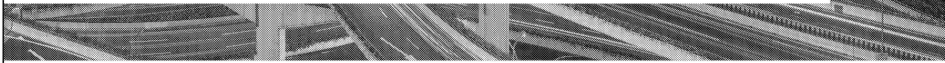




## Gas: the destination fuel

Bob Stout / September 2018



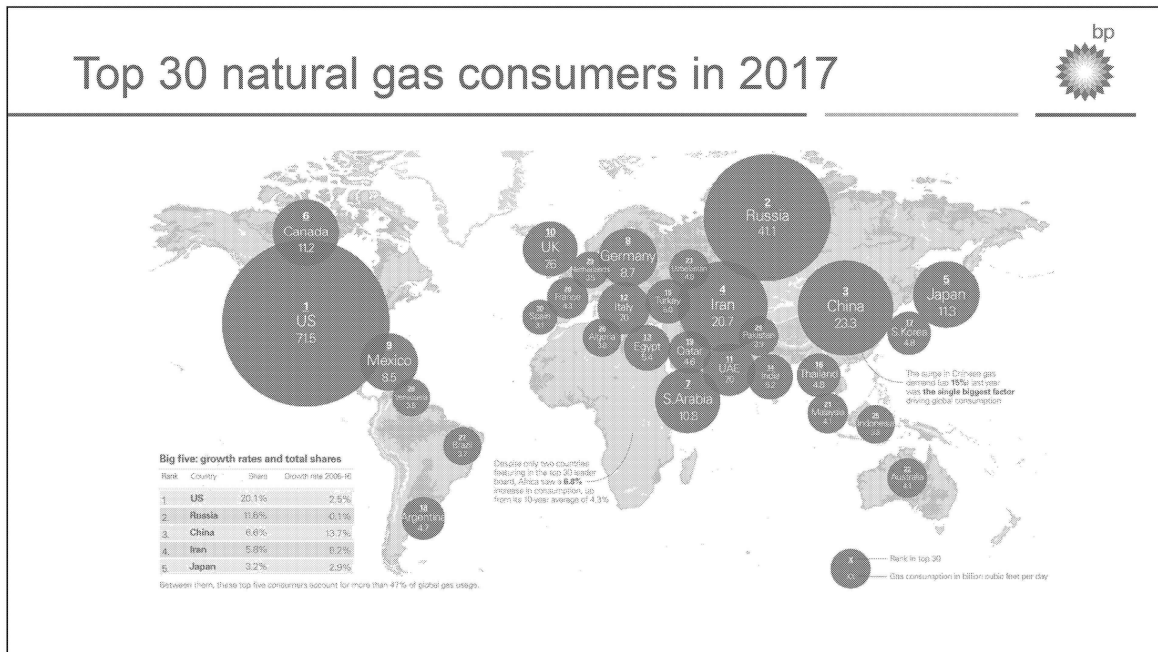
## Gas in 2017: a 'bumper year' globally



- Accounted for the **largest** source of growth in energy consumption
- Production grew by **almost twice** the ten-year average
- Predicted glut in LNG failed to materialize, despite 'tidal wave' of new projects sanctioned
- "We haven't yet seen significant amounts of capacity standing idle; some of that supply has come on less quickly than expected and that's given demand more time to grow." Spencer Dale, BP's chief economist

Set the scene with context from BP's energy economics team. A couple of months back, our chief economist Spencer Dale launched the annual Statistical Review of World Energy – what did that say about the role of gas last year?

"In 2017, gas accounted for the largest source of growth in energy consumption; production grew by almost twice the ten-year average"



He described it as a 'bumper year' for natural gas – highlighting the world's largest consumers with the US at no. 1, with Russia and China following.

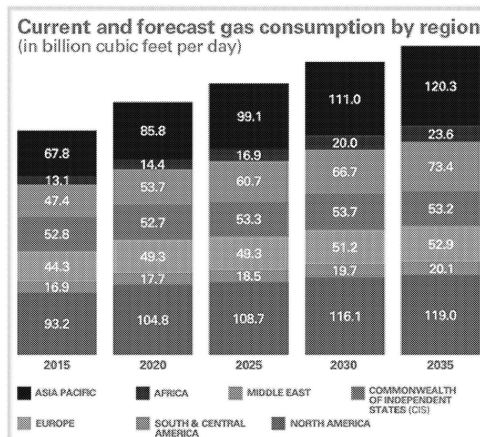
Another headline in Spencer's review of the gas market in 2017, was that the 'predicted glut in LNG failed to materialize even after what he described as a 'tidal wave' of new projects sanctioned.

"We haven't yet seen significant amounts of capacity standing idle; I think some of that supply has come on less quickly than expected and that's given demand more time to grow."

## Global outlook to 2040: gas is resilient



- No crystal ball but key trends for energy transition
- Energy mix likely to be the **most diverse** the world has ever seen
- Renewables are predicted to be the fastest-growing fuel source
- Gas set to replace coal as the **second largest** source of energy
- Gas resilient under a **range of scenarios** – be it faster renewable penetration, or less coal-to-gas switching.



That was last year's data though, and we all know that gas had a great year. But, what does the future hold?

None of us has a crystal ball, but Spencer and his team of economists also study key trends to examine how the energy transition may play out. BP also publishes an Energy Outlook that looks ahead to 2040, with the goal to better understand the nature of uncertainties and how they may play out in the energy world.

The Outlook uses a scenario-based approach, and while I'll only share data from one scenario for this discussion, there is a lot more information in the whole booklet on the other five scenarios.

According to the Outlook's Evolving Transition scenario, the overriding global themes that are likely to play out in the next two or three decades are:

-all the growth in energy demand will come from fast-growing emerging economies, with China and India each accounting for around 25% of that growth.

-global energy markets will become increasingly competitive as the world gets better at using energy more efficiently.

-improvements in technology will mean we get better at producing energy, so it will be abundant in all forms.

The energy mix in 2040: oil, gas, coal and non-fossil fuels are each projected to account for around a quarter of the world's energy. In fact, the energy mix is likely to be the most diverse the world has ever seen by 2040. Renewables are predicted to be the fastest-growing fuel source.

But, do they pose a threat to natural gas?

According to the Energy Outlook, the short answer is 'no'.

Natural gas is set to replace coal as the second largest source of energy, supported by increasing levels of industrialization and power demand in those fast-growing emerging economies, as well as increasing availability of low-cost supplies here in North America and the Middle East.

The Outlook also shows that gas is resilient under a range of scenarios – be it faster renewable penetration, less coal-to-gas switching or a more comprehensive set of climate policies.

And, even in a scenario that has carbon emissions from energy use broadly consistent with the Paris climate goals, gas demand in 2040 is similar to current levels, suggesting that – just as with oil – the world will require significant levels of investment in

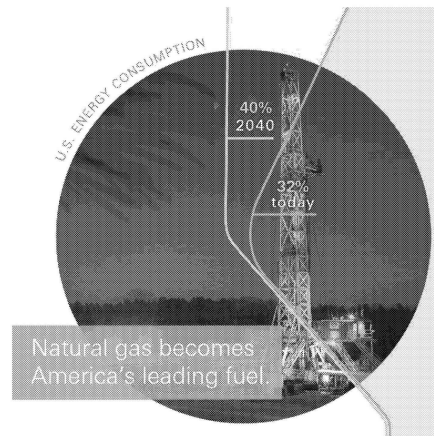


new gas production to be able to meet this demand.

## U.S. outlook 2040: extending production lead



- Energy self-sufficient in the early 2020s
- World's **largest producer** of liquid fuels and natural gas
- Nat gas becomes **leading** fuel, with 40% of energy consumption (32% today)
- Nat gas production increases by 46 Bcf/d to 118 Bcf/d



Let me share some U.S.-specific headlines from the Outlook:

It projects that the U.S. becomes energy self-sufficient in the early 2020s and maintains its position as the world's largest producer of liquid fuels and natural gas.

Natural gas becomes the leading fuel, accounting for 40% of US energy consumption, up from 32% today. Renewables (17% in 2040) also gain market share while coal and oil lose significant share (accounting for 5% and 30% of energy use, respectively, in 2040).

Natural gas production increases by 46 Bcf/d to 118 Bcf/d.

Domestic energy production increases by 39%; growth in natural gas (+65%), oil (+55%) and renewables (+220%) more than offset declines in coal (-48%) and nuclear power (-28%).

## Addressing the dual challenge



- The world demands more energy, but fewer emissions
- Gas is abundant, affordable and produces half the CO<sub>2</sub> emissions of coal when burned for power
- Switch from coal to gas reduced US emissions to 1990s levels
- BP sees natural gas as **ideal partner** to renewables as lower-carbon, cost-effective back up

Back to the present day, why does BP consider gas to be so important? You've just seen the numbers from our economics team about the need for continued investment in gas production in a future world where renewables alone will be insufficient to meet increasing global energy demand.

The downside of that energy demand growth is the pressure it creates through increasing greenhouse gas emissions. That's why gas is going to be more important than ever as part of the energy mix.

Gas is abundant, it's affordable – and if you use it instead of coal for power generation, you can cut the sector's carbon emissions by half.

Here in the US we've seen how switching from coal to gas has reduced emissions levels down to those last seen in the 1990s. Over in the UK they're down to levels of the 1890s.

In short, gas can support the dual challenge of increasing energy demand while lowering emissions. That's why gas has a prominent place in BP's global business strategy, as outlined in our Advancing the energy transition report, published in April.

BP has committed to producing more natural gas because:

-we see it as the ideal partner to renewables – as it can be a lower carbon, cost-effective back-up to the variability of wind, solar and hydropower generation.

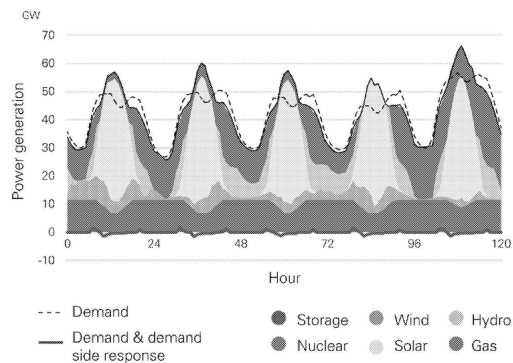
-emitting fewer pollutants, it is also better for air quality.

-gas is becoming more accessible and affordable around the world – thanks to a growing global gas market connected by ship and pipeline.

## The perfect partnership: gas with renewables



- What happens when sun doesn't shine or wind varies?
- Different forms of energy contribute to power demand in a future world.
- Gas, with hydropower in this case, can be **flexed up and down rapidly** making them more suited to role than nuclear power.
- Most plentiful, flexible, lower carbon and economic form of back-up generation = gas



Before we move onto talk about BP's gas portfolio, let's take a moment to delve deeper into how gas makes the ideal partner for renewable energy. Here's a chart that appears in BP's Technology Outlook 2018, showing how different forms of energy could contribute to power demand (in gigawatts) over five days in a future world if renewables (wind and solar) grow from around 6% of the power mix to 40%.

Taking a southern US state in the summer as an example, the simulation shows how solar peaks – in yellow – during the daylight hours of a typical working week.

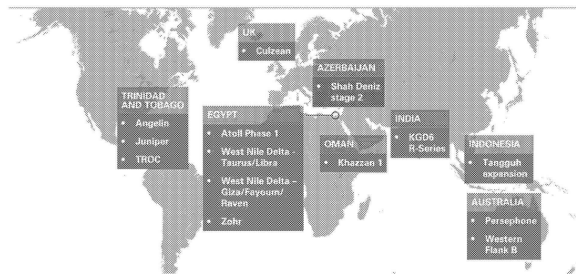
When the sun stops shining, nuclear provides a base of power with wind also making a contribution. But more is needed, particularly in the evening and at night. You can see those two fuels in blue and yellow at the bottom.

The graph shows how gas, along with hydropower in this case, can make up the remaining demand. They can be flexed up and down rapidly making them more suited to this role than nuclear power.

Hydropower is a good source of back-up, but it is limited geographically. This leaves gas as the most plentiful, flexible, lower carbon and economic form of back-up generation to provide for times when demand is high and renewables are not producing enough supply. Gas can be also mostly decarbonized using carbon capture use and storage, creating a near zero carbon power system.

And, more on CCUS later – but it's an interesting chart to demonstrate that it's unrealistic to assume that we'll be 100% reliant on renewables several decades from now.

## Growing gas: BP's global portfolio



- Six of seven major upstream project start-ups in 2017 were gas: Trinidad, Oman and Egypt.
- First commercial delivery to Turkey from mega-project Shah Deniz 2 in June.
- Out to 2020, BP is projected to see the greatest growth in gas production of all supermajors as new projects come on stream.
- In that timeframe, 14 of BP's 17 major projects are gas.

As we've seen, the flexibility of gas makes it an attractive long-term prospect – and BP is growing its global portfolio of gas projects. For example, the business started up seven major upstream projects in 2017, and six of those were gas projects – in diverse locations such as Trinidad, Oman and Egypt.

Earlier this summer, we delivered first commercial gas to Turkey from our mega-project Shah Deniz 2 in the Caspian Sea. This \$28 billion development provides a gateway for new gas supplies into Europe.

At the time, our chief executive Bob Dudley said:

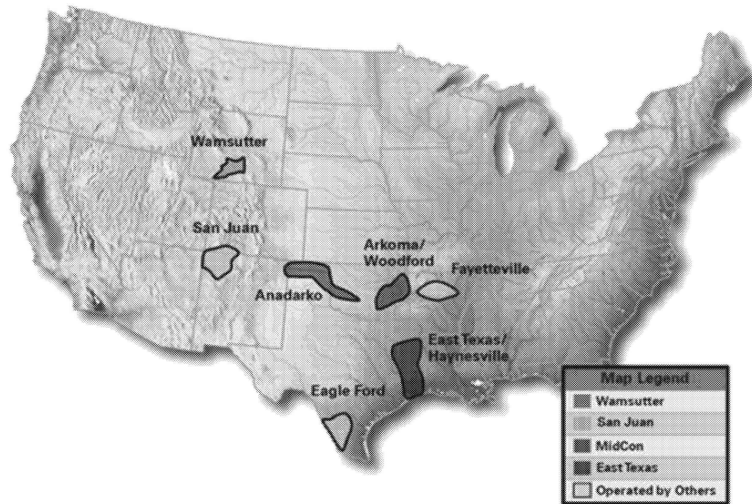
"Together with the Southern Gas Corridor pipeline system, Shah Deniz 2 will deliver significant new energy supplies to Europe, further diversifying its sources of energy and providing new supplies of natural gas which will be essential in the energy transition."

So, how does BP compare to its international oil company peers? Between 2017 and 2020, BP is projected to see the greatest growth in gas production of all the supermajors as new projects come onstream. In fact, out to 2020, 14 of BP's 17 major projects are gas.

As you can see, BP is active in finding and producing gas, as well as its transport, storage and sale. This puts us in a good position as the gas market grows and becomes increasingly competitive.

But, what about BP's natural gas position in the US?

## U.S. gas portfolio: Lower 48 onshore

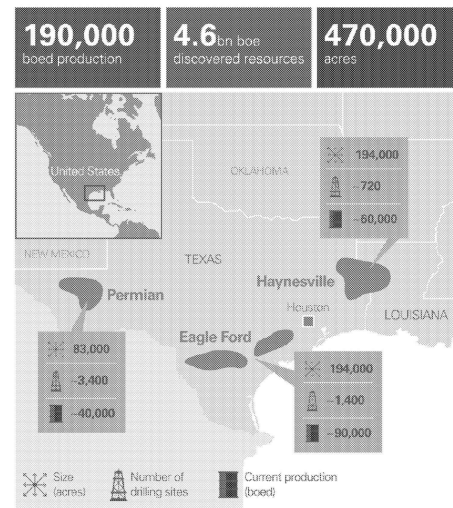


With operations that span five states — Colorado, New Mexico, Oklahoma, Texas and Wyoming — BP's Lower 48 onshore business is one of America's largest natural gas producers.

## BHP acquisition: 'transformational'



- Acquiring world-class unconventional oil and gas assets from BHP in \$10.5 billion deal.
- Permian-Delaware, Eagle Ford and Haynesville basins.
- 'Transformational' deal will reinforce position as a top onshore producer in U.S.



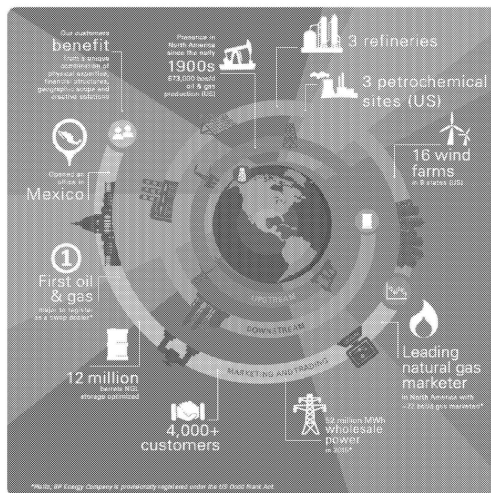
The business is set to grow dramatically with BP's agreement to acquire a portfolio of world-class unconventional oil and gas assets from BHP, in a \$10.5 billion deal announced at the end of July. To put the scale of the acquisition in context, it's BP's largest since buying Arco in 1999. And it will be fully accommodated within the company's current financial framework.

Intention to sell some assets in San Juan Basin, as well as the Anadarko Basin in Oklahoma and Texas, and the Arkoma Basin in Oklahoma – as part of plan to divest \$5-6 billion worth to help fund the purchase.

The BHP portfolio includes assets in the highly-prized Permian-Delaware basin in Texas, along with two premium positions in the Eagle Ford and Haynesville basins in Texas and Louisiana. The assets currently produce 190,000 barrels of oil equivalent (boed) per day, of which about 45% are liquid hydrocarbons.

This transformational deal will reinforce our position as a top onshore producer in this country.

# Energy marketing and trading: overview



- No. 1 marketer of natural gas in North America, buying and selling 20+ bcf each day.
- Manages more than 11+ bcf of transportation capacity and schedules gas flows on approx. 180 pipelines.
- BP has a unique combination of physical expertise, financial structures, geographic scope and creative solutions.

BP remains the number one marketer of natural gas in North America, buying and selling more than 20 billion cubic feet each day. (source: EIR 2018)

The company manages more than 11 billion cubic feet of transportation capacity and schedules gas flows on approximately 180 pipelines across North America.

Quote from Orlando Alvarez, head of BP's gas, NGLs, and power marketing and trading business in Houston:  
 "In addition to our gas and power businesses, we are expanding our natural gas liquids business both domestically and globally. We have deep expertise across the value chain – including in pipelines, railcars and ships – which allows us to deliver to multiple destinations for our U.S. customers."

Because the marketing and trading team is integrated with the rest of the company, BP can maximize the value of energy resources. Customers benefit from a unique combination of physical expertise, financial structures, geographic scope and creative solutions.

The energy industry is more complex and interconnected than ever before. Our marketing and trading business has evolved from one focused on natural gas and power to a unique, cross-commodity model that spans global energy markets. This transformation includes unprecedented coordination between asset optimization, trading and origination to deliver one-stop solutions.

BP is also one of the largest suppliers of renewable natural gas to the U.S. transportation sector. Produced entirely from organic waste, RNG – or 'biogas' – can reduce emissions by around 70 per cent compared with gasoline or diesel. Thanks to its partnership with Clean Energy Fuels, BP now owns RNG production facilities in Michigan and Tennessee, along with a share of two RNG plants currently under construction in Oklahoma and Georgia.

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Our partnership with Clean Energy is another reflection of BP's commitment to supporting the energy transition – accelerating the growth of renewable natural gas as well. But, when talking about natural gas in general, we're conscious of the need to tackle its 'Achilles heel' – and that's methane.



## 'Achilles heel' for gas: methane emissions



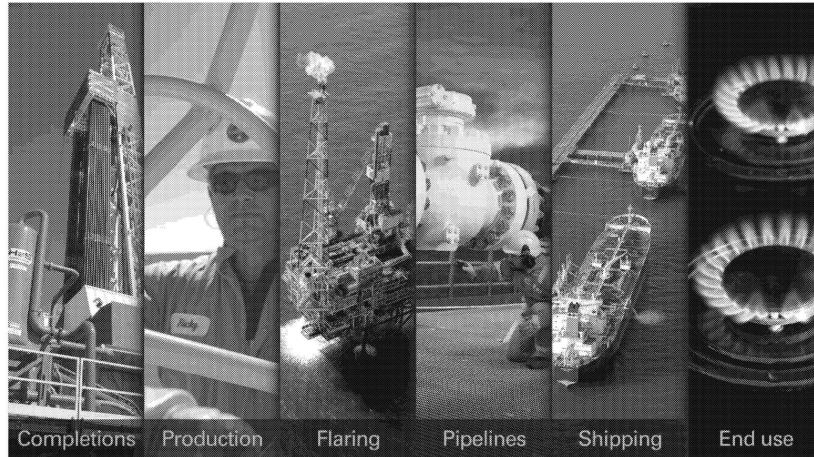
- Methane is the main component of natural gas; understood to have a **higher global warming potential** than carbon dioxide if it finds its way into the atmosphere before it's burned.
- Shorter lifetime in the atmosphere than CO<sub>2</sub>, so its impact as a greenhouse gas is **shorter-lived**.
- But, stopping leaks is important to avoid adding to future levels of greenhouse gases and maximise the emissions-lowering potential of gas as an alternative to coal.

Methane is the main component of natural gas and is understood to have a higher global warming potential than carbon dioxide if it finds its way into the atmosphere before it's burned. That potential is estimated to be at least 25 times that of carbon dioxide over 100 years.

So, while there is far less methane in the atmosphere than carbon dioxide, it accounts for around one-fifth of man-made global greenhouse emissions on a like-for-like basis.

Methane has a shorter lifetime in the atmosphere than carbon dioxide, so its impact as a greenhouse gas is shorter-lived. But, stopping leaks is important to avoid adding to future levels of greenhouse gases and maximise the emissions-lowering potential of gas as an alternative to coal.

## Potential methane sources in gas chain



Sources of methane: it can come from natural sources such as wetlands, freshwater and volcanoes, while up to three-fifths are estimated to come from human activity.

Of that proportion, around two-fifths are thought to come from agriculture and around one-fifth from oil and gas production. Methane is emitted in the energy industry when gas is vented or flared – which was once routine but is now increasingly avoided – or when it escapes from pipes or equipment, as so-called ‘fugitive’ emissions.

## Tackling the methane challenge



- BP committed to leading role in addressing methane emissions
- Targeting a **methane intensity of 0.2%**, holding below 0.3%
- “It really is an extraordinary number” - Professor Steve Pacala from Princeton
- Industry-wide initiatives include OGCI independent studies and tech investments; World Bank campaign for no routine flaring

The Intergovernmental Panel on Climate Change data suggests that methane accounts for around 20% of manmade GHG emissions. Since methane is the primary component of natural gas, BP is committed to taking a leading role in addressing the methane challenge.

Methane ‘intensity’ refers to the amount of methane emissions from BP’s operations where gas goes to market, expressed as a percentage of that gas. BP is targeting a methane intensity of 0.2%, and holding it below 0.3%.

Professor Steve Pacala, a leading climate scientist from Princeton University and co-director of the Carbon Mitigation Initiative – which is a 20-year-old partnership with BP – has said:

“If the industry as a whole were to adopt BP’s target then methane emissions from oil and gas infrastructure would no longer be a major component in the global warming problem. In fact, it would become a minor, almost negligible component.”

He went on to call BP’s target ‘an extraordinary number’.

There are plenty of industry-wide initiatives in this space too.

A lot of the ground work is simply to create better kit to detect and measure methane emissions. For example, the Oil & Gas Climate Initiative, of which BP is a founder member, has launched an independent study to measure and compare methane emissions in global gas supply chains. It is also looking at new technologies to tackle emissions.

The World Bank has led a campaign for zero routine flaring of gas by 2030, which BP and others support. And eight companies, including BP, signed a set of principles for tackling methane challenges in November 2017.

## Methane reduction: a priority in Lower 48



- ~50% of BP's total operated methane emissions from L48
- New technology: green completions, replacing high-bleed pneumatic controllers, trialling solar pumps, drones
- Total GHG emissions cut by more than 2 million metric tons of CO<sub>2</sub> equivalent since 2000
- "Good for environment, good for business" says L48 CEO



The Lower 48 business here in the US is responsible for around half of BP's total operated methane emissions – so we've made methane reduction here a priority:

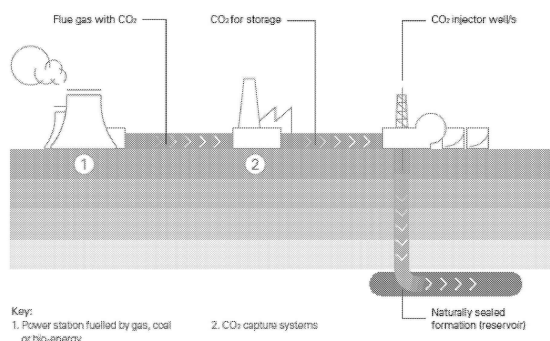
- we introduced the technique known as green completions, which captures gas that would otherwise be flared or vented during the completion and commissioning of wells.
- we replaced around 99% of its high-bleed pneumatic controllers with continuous low-bleed and intermittent pneumatic controllers. These controllers use energy from pressurized natural gas to operate valves and control pressure, flow, temperature and liquid levels. Depending on their design, they can release (or "bleed") natural gas into the atmosphere.
- we're trialling pumps powered by solar energy rather than gas, and the use of drones to detect and quantify methane leaks.
- we've optimized the compressor engine fleet to reduce the number and size of engines.
- the business has installed a waste heat recovery unit at its Florida River gas plant in Colorado. This unit allows the plant to capture exhaust gas waste heat and use it for energy.

Thanks to these actions and others, BP's Lower 48 business has slashed its total greenhouse gas emissions by more than 2 million metric tons of CO<sub>2</sub> equivalent since 2000, with methane reductions accounting for most of the decline.

Quote from Dave Lawler, CEO of Lower 48

"We understand that reducing methane emissions with advanced technology can help make our operations safer, stronger and more reliable. In that sense, tackling the methane challenge is not only good for the environment, but also good for business."

## Looking ahead: the changing future of power



- Carbon capture, use and storage (CCUS) can reduce emissions from power stations by capturing CO<sub>2</sub>, not venting it
- Technologies proven and ready, scale-up needs accelerating
- Requires targeted policy support and price on carbon
- BP exploring opportunities in operations, projects, products. For example, Algeria and UAE

CCUS is widely recognised as a tool that could potentially be critical and cost-effective in reducing emissions and helping to meet the Paris Agreement goals. It can achieve deep emissions reductions in existing power infrastructure and energy-intensive industries that rely on the use of fossil fuels.

It can be applied at power stations burning gas, coal or biomass, or at energy-intensive industrial facilities, with the captured carbon dioxide either being used for commercial purposes, for example in enhanced oil recovery (EOR), or stored securely underground in suitable geological formations.

The relevant technologies are proven and ready – been in use for 20 years – but their scale-up needs to be accelerated if they are to achieve their full potential to deliver a low-carbon energy system with optimal use of hydrocarbons.

CCUS is only set to become widely deployed in the power sector if it attracts targeted policy support to achieve greater cost reductions and carbon emissions are priced.

Collaboration is required to make CCUS a reality. Through the Oil and Gas Climate Initiative (OGCI), we are working to identify the policy mechanisms that may best enable the roll out and scale-up of CCUS on a regional basis.

BP has worked on the development of CCUS for many years with a project in Algeria, as well as through the CO<sub>2</sub> Capture Project, which is piloting technology and demonstrating secure geological containment.

We are exploring near term opportunities to deploy CCUS in our own operations, projects and products. For example, as part of a joint venture in the United Arab Emirates, we are using CO<sub>2</sub> from industrial processes to enhance oil recovery.

## In summary: BP's position on gas



- Gas has a crucial role to play:
  - ✓ A safe, clean, reliable partner to renewables
  - ✓ Half the carbon intensity of coal when burned for power generation
- A bigger role for gas means there is a need to understand and tackle the challenge of methane emissions
  - ✓ A flexible fuel to power clean, low carbon mobility
  - ✓ Vital to meeting the Paris climate goals
- BP is growing in gas
  - ✓ Deep experience of gas exploration and production
  - ✓ Developing some of the world's biggest resources in U.S., Oman
  - ✓ Advantaged positions in global gas trading and supply

Gas has a crucial role to play:

A safe, clean, reliable partner to renewables

Half the carbon intensity of coal when burned for power generation

A bigger role for gas means there is a need to understand and tackle the challenge of methane emissions

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Vital to meeting the Paris climate goals

BP is growing in gas

Deep experience of gas exploration and production

Developing some of the world's biggest resources in U.S., Oman

Advantaged positions in global gas trading and supply

## More than a transition fuel...



- Advocating for gas globally
- Gas is a 'destination' fuel - part of a low carbon future, not just a fuel for getting there.
- Needs investment in infrastructure and open markets
- Innovation and technology to decarbonize gas
- Partner gas with renewable power, plus carbon pricing



### Final thoughts

For all the reasons outlined, gas is important to BP. So much so, that we're advocating for it on a global level. We want to advance and protect the role of gas in the energy transition.

Might be interested to know that we have two main advocacy campaigns happening right now – one around the future of mobility, to encourage policy choices to support energy-system wide solutions, and another to support gas's continued role in the energy mix.

As part of those campaigns, we'll be reaching out to opinion leaders with our messages about, not only here in the US, but also in our other key geographies in Europe, the Middle East, India and China.

As a company, we see the opportunity to explain the benefits of gas as a 'destination fuel' and addresses its weakness i.e. methane. That's why you'll hear our top executives talking about it on a regular basis, just as chief executive Bob Dudley did at the World Gas Conference at the end of June. I'll leave you with some of his words on that occasion...

"We see gas not just as a transition fuel, but as a destination fuel. What does that mean exactly?

It means that we consider gas as a fuel that is part of a low carbon future, not just a fuel for getting there. To make that happen, as we've seen, we'll need:

- investment in infrastructure and open markets to create a more globalised market for gas.
- innovation and technology to decarbonise gas, particularly in carbon capture and storage.
- to partner gas with renewable power,
- carbon pricing, which will help to make all of those happen.

Wrap up and thanks