze whether small-scale tech (aero turbines, reciprocating engines, condensers, etc.) could provide enough stability

In this area, stakeholders should ask questions like:

- If the country has already introduced a significant amount of solar or wind energy to the grid, have there been more planned or unplanned power outages (load-shedding, brownouts, rolling or total blackouts, etc)? It is also important to understand the extent to which the problems have worsened, and the extent to which they are due to renewables rather than other common causes of power outages like equipment failures or damage caused by weather events, animals or third parties.
- If there are no serious problems now, when will the expansion of renewables actually start to destabilize the grid? How much solar or wind a grid can absorb without problems varies from place to place.

Some wealthier countries have added 10 to 15 percent before seeing issues that needed more careful management—a milestone that very few countries in the Global South have reached. Other studies have posited that developing countries could reach 20 percent or higher before integration challenges kick in, and a different rule of thumb is that the amount of solar or wind on the grid cannot exceed the average capacity factors of solar or wind farms in the country without causing instability. Countries with little or no renewables on the grid now should pay particular attention to these findings, especially if it takes years to build up solar or wind generation capacity. Because other, more cost-effective solutions than gas could be available to them by the time they start to experience serious intermittency problems.

- Has the government or any other actor modeled what will happen if the share of solar and/or wind power in total generation grows? The results can be found in a range of official documents, including grid integration studies or generation and transmission master plans.
- Do the government's plans for dealing with variability allow for solutions to change over time? The challenges of integrating renewables into the grid—and the best responses—can go through different stages as their share of total generation grows. One modeling-based study projected, for instance, that large gas power plants running CCGTs would only be effective at reducing curtailment at solar farms when solar made up 25-40 percent of the grid's total load. The benefits at higher and lower levels were much weaker.

In more dysfunctional power sectors, operating and market conditions might make it difficult to add any major new capacity to the grid, not just solar or wind.

If the problems are too severe, new gas-fired power could face many of the same challenges as solar or wind, and governments might need to focus on fixing underlying issues before adding lots of new generation capacity. Here are just a few of the problems new installations can face:

- Are there routine blackouts, grid failures, or other service interruptions?
- How high are transmission and distribution losses?
- Does the grid regularly fail because it is damaged or in disrepair? For example, due to poor maintenance, extreme weather, or criminal acts like illegal connections or sabotage.
- Are there plans to update or repair the grid? How much will these cost, who will pay, and what is the status?
- Does the supply chain include state-owned companies with deep technical, commercial or political problems?
- Is the local electricity market structured in unsustainable ways?
- Do actors in the supply chain often have to shut down or curtail service? For instance, because of fuel shortages, operator errors or financial distress caused by unpaid bills, high debts, high operating costs or low customer tariffs.
- What are the underlying causes of these problems? Possibilities include poor business models, labor and capacity shortages, corruption and vested interests, high debts, foreign currency shortages and customer inability to pay.
- What is being done to address them? Who supports and opposes the plans? How likely are they to succeed?
- Realistically, does the country have more potential to boost power generation and access through off-grid systems rather than on-grid?

Common claim 1.3

"Gas is a green fuel. Using more of it for electricity will help reduce our country's carbon footprint and fight climate change."

Background

Every country should want fast action on climate change, not least because they all stand to lose something. To avoid the most catastrophic impacts, the world needs to produce and burn much fewer fossil fuels starting now. Unfortunately, though, fossil fuel-producing countries as a group are not making plans capable of meeting the Paris Agreement goal of limiting global warming to below 1.5 degrees Celsius.

When it comes to gas, this is mainly the fault of a small group of richer, high-emitting gas producers and consumers such as the US, Canada and various EU countries, and so it is hardly surprising that many developing fossil fuel producers are rejecting calls to curb their ambitions for gas. Many see other goals, like expanding electricity access, as more pressing than climate action. Others resent the rich world's interference and hypocrisy, especially when the wealthy players that caused the climate crisis are still falling appallingly short on their international climate finance pledges. At the same time, other developing country voices are claiming that new investments in gas will help their country clean up its own environment and meet its Paris commitments.

Making climate concerns part of the debate on domestic energy policy is welcome anywhere. To support good outcomes, though, claims need to be grounded in evidence that lets stakeholders see all that is at stake. Some more pro-gas stakeholders point out, for instance, that:

- The carbon impacts of developing countries adding gas will be small because their emissions are tiny compared to the rich world. The entire African content, for instance, accounts for just 3 percent of all CO_2 emissions, and one study estimated that if Sub-Saharan Africa tripled its electricity consumption overnight and 100% of the new power came from gas, global emissions would only grow by 0.62 percent.
- Gas is cleaner than the fuels many developing countries are burning for power now. As a rule of thumb, burning gas for power emits about half the CO_2/MWh as coal and two-thirds that of diesel or fuel oil. It is also cleaner than flaring gas at production sites.

These arguments hold some truth, at least in the shorter term. But the "green" benefits of gas can be overestimated, especially when the total emissions of new projects are underestimated and individual investments help "lock in" a bigger, higher-carbon future (see Common claim 1.1). Once again, countries should ask themselves whether there could be bigger, hidden costs down the road, both for themselves and the planet.

Considerations and questions

Gas-to-power projects don't just emit greenhouse gases when they burn gas. Other, less visible sources of emissions also need to be factored in.

When burned for electricity, gas may give off fewer GHGs per unit than coal or some other fuels. But a project's full emissions intensity will also depend on many other factors, including:

- The chemical properties of the gas
- How it is transported, and over what distances
- What is done to contain emissions elsewhere in the supply chain—for instance, those that happen through infrastructure leaks, venting or flaring of gas

These variables can limit or even erase the "green" benefits of gas. One study from the US estimated, for instance, that under certain circumstances, electricity generated from gas could have the same or higher GHG emissions as coal over 20 years. And the longer a project's supply chain, the more opportunities there could be for harmful emissions of CO_2 and methane.

Modeling all these variables is a complex task. At a minimum, though, stakeholders may want to ask decision-makers a few basic, important questions:

- Has anyone modeled the project's emissions? What were the results?
- Do the emissions figures for the project include methane leaks across its supply chain? How high would the leaks be? Methane (CH_4) is the largest ingredient in so-called "natural gas," along with smaller amounts of other greenhouse gases (GHGs) that cause global warming, for example, CO_2, nitrogen oxide (NO_x), and sulfur oxide (SO_x). It is an especially destructive and long-lasting GHG, contributing far more to climate change than was previously thought. One study found that methane is 28 times more potent than CO_2 over a century and 86 times more potent over 20 years.

Methane leaks happen all along the gas supply chain and have been chronically undercounted. If they occur at high enough rates, they could cancel out any climate-related benefits of burning gas in place of other fossil fuels. One study found, for instance, that poorly-managed gas infrastructure leaked methane at rates as high as 4 percent, while another concluded that the emission savings of switching from coal-fired power to gas disappear when methane leaks are higher than 2 to 3 percent.

- Will the project require LNG imports, and have emissions from those been factored in? Liquification and regasification of gas emit still more methane and CO_2, though some investors are looking into how to power LNG plants with renewables. Marine transport of LNG is also carbon intensive, and emissions from transnational shipping are often undercounted in the country and global totals.

A gas-to-power project's climate benefits could be doubtful if the project includes new gas production.

Global studies and models have found that at this point, new gas production would be incompatible with a 1.5C temperature rise, and with reaching net zero by 2050. This would especially be the case if larger, richer gas-producing countries don't move quickly to phase out extraction. The world could already be on track to producing double the fossil fuels allowable in a 1.5-degree scenario by 2030.

- How much gas would be produced under the new project?
- Would the new gas produced be associated gas? If so, the project will also produce more oil that will need to find a buyer, which means more carbon.

How—and how long—a gas-to-power project operates will affect whether it is compatible with Paris goals.

- In what year will the project shut down? Gas-fired power plants have average useful lifespans of 30 years or more; gas pipelines normally stay in service for at least 50 years. And even before they start running, gas power plants take an average of 4-5 years to build. Thus, most any gas-to-power project planned today almost certainly will run past 2050—a strong sign it goes against Paris goals and, possibly, the country's own climate commitments.
- Will the plant consistently be used for baseload power or for other services (see Common claim 1.1)? The more hours a gas-fired facility will run, the lower its chances of being Paris-aligned.
- Which type of turbine will the gas plant use? On average, a modern CCGT emits less CO_2/MWh than an OCGT—about 0.34 tons versus 0.52 tons. However, an OCGT's economics allow it to run for fewer hours over fewer years, which could make open-cycle turbines the less-polluting option in some cases, provided they are not used extensively for baseload power.
- Could the project end up flaring gas? If the government gets the project's supply and demand estimates wrong, or the project starts producing gas before customers are ready to use it, its operators might have to flare gas while they are waiting.
- If the plant operates past 2050, would it install carbon capture technology or transition to burning lower carbon gases like hydrogen or biomethane? If neither of these steps are taken, the plant likely would not be Paris-aligned. Yet this type of technological transition would be costly and often difficult to achieve, especially in developing countries.

Even if individual gas projects have marginal climate costs, they can put a country on a path to a more fossil fuel- and emissions-heavy future.

Whether a power plant can be part of a 1.5-degree scenario depends not just on the fuel it burns but also on the broader energy sector and economy it serves. Many lower-income countries, the least developed especially, have not reached their peak GHG emissions. In Africa alone, higher incomes, urbanization and fast-growing populations could cause electricity to more than triple by 2040. For all these reasons, stakeholders should ask whether investing in a single gas plant could risk deeper problems of carbon lock-in (see questions in Common claim 1.1, above).

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