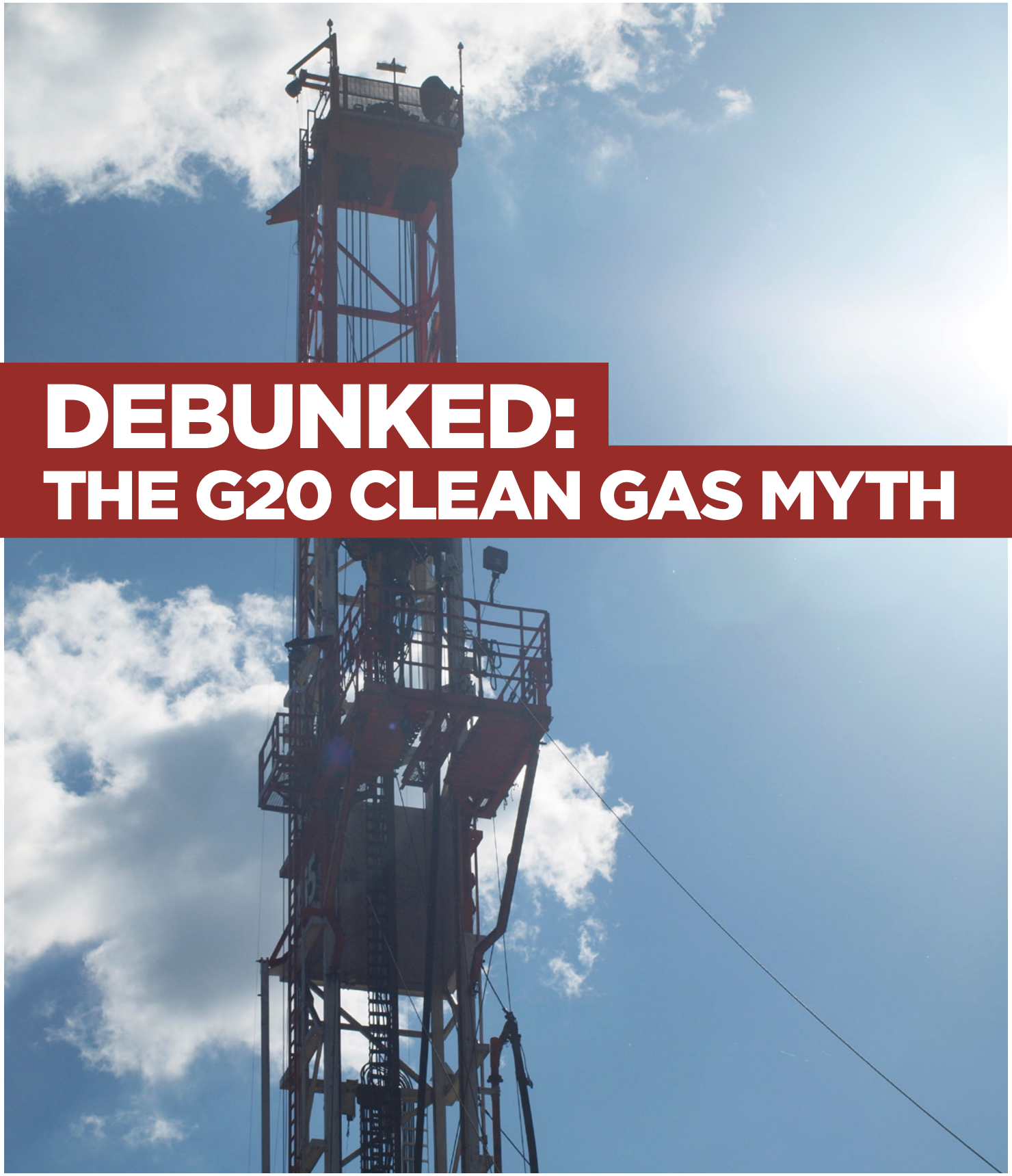


DEBUNKED:
THE G20 CLEAN GAS MYTH

OILCHANGE INTERNATIONAL
350.org
AMAZON WATCH
APMDD
christian aid
ENGAJAMUNDO
food&water watch
food&water europe
GREENPEACE
HOMEF
LINGO
LEGAMBIENTE O.N.L.U.S.
ODG
RAINFOREST ACTION NETWORK
UKYCC

This report was researched and written by Lorne Stockman, with contributions from Greg Muttitt, Alex Doukas, and Collin Rees. It was edited by Collin Rees and translated into Spanish by Mercedes Camps. All are with Oil Change International.

The author is grateful for feedback from the following reviewers: Paul Horsman and Ingo Boltz. Both are with Greenpeace.

Design: paul@hellopaul.com
Cover Image: Top of drilling rig in operation in West Virginia, USA, September 2013. Photo by Samantha Malone. Provided by The FracTracker Alliance, www.fractracker.org/photos

June 2018.

Published by Oil Change International (www.priceofoil.org), in collaboration with: Greenpeace, 350.org, Amazon Watch, Asian Peoples' Movement on Debt & Development, Christian Aid, Engajamundo, Food & Water Europe, Food & Water Watch, Health of Mother Earth Foundation, Leave it in the Ground Initiative, Legambiente, Observatori del Deute en la Globalització, Platform, Rainforest Action Network, and UK Youth Climate Coalition.

Oil Change International is a research, communications, and advocacy organization focused on exposing the true costs of fossil fuels and facilitating the coming transition towards clean energy.

Oil Change International
714 G Street SE, Suite 202
Washington, DC 20003 USA
www.priceofoil.org

This report is one of two reports published simultaneously that question the ongoing push for expanding fossil gas production in G20 countries. Both reports debunk the notion that gas is a clean fuel that is essential for transitioning to a climate-safe energy future.

This report, 'Debunked: The G20 Clean Gas Myth,' focuses on fossil gas development in the G20 and debunking the myth of fossil gas as a clean transition fuel. It is published by Oil Change International. The partner report, 'Debunked: The Promise of Argentina's Vaca Muerta Shale Play,' focuses on the myths surrounding the development of shale gas in Argentina, particularly the Vaca Muerta shale play. It is published by Greenpeace Argentina and available at http://priceofoil.org/debunked-vaca-muerta

CONTENTS

EXECUTIVE SUMMARY	**5**
INTRODUCTION	**6**
G20 GAS INVESTMENT TO 2030	**7**
G20 Gas Expansion and the Paris Agreement	**8**
How Much Gas?	**9**
IS GAS A BRIDGE FUEL?	**12**
All About Methane?	**12**
FIVE CHALLENGES TO THE BRIDGE FUEL CONCEPT	**13**
No Room for New Fossil Gas (Even to Replace Coal)	**13**
New Gas Is Holding Back Renewable Energy	**14**
LNG Export: Making a Bad Problem Worse	**15**
The Wrong Gas at the Wrong Time	**15**
Battery Storage Is Here Now and Cost-Competitive	**15**
Bait and Switch	**15**
New Gas Locks in Emissions	**16**
Too Much Gas Already	**16**
CONCLUSION	**17**

Pipeline construction, Loma Campana, Argentina. ©Jesus Rolle/Greenpeace

Rig, West Virginia, USA, 2013. Photo by Brook Lenker. Provided by The FracTracker Alliance.

EXECUTIVE SUMMARY

As G20 energy ministers gather in Argentina, the promotion of fossil gas[a] as a transition fuel is likely to be high on the agenda. This comes as Argentina is poised to unlock vast quantities of gas within its shale gas formations, with the help of billions of dollars in both international and national public finance.

But Argentina is not the only G20 country planning large increases in fossil gas production. This briefing finds that:

- By 2030, G20 countries are projected to host investment of over USD 1.6 trillion[b] in new gas projects.[1] If this happens, emissions from fossil gas produced by G20 countries through 2050 would consume nearly two-thirds of a carbon budget that offers a 50 percent chance of limiting global warming to below 1.5 degrees Celsius. This would make it extremely difficult to meet the goals of the Paris Agreement, which has been signed by all G20 members.[c]

- Five countries – the United States, Russia, Australia, China, and Canada – are projected to host 75 percent of capital expenditures in gas production in G20 countries from 2018 to 2030. The United States, Russia, and Australia alone comprise nearly 60 percent of total G20 projected capital expenditures in gas production.

- Argentina's push to open massive shale gas deposits to investment risks undermining its commitment to the Paris Agreement and the work of the Energy Transitions Working Group during its G20 Presidency. If exploited to its fullest extent, Argentina's shale gas could consume as much as 15 percent of the remaining carbon budget that offers a 50 percent chance of limiting warming to below 1.5 degrees Celsius.

This briefing also examines the notion that fossil gas can function as a 'bridge fuel' and finds that given the climate implications of expanded fossil gas supply and the pace of the energy transition required to meet the aims of the Paris Agreement, the idea that fossil gas can effectively function as a 'bridge fuel' towards a low-carbon future is a myth:

1. Climate goals require the power sector to be decarbonized by mid-century. This means fossil gas use must be phased out, not increased.

2. Wind and solar are now cheaper than coal and fossil gas in many regions. This means new fossil gas capacity often displaces new wind and solar rather than old coal.

3. Claims that fossil gas supports renewable energy development are false. The cheapest fossil gas generation technology, Combined Cycle Gas Turbine, is designed for baseload operation, not intermittent peaking. Regardless, most grids are far from renewable energy penetration levels that would require back up. Storage and demand response technologies will be ready to step in by the time they are required.

4. Companies building multibillion-dollar fossil gas infrastructure today expect to operate these assets for 30 years or more. Emissions goals mean this expectation cannot be met.

5. The coal, oil, and fossil gas in currently producing and under-construction projects are enough to exceed climate goals. Opening new fossil gas fields is inconsistent with the Paris goals.

There is an urgent need for G20 leaders to use climate goals as a starting point for decisions around energy and fossil fuels in particular, and fossil gas is no exception. Our research suggests that some G20 leaders may be more influenced by the abundant fossil gas supply that new drilling methods and technology have unleashed than by their commitments to achieve the goals of the Paris Agreement. The evidence is clear: Expanding the production of fossil gas threatens to undermine climate action.

a We use the term fossil gas in place of 'natural gas', meaning gas produced from fossil fuel sources.
b All figures in this report are rounded using U.S. numbering. In numerals this is USD $1,613,162,000,000.
c In 2017, the United States – a G20 member – announced its intention to withdraw from the Paris Agreement, which has been signed by all the countries of the world. This withdrawal cannot take effect until November 4, 2020. The rejectionism of the current U.S. administration appears to have strengthened the resolve of other countries on climate change.

INTRODUCTION

Last year's G20 Hamburg Climate and Energy Action Plan for Growth included the following statement regarding the role of fossil gas: *"We recognise that, depending on national circumstances, natural gas can play an important role in the energy transition, moving towards a low greenhouse gas emission energy future, including for providing increased flexibility for the integration of variable renewable energy."*[2]

In 2018, fossil gas again appears to be high on the agenda for G20 governments, and energy ministers are set to gather in Argentina on June 15 to shape the G20 energy agenda going forward. This ministerial meeting is to be preceded by an event promoting the role of fossil gas in the future energy mix.

In the context of the G20 statement on fossil gas, this briefing explores three issues:

1. The market for new gas supplies in G20 countries, and their potential climate impact;
2. Argentina's shale gas expansion plans, and their potential climate impact;
3. Five reasons why the concept of fossil gas functioning as a 'bridge fuel' toward a low-emissions future is a myth.

Liquid depository, La Caleta, Argentina. ©Sebastian Pani/Greenpeace

G20 GAS INVESTMENT TO 2030

Many G20 countries are leading a global push to rapidly expand fossil gas production. We analyzed the projected capital expenditure (capex) in gas production globally from 2018 to 2030 using the Rystad UCube, an oil industry database.[3] We found that G20 countries,[d] including the 19 individual country members plus the members of the European Union not directly in the G20, are projected to host 65 percent of global capex for gas production to 2030. Eleven of the top twenty countries globally are in the G20, and the top six are all G20 countries (see Tables 1 & 2).

G20 countries are projected to see investments of over USD 1.6 trillion[e] (in 2018 dollars) in gas production in this period. This is a major threat to climate action because these projects will lock in greenhouse gas (GHG) emissions that massively exceed the Paris goals.

Table 2: Top 20 Global Countries by Projected Gas Production Capex 2018-2030 (G20 Countries Highlighted)

Country	Million USD real
United States	**385,515**
Russia	**317,888**
Australia	**233,347**
China	**194,037**
Canada	**80,722**
Indonesia	**70,872**
Norway	69,561
Iran	59,614
Qatar	54,902
Mozambique	54,613
Argentina	**50,618**
India	**45,018**
Turkmenistan	40,907
Mexico	**40,430**
United Kingdom	**39,501**
Algeria	38,536
Brazil	**38,513**
Malaysia	36,392
Egypt	35,333
Myanmar	31,753
Total	**1,918,073**

Source: Rystad AS (May 2018)

Table 1: G20 Projected Capex in Gas Production 2018-2030

Country	Million USD real
United States	385,515
Russia	317,888
Australia	233,347
China	194,037
Canada	80,722
Indonesia	70,872
Argentina	50,618
India	45,018
Mexico	40,430
United Kingdom	39,501
Brazil	38,513
Saudi Arabia	19,812
Italy	15,595
Netherlands*	13,499
Cyprus*	12,452
Romania*	9,400
South Africa	7,723
Poland*	7,461
Denmark*	6,612
Germany	4,320
Hungary*	3,936
Turkey	3,309
Ireland*	2,506
Greece*	1,974
Croatia*	1,617
South Korea	1,012
Japan	939
Spain*	743
Bulgaria*	518
Slovakia*	492
France	426
Austria*	410
Slovenia*	380
Czech Republic*	374
Portugal*	271
Latvia*	25
Sweden*	24
Belgium*	18
Malta*	5
Lithuania*	3
Total	**1,613,162**

Source: Rystad AS (May 2018)

*In the G20 as part of the EU. Together, EU countries that are not individually represented in the G20 have projected capital expenditures in gas production of USD 62,719,000,000 from 2018 to 2030.

d G20 countries are Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, the Republic of Korea, the Russian Federation, Saudi Arabia, South Africa, Turkey, the United Kingdom, the United States, and the European Union. EU members not in the G20 are Austria, Belgium, Bulgaria, Croatia, the Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Ireland, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden.

e $1,613,162,000,000.

Apple orchard conversion, Allen Rio Negro, Argentina. ©Nicolas Villalobos/Greenpeace.

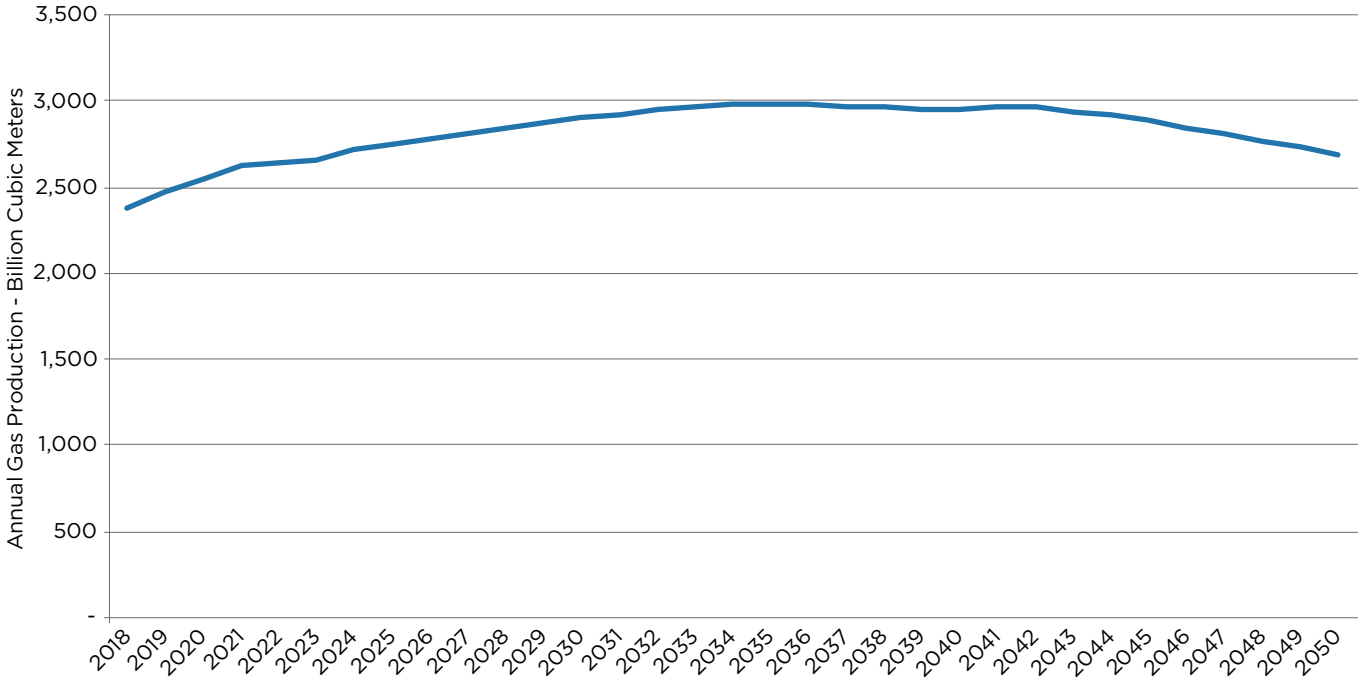
G20 Gas Expansion and the Paris Agreement

The most pressing energy issue of the twenty-first century is how to avoid dangerous climate change. G20 members have recognized this and committed to action.[4] Failure to avert significant warming would lead to major damage to human health, destruction of infrastructure, disruption of food supplies, mass migration, economic destabilization, and an acceleration in the loss of biodiversity, among other consequences.[5]

All G20 member countries have signed the Paris Agreement, and in doing so committed to keep warming to "well below" 2 degrees Celsius and aim to keep it to below 1.5 degrees Celsius. Delivering on that commitment requires urgent action. The emissions budget for a 50 percent probability of keeping warming to 1.5 degrees Celsius will be exhausted within eight years at current rates; the budget for a 66 percent chance of staying below 2 degrees Celsius will be exhausted within 19 years.[6]

It is with these budgets in mind that we analyze the impact of G20 countries' fossil gas production plans. If the projects that are currently being planned go ahead, how much carbon dioxide (CO_2) might they release, and how do those emissions fit into the limited emissions budget we have left? We then examine the arguments for fossil gas as a transition fuel.

Figure 1: Projected G20 Gas Production 2018-2050



Source: Rystad Energy AS (May 2018)

How Much Gas?

Our analysis looked at fossil gas production in the G20 countries out to 2050.[f] The projections suggest that – in the absence of additional action to address fossil gas supply – annual G20 fossil gas production will plateau in the late 2030s at around 3 trillion cubic meters, or 105 trillion cubic feet.[g]

The total amount of fossil gas produced and combusted would be almost 93.5 trillion cubic meters, or nearly 3.3 quadrillion cubic feet.[h]

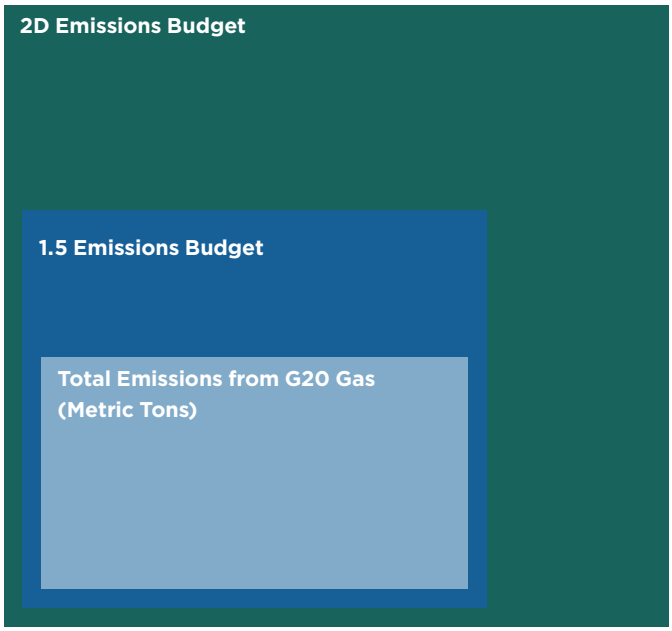
Burning all this gas would result in CO_2 emissions totaling over 197 billion metric tons.[i]

The Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report estimated that as of the end of 2011, the carbon budget for a 50 percent chance of keeping warming below 1.5 degrees Celsius was 550 billion tons of carbon dioxide (Gt CO_2), and for a 66 percent ("likely") chance of keeping warming below 2 degrees Celsius was 1,000 Gt CO_2.[7] Between 2012 and 2017, approximately 240 Gt CO_2 were emitted,[8] leaving carbon budgets of 310 and 760 Gt CO_2 respectively at the start of 2018.

G20 fossil gas production to 2050 would thus lead to emissions equivalent to 64 percent of the remaining emissions budget for a 50 percent chance of hitting the 1.5-degree Celsius target, and 26 percent of the budget for a 66 percent chance of the 2-degree Celsius target.

Pursuing the expansion of fossil gas extraction – as many G20 countries are currently doing – risks undermining the commitments made in the Paris Agreement, overshooting crucial climate goals, and threatening to lock in the disruptions and disasters that those goals seek to avoid.

Figure 2: 2-Degree and 1.5-Degree Carbon Emissions Budgets Compared to Projected G20 Gas Emissions to 2050



f The Rystad UCube database projects production out to 2100, but we used 2050 as a cutoff point due to the increased uncertainty for projections beyond that point. It should be noted that absent coherent climate policies aimed at leaving fossil fuels in the ground, fossil gas production would of course continue beyond 2050, adding to the emissions discussed here. Indeed, the current base case projection sees fossil gas production growing into the 2060s. This stands in stark contrast to the need to wind down all fossil fuel emissions by mid-century to avoid the worst impacts of climate change.

g 3,000,000,000,000 cubic meters or 105,000,000,000,000 cubic feet

h 93,478,000,000,000 cubic meters and 3,299,772,000,000,000 cubic feet.

i 196,460,733,442 metric tons

Box: Argentine Shale Gas Threatens Climate Goals

Argentina has assumed the presidency of the G20 for 2018 and will host ministerial meetings throughout the year, culminating in the annual G20 summit in late November. The stated theme of the G20 presidency is "Building Consensus for Fair and Sustainable Development." Three priorities for the presidency and several additional themes aimed at continuing the work of previous presidencies have been identified; "Taking responsibility on climate action" is one of these continuing themes.[9]

The Energy Transitions Working Group (ETWG) meets in Bariloche, Argentina, on June 12 and 13, followed by an Energy Ministerial on June 15. A side event is planned for the ETWG meetings on "the role of natural gas, and its complementation with renewable energy."

That Argentina's effort seeks to promote fossil gas as a clean energy solution is not a surprise. The country's shale gas deposits have solicited increasing international attention in recent years and have been described as the second largest in the world.[10] Drilling activity has increased in the past three years, and 2018 shale gas production is expected to be nearly 300 percent above 2015 levels.[11]

However, Argentina's shale gas boom may just be beginning. Estimates of potential recoverable reserves suggest that very large fossil gas deposits exist deep below Argentine soil. While the economics and logistics of large-scale extraction continue to be tested, the "clean gas" myth that this report debunks continues to obscure the deeper question of whether an increase in fossil gas production meshes with Argentina's commitments to climate action.

We estimate a range of potential Argentine shale gas emissions based on two data sources: the United States Department of Energy's Energy Information Administration (U.S. EIA) and the Rystad Energy UCube database.

As with the G20 analysis above, we queried the Rystad Energy UCube database for projections of Argentine fossil gas production to 2050. These projections currently show a decline in the growth rate for fossil gas production from 2018 until growth picks up in the 2030s (see Figure B1). This is the result of a steep projected decline in conventional fossil gas production, so while shale gas grows it is offset by these declines until the 2030s.

This projection contains a high degree of uncertainty due to the early stage of Argentine shale gas production development, and the assumption that Argentine shale gas production may be too expensive to be competitive in the nearer term. However, experience in North America over the last decade suggests that once shale gas production ramps up, production can accelerate surprisingly quickly, and expectations can change as costs decline and techniques improve.[12] Given the potential for this, we also examine a longer-term estimate of recoverable Argentine shale gas reserves for a high-end estimate of the potential.

In 2015, the EIA estimated Argentina's technically recoverable shale gas reserves at 22.7 trillion cubic meters, or 802 trillion cubic feet.[j, 13] However, currently much of the activity and discussion regarding shale gas in Argentina centers on the Vaca Muerta play. EIA estimates technically recoverable reserves for Vaca Muerta at 8.7 trillion cubic meters, or 308 trillion cubic feet.[k, 14] This figure is commonly used by the state oil company and in the Argentine media.[15]

Looking at these three different estimates of potential future gas extraction in Argentina provides an indication of the potential impact on emissions budgets (see Tables B1 and B2).

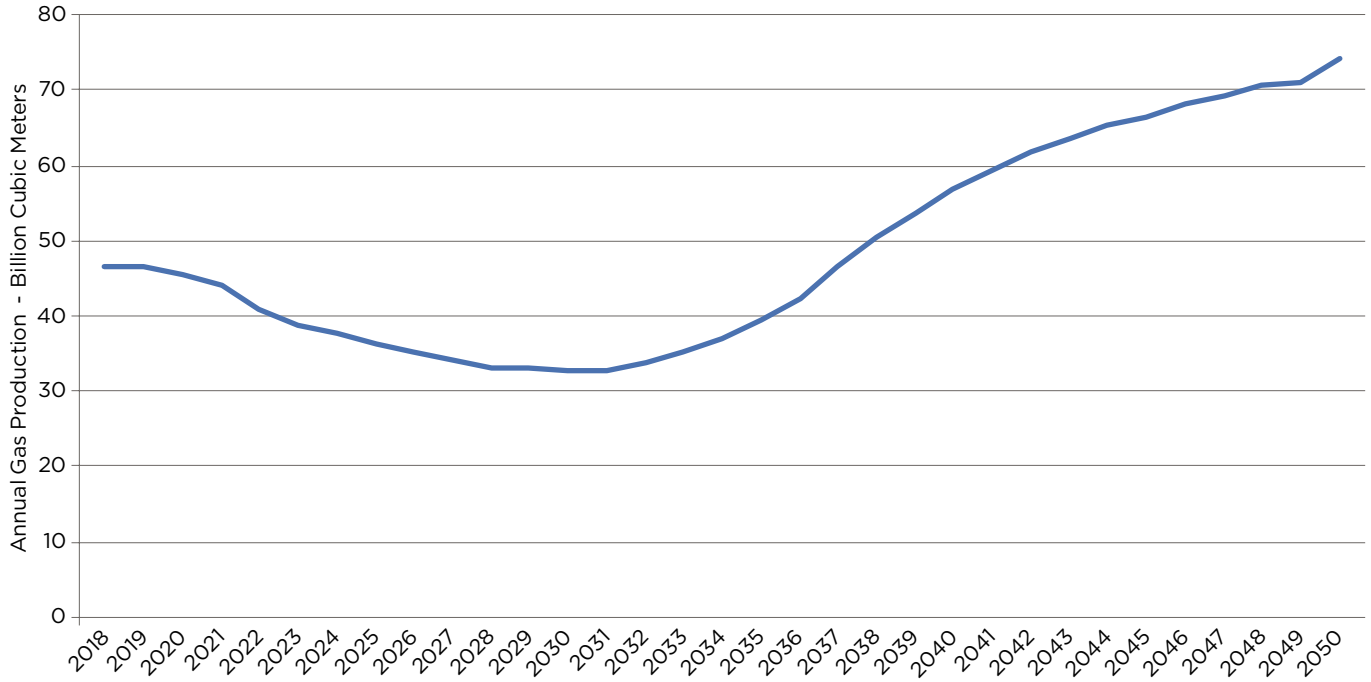
Table B2 shows the emissions budgets for the two temperature targets and the emissions from combustion of the Argentine gas reserves shown in Table B1.

The current Rystad production projection for Argentine shale gas leads to between 0.4 percent and 1.1 percent of global emissions budgets. EIA estimates translate to between 2 percent and 15 percent of global emissions budgets potentially being consumed by developing Argentine shale gas. This is illustrated in Figure B2.

Opening the Vaca Muerta shale play in Argentina risks triggering the full development of Argentine shale gas, a huge quantity of fossil gas estimated to be the second-largest in the world. If Argentine shale gas development follows a similar path to that in North America, its full development risks claiming a very large percentage of the remaining global emissions budget, exposing the myth that shale gas can play any role as a transition fuel.

j 22,700,000,000,000 cubic meters or 802,000,000,000,000 cubic feet
k 8,700,000,000,000 cubic meters or 308,000,000,000,000 cubic feet

Figure B1: Argentine Gas Production Projection 2018-2050



Source: Rystad AS (May 2018)

Table B1: Argentine Gas Reserve Estimates

Reserves	Rystad Projected Production to 2050	EIA Vaca Muerta (Technically Recoverable)	EIA All Argentine Shale Gas (Technically Recoverable)
Trillion Cubic Meters	1.6	8.7	22.7
Trillion Cubic Feet	56.5	308	802

Table B2: Emissions from Burning Argentine Gas Reserves Compared to Global Emissions Budgets ($GtCO_2$)

Temperature Limit	Total Emissions Budget	Rystad Production to 2050 (Gt/%)	EIA Vaca Muerta (Gt/%)	EIA All Argentine Shale Gas (Gt/%)
1.5°C (50% chance)	310	3.4 / 1.1%	18.4 / 6%	47.9 / 15%
2°C (66% chance)	760	3.4 / 0.4%	18.4 / 2%	47.9 / 6%

Figure B2: 2-Degree and 1.5-Degree Carbon Emissions Budgets Compared to Argentine Gas Reserves Estimates

IS GAS A BRIDGE FUEL?

The idea of fossil gas as a transition fuel or "bridge fuel", between coal and/or oil and renewable energy, is not new. Indeed, the idea became popular with environmental NGOs in the early 2000s when the Worldwatch Institute posited the idea of fossil gas as a bridge to the 'hydrogen economy.'[16] In this incarnation, fossil gas would be used to make hydrogen to replace oil for transportation and would later be replaced by renewable energy deployed for the same purpose.

In 2001, the oil company Royal Dutch Shell published a set of energy scenarios to 2050 in which one of five "common features" included, "the important role of natural gas as a bridge fuel over at least the next two decades."[17] Almost two decades later, the "bridge fuel" idea remains a staple used by proponents of new fossil gas extraction and infrastructure that is designed to deliver increasing quantities of fossil gas for many more decades to come.

All About Methane?

As shale gas production has grown in North America since 2005 – enabled by the development of hydraulic fracturing (fracking) and horizontal drilling – much of the controversy over whether increased fossil gas production and consumption can deliver a transition to a cleaner energy system has centered around the issue of methane leakage. Methane, the primary hydrocarbon contained in fossil gas, is a highly potent greenhouse gas (GHG) when vented or leaked to the atmosphere.

Studies have found that methane leakage levels can be much higher for gas produced via fracking than for conventionally produced gas.[18] If elevated levels of methane are leaked in the process of producing and delivering fossil gas to consumers, then its emissions advantage over coal for power generation or other uses is reduced or negated, and the bridge fuel idea is mistaken. Many additional studies have been conducted to ascertain how much leakage is occurring and what levels of leakage constitute a greater or lesser climate impact for fossil gas compared to the dirtier fuels it supposedly substitutes.[19]

In 2016, former U.S. President Barack Obama and Canadian Prime Minister Trudeau announced regulations to reduce methane emissions in the oil and gas sector.[20] The intent behind these regulations was surely that with methane emissions reduced, the role of fossil gas as a bridge fuel would be clear.

With methane levels in the atmosphere rising fast, there is no doubt about the importance of reducing methane leakage from existing oil and gas operations.[21] But the question of whether opening massive new shale gas resources can be positive or negative for the climate goes far beyond the issue of preventing methane emissions.

Setting methane leakage aside, we demonstrate that even in the hypothetical case of zero methane leakage, fossil gas cannot be a bridge fuel. This demonstrates that methane leakage is not the sole determinant of whether fossil gas causes net harm to the climate. To meet climate goals, fossil gas production and consumption must, as with other fossil fuels, be phased out, and reducing methane leakage does not alter that fact.

Liquid depository, La Caleta, Argentina. ©Sebastian Pani/Greenpeace

FIVE CHALLENGES TO THE BRIDGE FUEL CONCEPT

This section discusses five key issues.

1. **How Much Room for New Gas?** Climate goals require the power sector to be decarbonized by mid-century. This means fossil gas use must be phased out, not increased (see Figure 2).
2. **Is New Gas Holding Back Renewable Energy?** Wind and solar are now cheaper than coal and gas in many regions. This means new fossil gas capacity often displaces new wind and solar rather than old coal.
3. **The Wrong Gas at the Wrong Time:** Claims that fossil gas supports renewable energy development are false. The cheapest gas generation technology, Combined Cycle Gas Turbines (CCGT), is designed for base load operation, not intermittent peaking. Regardless, most grids are far from renewable energy penetration levels that would require back up. In many regions, storage and demand response technologies will be ready to step in by the time they are required.
4. **New Gas Locks in Emissions for 40+ Years:** Companies building multibillion-dollar fossil gas infrastructure today expect to operate their assets for around 40 years. Emissions goals mean this expectation cannot be met.
5. **Too Much Gas Already:** The coal, oil, and fossil gas in the world's currently producing and under-construction projects, if fully extracted and burned, would take the world far beyond safe climate limits. Opening new fossil gas fields is inconsistent with the Paris climate goals.

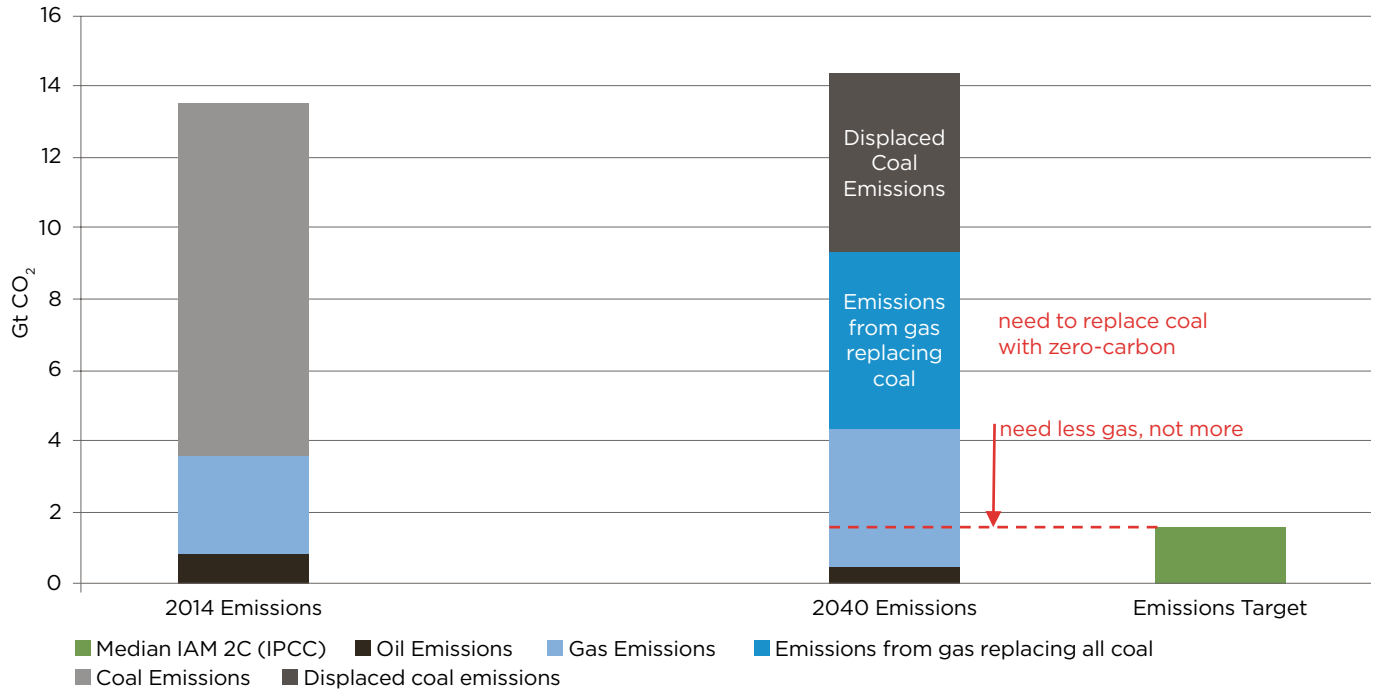
No Room for New Fossil Gas (Even to Replace Coal)

The projected growth in fossil gas consumption is primarily attributed to its increasing use in electricity generation. While growth in electricity demand globally is slowing, particularly in developed countries,[22] the assumption is that coal-fired power plants will be replaced by gas-fired ones, with a potential reduction in emissions of 40 to 60 percent.

The Intergovernmental Panel on Climate Change (IPCC) reports that to stay within the Paris Agreement's long-term temperature goal, the electricity sector must rapidly decarbonize and, globally, must be carbon-free by roughly midcentury.[23] Shifting reliance from one high-carbon energy source to one that is around half as polluting is not a path to decarbonization.[24] The reductions needed are much greater than a switch from coal to fossil gas would achieve.

Figure 3 shows that if all of the International Energy Agency's (IEA's) projected coal-fired generation in 2040[25] is replaced with fossil gas-fired generation, emissions from the power sector would still be more than five times the median of IPCC scenarios for a likely chance of keeping warming below 2 degrees Celsius.[26] Indeed, the figure shows that emissions from oil and gas power alone are too great, meaning that none of the coal can be replaced with fossil gas; it must all be replaced with zero-

Figure 3: Global Power Sector Emissions – 2014 and Projected 2040 – Compared with Median IPCC 2040 Power Sector Emissions for 2°C (assuming all coal is displaced by gas)



Source: Oil Change International analysis, using data and projections from IEA[29] and IPCC[30]

carbon energy sources. And at the same time, the world must reduce fossil gas consumption, not increase it.

The fact that fossil gas emissions will need to decline along with coal emissions is being obscured by a narrative driven by the fossil gas industry and its supporters in government and multilateral institutions such as the IEA.[27] This narrative is driven in part by the newfound abundance of fossil gas, enabled by the development of hydraulic fracturing (fracking) and horizontal drilling. There is a clamor to find a use for all the fossil gas available, rather than a clear-headed analysis of how much gas use is compatible with climate goals. At the same time, the rising urgency of the climate threat has forced some oil companies to belatedly embrace the idea of reducing emissions, which they have done by blaming coal (in which they have no stake) and calling for its replacement by gas (one of their two core products).[28]

This drive to maximize fossil gas consumption[31] simply does not line up with the climate goals that all the nations of the world have agreed to. While the analysis in Figure 3 is clear, it raises another question. That question goes to the very heart of the bridge fuel idea; do we need more fossil gas to help us transition to a zero-carbon world?

New Gas Is Holding Back Renewable Energy

The problem is not just that fossil gas does not go far enough in reducing emissions; it also makes the climate problem worse. Switching from coal to fossil gas might – in theory, with very low methane leakage – reduce emissions from a business-as-usual scenario. But this hypothetical situation assumes that new gas displaces dirtier coal. In reality, much of the new gas being developed will displace new renewable energy.

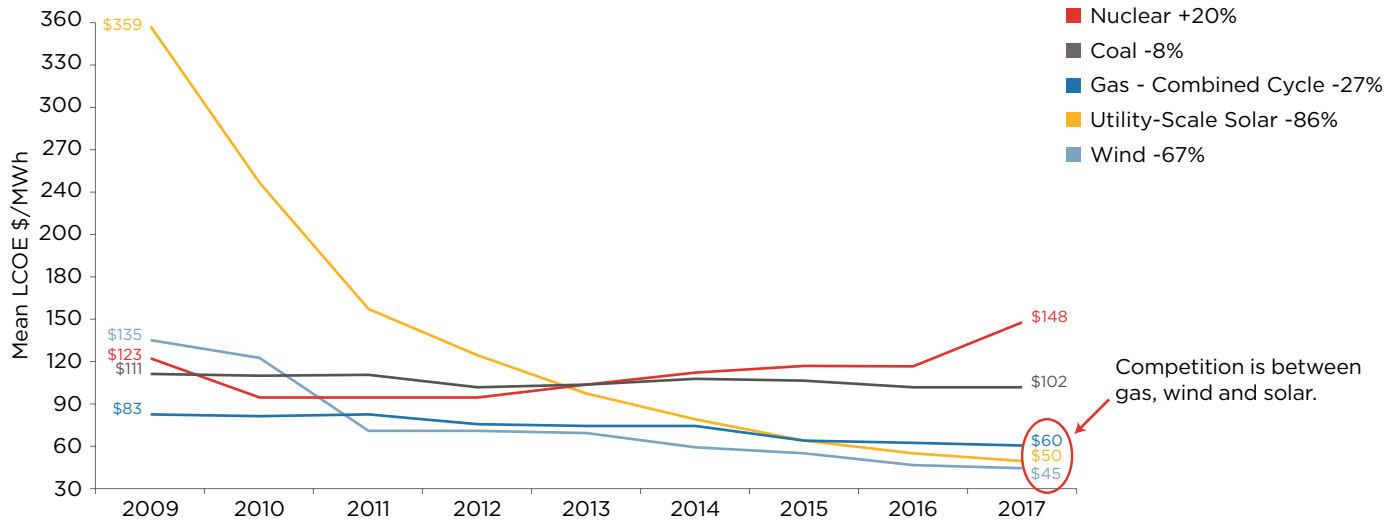
The cost of renewable energy has plummeted, and costs are projected to continue to fall to at least 2040. Bloomberg New Energy Finance (BNEF) found the unsubsidized cost of financing, building, and operating (the Levelized Cost of Energy or LCOE) for utility-scale solar photovoltaics (PV) and onshore wind projects fell 20 percent and 12 percent respectively from early 2017 to early 2018.[32] These energy sources are now the cheapest form of energy generation even in countries with cheap coal-fired generation, such as China and India. BNEF went on to point out that India now has the lowest-cost onshore wind and solar in the world.[33]

While the cost of fossil gas remains near historic lows today, the finite nature of fossil fuels signal that it is unlikely to get cheaper, quite the opposite. But for solar and onshore wind, BNEF projects cost reductions of 62 percent and 48 percent respectively by 2040.[34] According to BNEF, solar and onshore wind will become "the cheapest bulk generation almost everywhere by 2023."[35]

Figure 4 shows an LCOE analysis by Lazard from November 2017, showing the average unsubsidized costs of wind, solar, fossil gas, coal, and nuclear power since 2009. This clearly shows that competition for new generation capacity in the power sector today is between gas and renewable energy, not coal and gas. Therefore, public policy supporting fossil gas as a transition fuel from coal to renewable energy makes no sense.

Academic studies on this issue lead to a similar conclusion. Several recent studies in the United States have modeled the competition between different fuels, finding that greater supplies of fossil gas will not significantly reduce emissions (absent other regulatory measures on climate), in large part because some of the additional gas displaces zero-carbon energy as well as coal.[37]

Figure 4: Gas Competes with Wind and Solar More than Coal



Source: Lazard 2017[36]

A global study, using five integrated assessment models, found that increased gas availability or reduced gas cost led to either equivalent or even higher levels of emissions.[38]

LNG Export: Making a Bad Problem Worse

Liquified Natural Gas (LNG) is fossil gas that is cooled to -162 degrees Celsius (-260 degrees Fahrenheit) to reduce volume and facilitate shipping across oceans. On arrival the liquefied gas is generally regasified to be further transported by pipeline to its final destination.

As might be expected, this intense process requires a lot of energy. Electricity and fossil gas are generally used to power the plants that chill the gas into LNG. Where fossil gas is used, it is estimated that six to ten percent of the gas processed is required for powering the plant.[39] There is also energy required for shipping and regasification. So, the LNG process adds a significant amount to the full lifecycle emissions of producing and using fossil gas. If methane leakage is not kept at very low levels – well below 2 percent, depending on shipping distance and other factors – replacing coal with LNG may result in increased GHG emissions.[40]

Additionally, it is also dangerous to assume that LNG exports automatically lead to the displacement of coal in destination markets. A paper published in November 2017 in the international journal *Energy* in November 2017 studied this issue in detail, examining scenarios in which U.S. LNG is exported to Asia.[41] The study found that the displacement of coal by LNG exports is far from a given, and that, as a result of U.S. exports of LNG, GHG emissions are not likely to decrease and may significantly increase due to greater global energy consumption, higher emissions in the United States, and methane leakage."[42]

The Wrong Gas at the Wrong Time

As renewable energy costs have declined, fossil gas advocates have increased their emphasis on questions regarding the intermittency and reliability of wind and solar. The sun does not always shine, and the wind does not always blow, and therefore – they argue – gas-fired generation is needed to balance peaks and troughs in supply and demand. There are several flaws to this argument.

Nobody expects the transition to renewable energy to happen overnight. It is a decades-long process and while climate goals do require the transition to accelerate from today's adoption rates, it will be at least a decade before mature grids (in developed countries) achieve levels of renewable penetration that would trigger system reliability issues (roughly 50 percent or higher). For example, the operator of the electrical grid in northeast Germany says the country's grid can handle up to 70 to 80 percent wind and solar even without additional flexibility options such as storage.[43] Australian grid operator TransGrid goes further, saying that 100 percent renewable energy is both affordable and practical using a combination of existing technology for storage, demand management, and efficiency.[44]

It makes no sense to install gas today to address renewable energy-related grid stability issues that may or may not be a concern ten years from now. It is a solution without a problem. Indeed, where high renewable energy penetration exists today, such as in the U.S. states of Texas and California, gas plant utilization rates have dropped, and gas demand has declined,[45] suggesting that those systems already have more gas generation capacity than they need.[46]

Battery Storage Is Here Now and Cost-Competitive

The cost of lithium-ion batteries has declined 79 percent since 2010[47] and 24 percent in 2017 alone.[48] The declining cost of battery storage means that the combination of renewable energy and batteries is already cost-competitive with coal and fossil gas generation.[49] However, capacity limitations mean that current systems can only handle "narrow peaks," meaning that batteries can only supply power for short periods. The challenge is scaling up batteries to run for several hours. BNEF projects that four-hour energy storage will begin to compete with peaker gas plants by 2025, even in countries with low-cost gas generation such as in the United States.[50]

BNEF's chief editor noted at the beginning of 2018 that energy storage is currently poorly understood by many policymakers. He notes that, "(t)his matters hugely since investing in alternatives (to storage) such as natural gas power plants with a 25-plus year lifetime will either create a long lock-in period that would limit opportunities for other flexible resources such as storage or result in stranded assets further down the line." Coming from one of the world's leading clean energy analysts, this provides a stark warning to policymakers and investors that assumptions about fossil gas demand and renewable energy intermittency need to be re-examined.

Bait and Switch

Another problem with the claim that fossil gas is an integral partner for renewables, and with the emissions claims that are associated with that relationship, is that the cheapest and most efficient gas generation technology, combined cycle gas turbine (CCGT), is not the technology best suited for balancing renewable energy intermittency.

When many analysts compare the cost and/or emissions of fossil gas with renewable energy or coal, they generally use CCGT for the comparison. But because of the high upfront costs of building CCGT plants, they only make sense as base load plants that are run at high utilization rates. CCGT is not economical for flexible generation, which is the kind of generation needed for gas to partner with renewable energy. Open-cycle gas plants may be cheaper to build than CCGT and can be profitable when run as 'peakers,' which are plants that operate intermittently to handle periods of high demand or constrained supply. But these plants are less efficient and have higher emissions per unit of energy produced than CCGT.[51] Recent analysis from BNEF also shows that these plants have a higher LCOE than wind and solar partnered with battery storage.[52]

If the goal is to reduce emissions as much and as quickly as possible, then increasing renewable energy and storage capacity is the key. While stability will need to be addressed at

different points for different systems, the most cost-effective and least emissions-intensive solution is increasingly something other than a fossil gas plant.

New Gas Locks in Emissions

The problem with building a lot of new fossil gas capacity is that the companies investing in gas infrastructure expect to operate their plants for decades to come. Power plants and related infrastructure like pipelines and LNG terminals are multibillion-dollar investments that require decades of operation to turn a profit. Nobody investing today expects to retire the infrastructure earlier than 30 years into its lifetime at minimum, while many power plants operate for much longer.[53] This means that gas plants built over the next few years could still be operating beyond 2050, when emissions from the power sector must be nearing zero.

What's more, the problem of lock-in makes it very difficult to shut down a power plant once it is built. Once the capital has been sunk, the operator will always keep running a plant as long as it can sell power for more than the marginal cost of producing it – even if it incurs a loss on the invested capital. This makes it harder for new generation capacity to compete. Furthermore, there are substantial legal barriers to the early shutdown of plants, as well as strong lobbying power arguing against such a course of action.

In a paper published in 2016, a team of researchers from Oxford University identified additional risks of building new gas generation in a paper published in 2016.[54] They found that emissions from the world's current stock of gas, coal, and oil power plants, if operated for their full economic lifetime, would be enough to take the world to 2 degrees Celsius of warming. Building more fossil fuel capacity – whether fossil gas, coal, or oil – can only lead to overshooting climate goals, unless some of this capacity is shut down before its expected expiry date.

It is total cumulative emissions that matter for staying within safe climate limits. Once the atmospheric space is filled with CO_2, there is no turning back. In the case of a coal plant with ten years of economic life left, shutting the coal plant early and replacing it with a gas-fired generator may cut emissions in half (assuming no methane leakage) for those first ten years. But when the gas plant's economic life is 40 years, the cumulative emissions from the gas plant would in fact be twice as much as those from operating the coal plant for ten more years. This is because the gas plant would emit half as much CO_2 per year, but for forty years rather than ten.

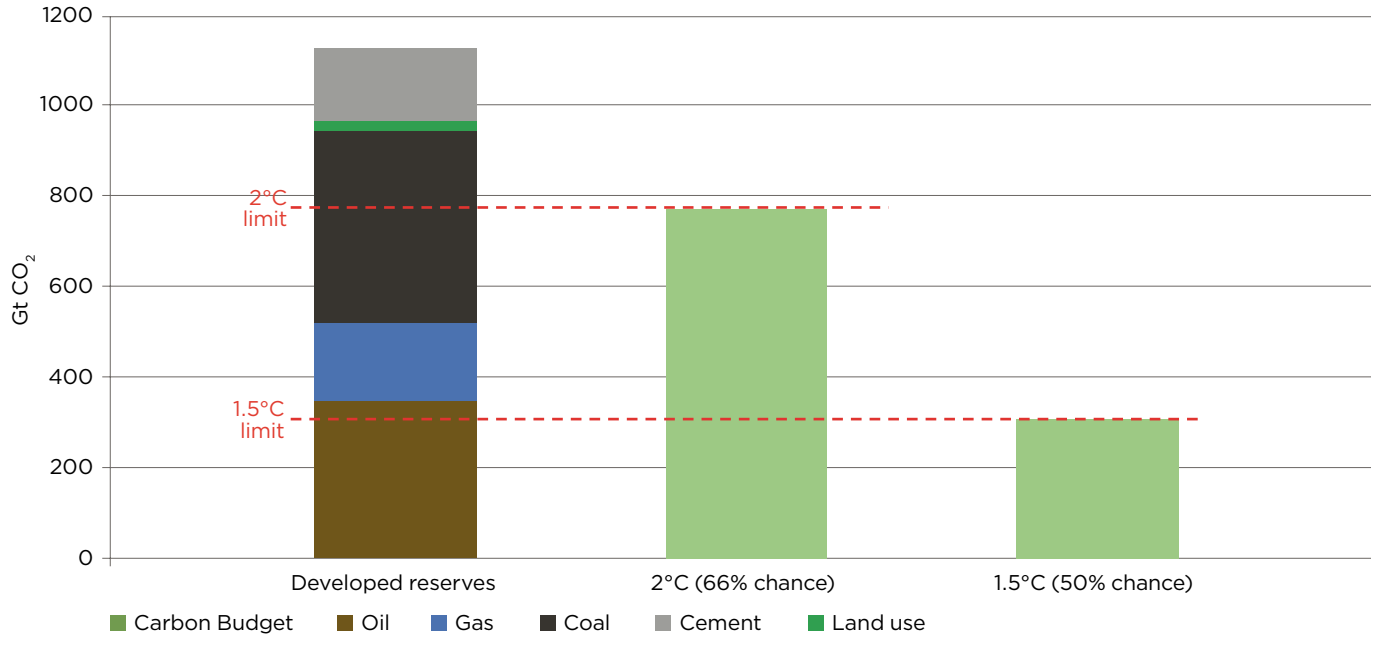
It seems clear that within the timeframe that we are working with, the addition of new gas power plants would push emissions beyond safe limits.

Too Much Gas Already

We can also illustrate the problem of lock-in by comparing emissions from already-operating oil fields, fossil gas fields, and coal mines with how much total oil, gas, and coal the world can afford to burn while achieving the Paris Agreement goals: the carbon budgets.[55]

In Figure 5, we can see there is enough fossil gas, coal, and oil in existing fields and mines to take the world beyond the carbon budget for 2 degrees Celsius. And even if all the coal mines were shut tomorrow, the gas and oil alone would take us beyond the carbon budget for 1.5 degrees Celsius. Even to stay within the upper limit of tolerable warming, 2 degrees Celsius, no new fossil gas fields can be developed unless more than a third of existing coal mines are shut down early. Just like with fossil gas power plants, there is no room for new fossil gas fields – but rather a need to wind down already existing production while ramping up clean energy to take its place.

Figure 5: No Room for More Gas: Locked-in Emissions from Existing Fields and Mines Already Exceed Carbon Budgets



Source: Oil Change International analysis; data from Rystad Energy, IEA, IPCC[56]

CONCLUSION

The myth of fossil gas as a “bridge” to a stable climate does not stand up to scrutiny. While much of the debate to date has focused on methane leakage, the data shows that the GHG emissions just from burning the fossil gas itself are enough to overshoot climate goals. We must reduce fossil gas combustion rather than increase it, and the fact that methane leakage will never be reduced to zero only makes this task more urgent.

Expanding the renewable energy sector does not require expanding fossil gas use. Existing gas plants will not be shut down immediately, but storage, demand response, and other grid management solutions will increasingly support renewable energy as fossil gas is phased down.

Despite this, many G20 countries are pushing forward with the development of fossil gas infrastructure, using the myth of gas as a clean energy transition fuel to burnish the endeavor with green credentials. But current plans for fossil gas extraction in G20 countries alone – excluding the rest of the world’s fossil gas fields – risks claiming a huge percentage of the remaining emissions budget, rendering the transition fuel idea a dangerous myth.

There is an urgent need for policymakers and investors to use climate goals as a starting point for decisions around fossil gas, in the G20 process and elsewhere. Rather than searching for ways to justify using the abundant supply that new drilling methods have unleashed, policymakers and investors should consider how much fossil gas is compatible with achieving the goals of the Paris Agreement. The answer is the same for fossil gas as it is for coal and oil: We need less, not more.

Endnotes

1 Data from Rystad Energy AS UCube database, April 2018.
2 G20 Hamburg Climate and Energy Action Plan for Growth. http://www.g20.utoronto.ca/2017/2017-g20-climate-and-energy.html
3 https://www.rystadenergy.com/products/EnP-Solutions/ucube/
4 G20 Hamburg Climate and Energy Action Plan for Growth. http://www.g20.utoronto.ca/2017/2017-g20-climate-and-energy.html
5 IPCC, Climate Change 2014, Working Group 2 Report, Summary for Policymakers, pp.13ff, http://ipcc.ch/pdf/assessment-report/ar5/wg2/ar5_wgII_spm_en.pdf
6 As of end-2011, the remaining carbon budgets were respectively 1,000 and 550 GtCO2 (IPCC, Climate Change 2014, Synthesis Report (SYR), table 2.2, p.64, http://ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_All_Topics.pdf Emissions were 160 GtCO2 in 2012-15 (Carbon Dioxide Information Analysis Center / Global Carbon Project, 2016 Budget v1.0, http://cdiac.ornl.gov/GCP/); and an estimated 36.4 Gt from fossil fuels in 2016 and 36.8 Gt in 2017, plus 4.8 Gt from land use change in each of 2016 and 2017 (Corinne le Quéré et al, "Global Carbon Budget 2017," Earth Syst. Sci. Data, 10, 2018, pp.429-430, https://doi.org/10.5194/essd-10-405-2018
7 IPCC, Climate Change 2014, Synthesis Report, table 2.2, p.64, http://ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_All_Topics.pdf
8 Carbon Dioxide Information Analysis Center / Global Carbon Project, 2016 Budget v1.0, http://cdiac.ornl.gov/GCP/ ; Corinne le Quéré et al, "Global Carbon Budget 2017," Earth Syst. Sci. Data, 10, 2018, pp.429-430, https://doi.org/10.5194/essd-10-405-2018
9 'Overview of Argentina's G20 Presidency 2018: Building Consensus for Fair and Sustainable Development.'. Dec. 1, 2017. https://g20.argentina.gob.ar/en/overview-argentinas-g20-presidency-2018
10 Ieda Gomes & Roberto Brandt, 'Unconventional Gas in Argentina: Wil it become a Game Changer? The Oxford Institute for Energy Studies. October 2016. OIES PAPER: NG 113. https://www.oxfordenergy.org/wpcms/wp-content/uploads/2016/10/Unconventional-Gas-in-Argentina-Will-it-become-a-Game-Changer-NG-113.pdf
11 Rystad Energy AS, UCube Database (May 2018) Argentine shale gas production was 3.3 million cm/d in 2015 and is projected to be 12.6 million cm/d in 2018.
12 Since 2014, average breakeven costs are down over 40 percent for U.S. shale plays. See: The World Bank Group, 'Commodity Markets Outlook' Oct. 2017. http://pubdocs.worldbank.org/en/743431507927822505/CMO-October-2017-Full-Report.pdf
13 U.S. Department of Energy, Energy Information Administration. 'Technically Recoverable Shale Oil and Gas Resources: Argentina''. Sept. 2015. https://www.eia.gov/analysis/studies/worldshalegas/pdf/Argentina_2013.pdf
14 Ibid. Page V-2
15 For example, https://www.ypf.com/energiaypf/paginas/vaca-muerta.html and for example: https://www.cronista.com/economiapolitica/Vaca-Muerta-de-mayor-yacimiento-de-shale-gas-del-pais-a-corredor-turistico-20170208-0020.html
16 http://www.earth-policy.org/mobile/books/eco/eech5_ss6
17 https://www.shell.com/energy-and-innovation/the-energy-future/scenarios/new-lenses-on-the-future/earlier-scenarios/_jcr_content/par/expandablelist/expandablesection.stream/1447230508646/1896c29e49529180809859f969c32c463a3d5f1437f4b0a7e39dce95e382bf7a/scenarios-energy-needs-choices-and-possibilities.pdf
18 Robert W Howarth, 'Methane Emissions and climatic warming risk from hydraulic fracturing and shale gas development: implications for policy.' Energy and Emissions Control Technologies. Oct. 8, 2015. http://www.eeb.cornell.edu/howarth/publications/f_EECT-61539-perspectives-on-air-emissions-of-methane-and-climatic-warmin_100815_27470.pdf
19 An extensive database of studies on fossil gas and methane impacts can be found here: https://www.zotero.org/groups/248773/pse_study_citation_database/items/collectionKey/WEICK6IC/order/dateModified/sort/desc
20 https://obamawhitehouse.archives.gov/the-press-office/2016/03/10/us-canada-joint-statement-climate-energy-and-arctic-leadership
21 Carol Rasmussen, 'NASA-led study solves a methane puzzle'. NASA Global Climate Change. Jan. 2, 2018. https://climate.nasa.gov/news/2668/nasa-led-study-solves-a-methane-puzzle/
22 Rembrandt Sutorius and Matt Frank, "The drivers of global energy demand to 2050," McKinsey & Company Energy Insights, June 2016. https://www.mckinseyenergyinsights.com/insights/the-drivers-of-global-energy-demand-growth-to-2050/
23 IPCC, Fifth Assessment Report, Working Group III report, Fig 7.9, p. 555. http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter7.pdf
24 Climate Action Tracker, "Foot off the gas: increased reliance on natural gas in the power sector risks an emissions lock-in," June 2017. http://climateactiontracker.org/assets/publications/briefing_papers/CAT-2017-06-16-DecarbonisationSeries-NaturalGas.pdf
25 IEA, "World Energy Outlook," 2016, p. 552. http://www.iea.org/newsroom/news/2016/november/world-energy-outlook-2016.html
26 IPCC, Fifth Assessment Report, Working Group III report, Fig 7.9, p. 555. http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter7.pdf
27 IEA, "Commentary: The environmental case for natural gas," October 23, 2017. https://www.iea.org/newsroom/news/2017/october/commentary-the-environmental-case-for-natural-gas.html
28 BG Group, BP, Eni, Royal Dutch Shell, Statoil, and Total, letter to Laurent Fabius and Christiana Figueres, June 1, 2015. http://newsroom.unfccc.int/unfccc-newsroom/major-oil-companies-letter-to-un/
29 We use the IEA New Policies Scenario for 2040 power sector emissions. IEA, "World Energy Outlook," 2016, p. 552. http://www.iea.org/newsroom/news/2016/november/world-energy-outlook-2016.html
30 We use the median of IPCC scenarios for 2040 power sector emissions based on likely keeping warming below 2 degrees Celsius. IPCC, Fifth Assessment Report, Working Group III report, Fig 7.9, p. 555. http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter7.pdf
31 Peery Williams, Dan Murtaugh, and Yvonne Man, "Shell Invests to Boost Global Gas Demand," Bloomberg Markets, September 5, 2017. https://www.bloomberg.com/news/articles/2017-09-06/shell-seeks-to-boost-lng-demand-as-canada-in-mix-for-new-plant
32 Elena Giannakopulou and Tifenn Brandily, '1H 2018 LCOE Update Global'. Bloomberg New Energy Finance. March 28, 2018. P.6 Available by subscription only.
33 Ibid.
34 Ibid.
35 Ibid.
36 Lazard, "Levelized Cost of Energy 2017," November 2017. https://www.lazard.com/perspective/levelized-cost-of-energy-2017/
37 Energy Modeling Forum. "Changing the Game? Emissions and Market Implications of New Natural Gas Supplies." EMF Report 26. September 2013. Vol. I. Shearer, C. et al., "The effect of natural gas supply on US renewable energy and CO2 emissions," Environ. Res. Lett. September 24, 2014. Vol. 9
38 H McJeon et al., "Limited impact on decadal-scale climate change from increased use of natural gas," Nature. October 23, 2014; 514(7523):482-5. doi: 10.1038/nature13837
39 https://www.aemo.com.au/-/media/Files/PDF/Projections-of-Gas-and-Electricity-Used-in-LNG--Public-Report--Final.pdf and http://www.ep.total.com/en/areas/liquefied-natural-gas/lng-energy-source-bright-future
40 Lorne Stockman, 'Jordan Cove LNG and Pacific Connector Pipeline Greenhouse Gas Emissions Briefing' Oil Change International. Jan. 2018. http://priceofoil.org/content/uploads/2018/01/JCEP_GHG_Final-Screen.pdf
41 Gilbert, A. Q. & Sovacool, B. K., "US liquefied natural gas (LNG) exports: Boom or bust for the global climate?," Energy, Volume 141,December 15, 2017, pp. 1671-1680. https://doi.org/10.1016/j.energy.2017.11.098
42 Ibid.
43 Tagesspiegel interview, clipping summarized in Clean Energy Wire, "Grid operator says 80% renewables no problem," June 6, 2016. https://www.cleanenergywire.org/news/grid-operator-says-80-renewables-no-problem-environment-ministry-turns-30
44 Giles Parkinson, "Transgrid: 100% renewables is feasible and affordable," RenewEconomy, July 20, 2017. http://reneweconomy.com.au/transgrid-100-renewables-is-feasible-and-affordable-92062/
45 Herman K. Trabish, "As gas plants struggle, California seeks new flexible capacity strategies," Utility Dive, June 27, 2017. https://www.utilitydive.com/news/as-gas-plants-struggle-california-seeks-new-flexible-capacity-strategies/445760/
46 Herman K. Trabish, "Is renewable energy threatening power reliability? Reliability concerns are merely a 'Chicken Little argument' fossil generators use to advance their interests, analysts say," Utility Dive, June 1, 2017. https://www.utilitydive.com/news/is-renewable-energy-threatening-power-reliability/443701
47 Elena Giannakopulou and Tifenn Brandily BNEF, Op. Cit.
48 Angus McCrone 'The Force Is With Clean Energy: 10 Predictions for 2018' BNEF. https://about.bnef.com/blog/clean-energy-10-predictions-2018/
49 Elena Giannakopulou and Tifenn Brandily BNEF, Op. Cit.
50 Ibid.
51 Amber Lin, "Natural gas as a transition fuel: A bridge too far?," Bulletin of the Atomic Scientists, July 20, 2016. https://thebulletin.org/natural-gas-transition-fuel-bridge-too-far9671
52 Elena Giannakopulou and Tifenn Brandily BNEF, Op. Cit.
53 Karen C. Seto et al, "Carbon Lock-In: Types, Causes, and Policy Implications," Annu. Rev. Environ. Resour. 2016. 41:425–52, doi:10.1146/annurev-environ-110615-085934
54 Alexander Pfeiffer et al., "The '2°C capital stock' for electricity generation: Committed cumulative carbon emissions from the electricity generation sector and the transition to a green economy," Applied Energy, Volume 179, October 1, 2016, pages 1395-1408. http://www.sciencedirect.com/science/article/pii/S0306261916302495
55 Greg Muttitt, "The Sky's Limit: Why the Paris Climate Goals Require A Managed Decline of Fossil Fuel Production," Oil Change International, September 22, 2016, pg. 21. http://priceofoil.org/2016/09/22/the-skys-limit-report/
56 For detailed methodology see Muttitt, Sky's Limit, op.cit., Section 2