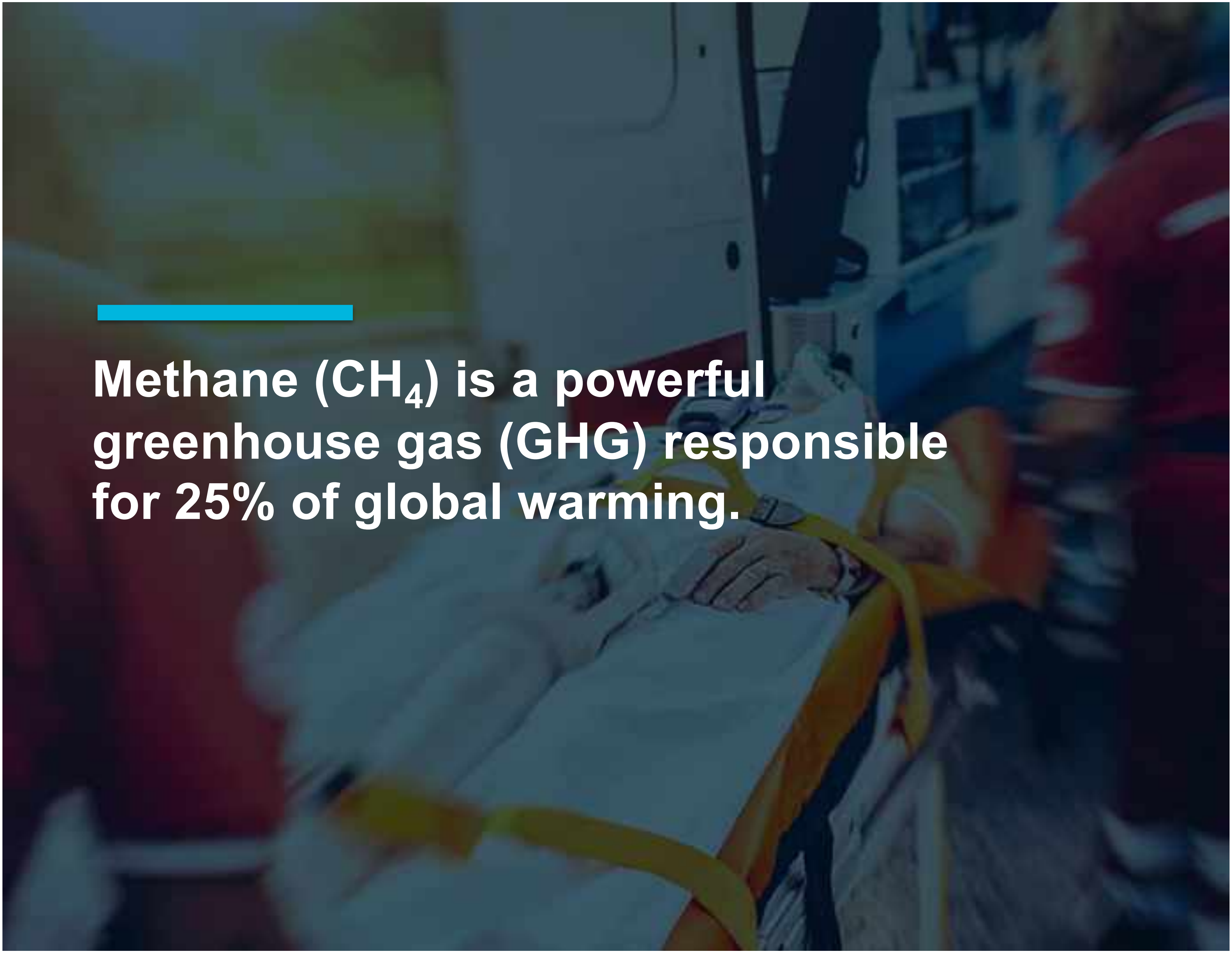
Methane 101

What is methane and why should you care?

Understanding methane and the role of natural gas

Produced by the Global Methane Solutions RMI-SYSTEMIQ Partnership | 2019


Methane (CH_4) is a powerful greenhouse gas (GHG) responsible for 25% of global warming.

Methane is considerably more potent than CO_2, although exactly how much depends on your time frame.

Methane is 84 times as bad as CO_2 on a 20-year time frame

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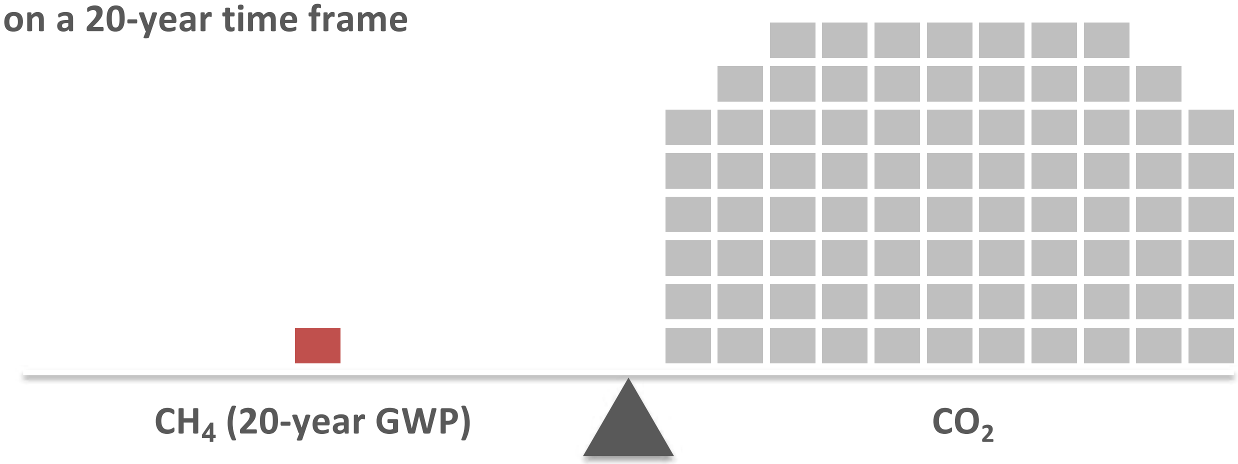
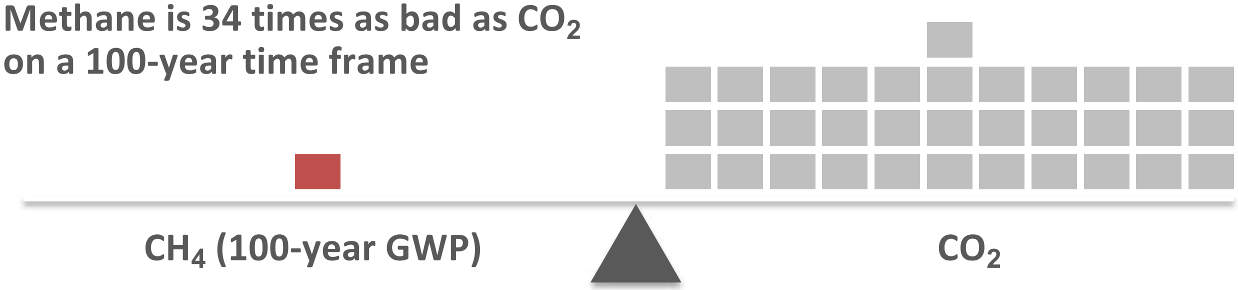


Methane is 34 times as bad as CO_2 on a 100-year time frame



Unlike CO_2, which persists in the atmosphere for many centuries, **methane stays in the atmosphere** for only a few decades before decaying to CO_2.

During those decades, the global warming potential (GWP) of **methane is really intense** (~84 times as bad as CO_2 in 20 years), but it fades as time goes by (to ~34 times as bad as CO_2 in 100 years).

Both measures are valid, and the **oil and gas industry usually uses the 100-year time frame.** However, most climate-aware groups focus on the 20-year time frame because **we have a limited window** within which to act on our urgent climate crisis.

Global methane levels are on the rise, with serious consequences for the climate.

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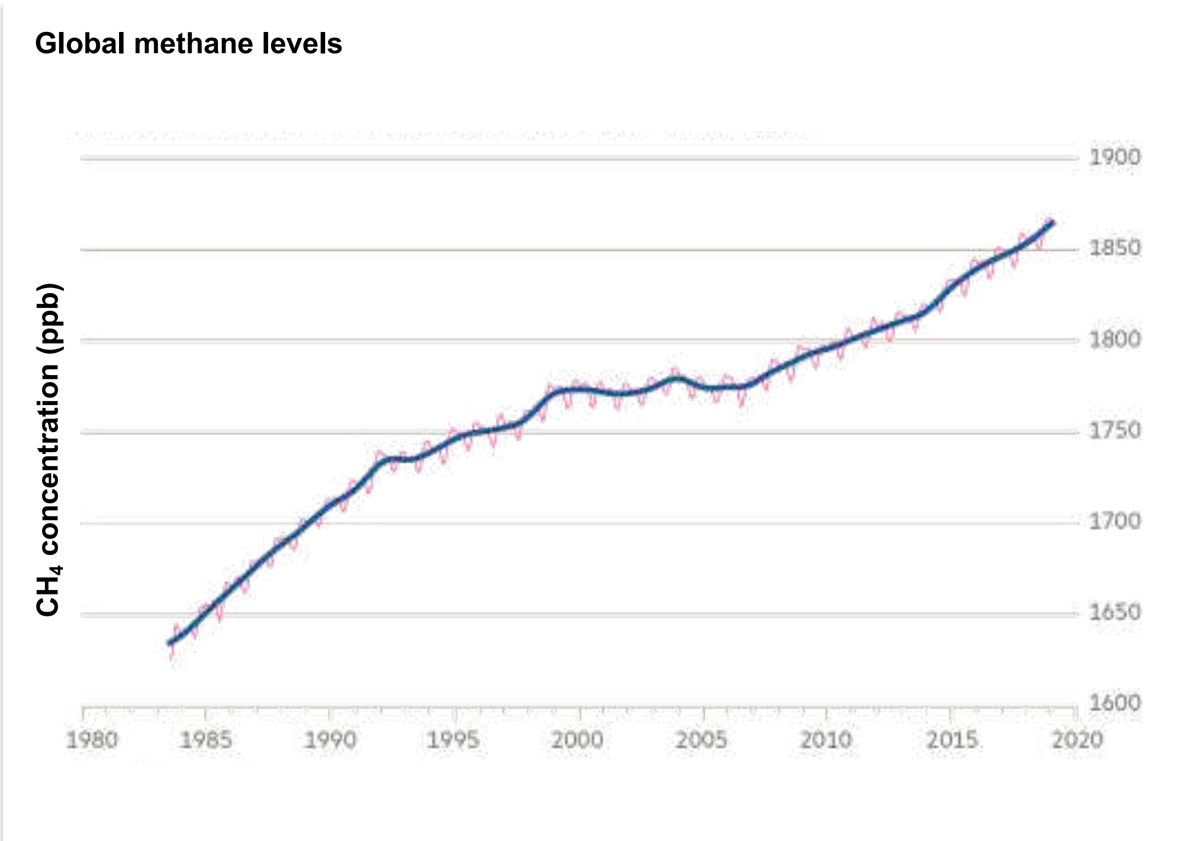
Atmospheric methane hit a record high last year



Source: FT, US National Oceanic and Atmospheric Administration

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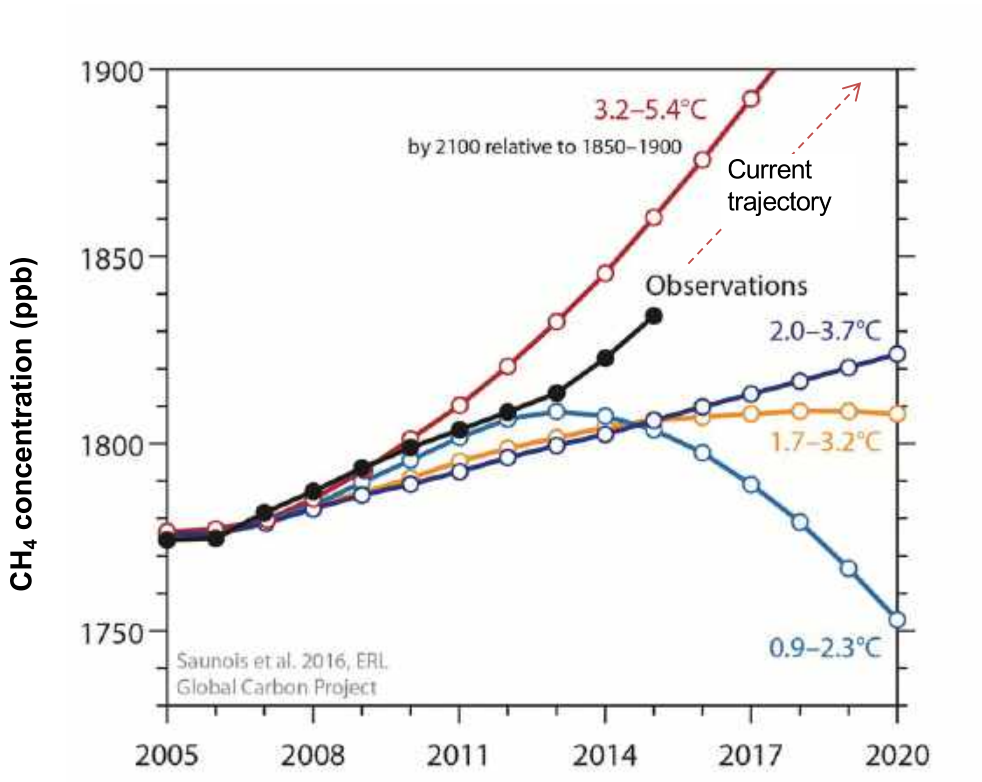
If we do not seriously limit methane emissions, we will have no chance to limit warming to below 2 degrees

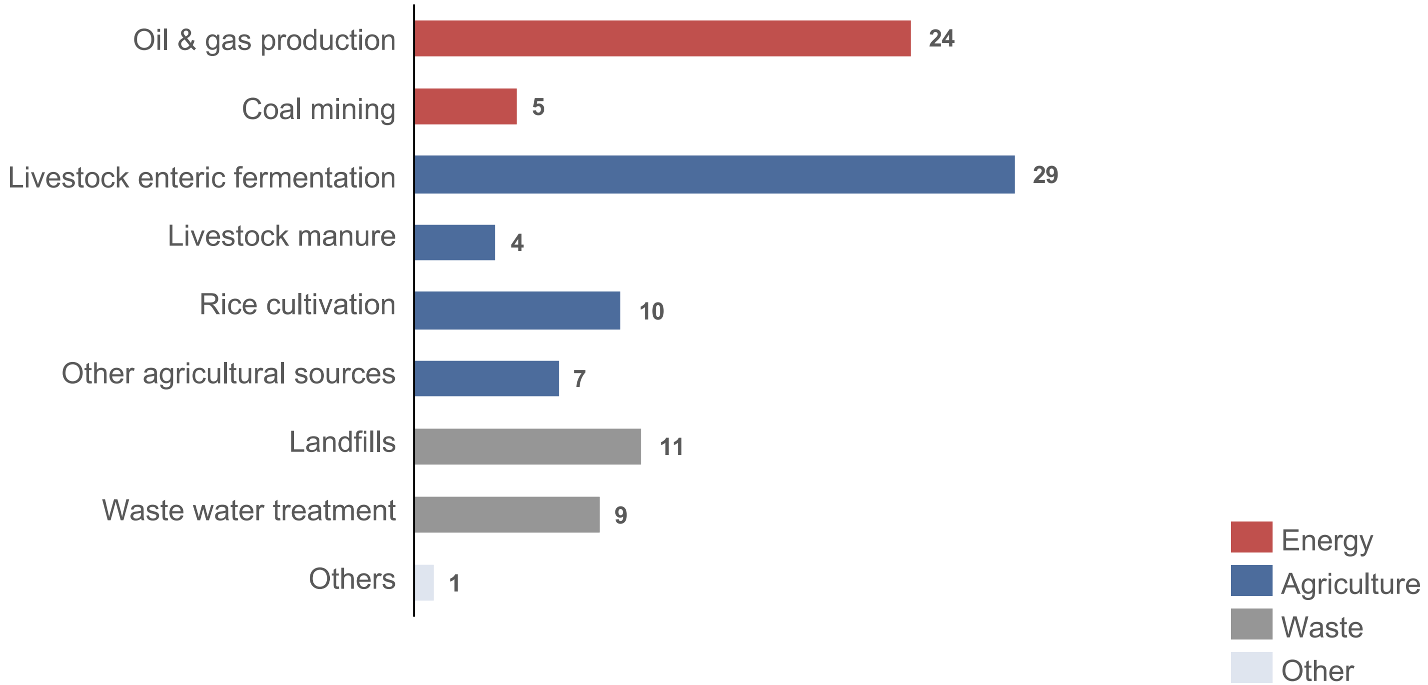


International Panel on Climate Change methane concentration pathways and methane observation from National Oceanic and Atmospheric Administration

Source: http://theconversation.com/methane-from-food-production-might-be-the-next-wildcard-in-climate-change-69894

Methane comes from a variety of both natural and manmade sources

Estimated of global methane emissions from anthropogenic sources by 2010



Note: Numbers from methane sources are an approximation based on best available data
Source: Climate and Clean Air Coalition

Methane from anthropogenic sources is causing an overbalance in the natural cycle.

- The atmosphere has a natural methane cycle that balances emissions and sinks.
- **Anthropogenic (or human-caused) methane emissions** have caused an **overbalance of methane in the atmosphere.**
- Of all these methane emissions sources, anthropogenic emissions from our energy system account for approximately one-third of total emissions.

Focusing on abatement from oil & gas emissions can address this overbalance

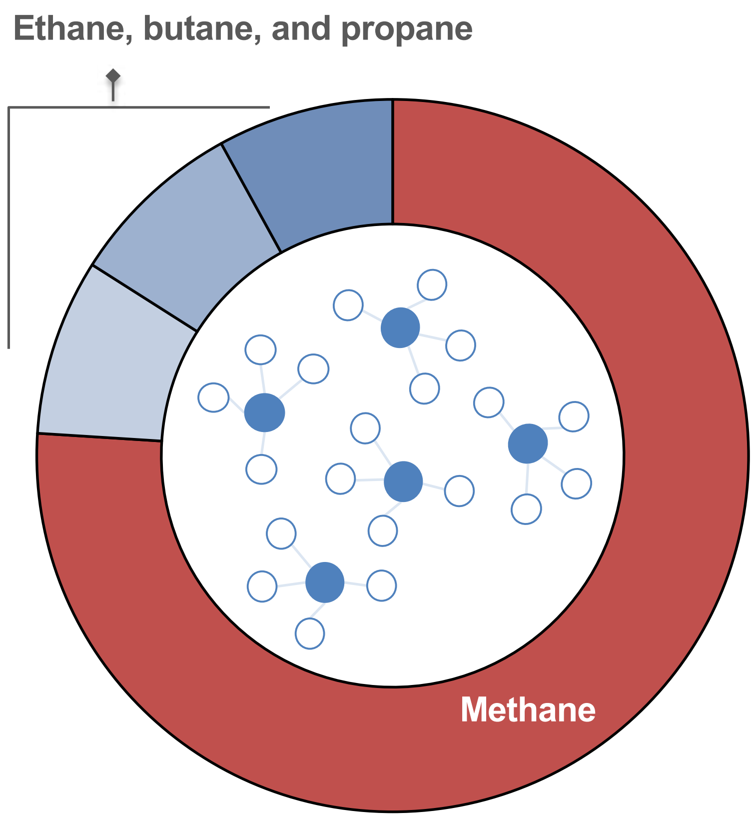
- **Methane from oil & gas is the largest contributor to human-caused emissions,** with the exception of enteric fermentation (think burping cows) for which we have limited abatement options

- **Scaling up existing technology and policy options for oil & gas methane can be done relatively quickly and cost effectively,** compared to other sectors where diffuse point sources make abatement more challenging

- **Substantive actions by a few industry leaders has the potential to serve as a tipping point to change industry practices as a whole.** The global oil & gas industry is dominated by a few multinational giants, the actions of which can set the tone and practice for the industry as a whole. Many of these influential leaders have already made public methane reduction commitments. The key is holding them accountable and ensuring they are implementing the most rigorous and effective reduction strategies.

Within the natural gas system, the primary component of natural gas is methane.

Natural gas primarily consists of:



*Exact composition varies based on the basin, age of the well, etc.

Average composition of natural gas*

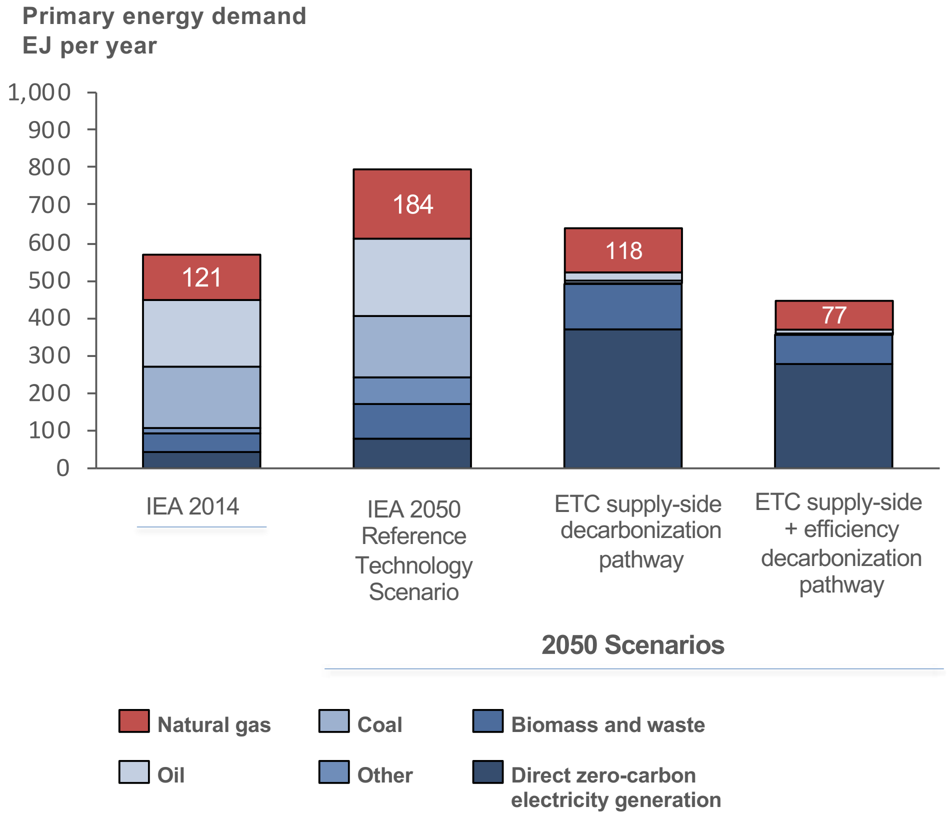
- **Methane (77-92%)**
- **Ethane (0-20%)**
- **Butane (0-20%)**
- **Propane (0-20%)**

Source: http://www.iea.org/publications/freepublications/publication/ngl2010_free.pdf

Halting all oil and gas today is not realistic. For better or worse, natural gas will likely be a part of our energy system for several more decades.

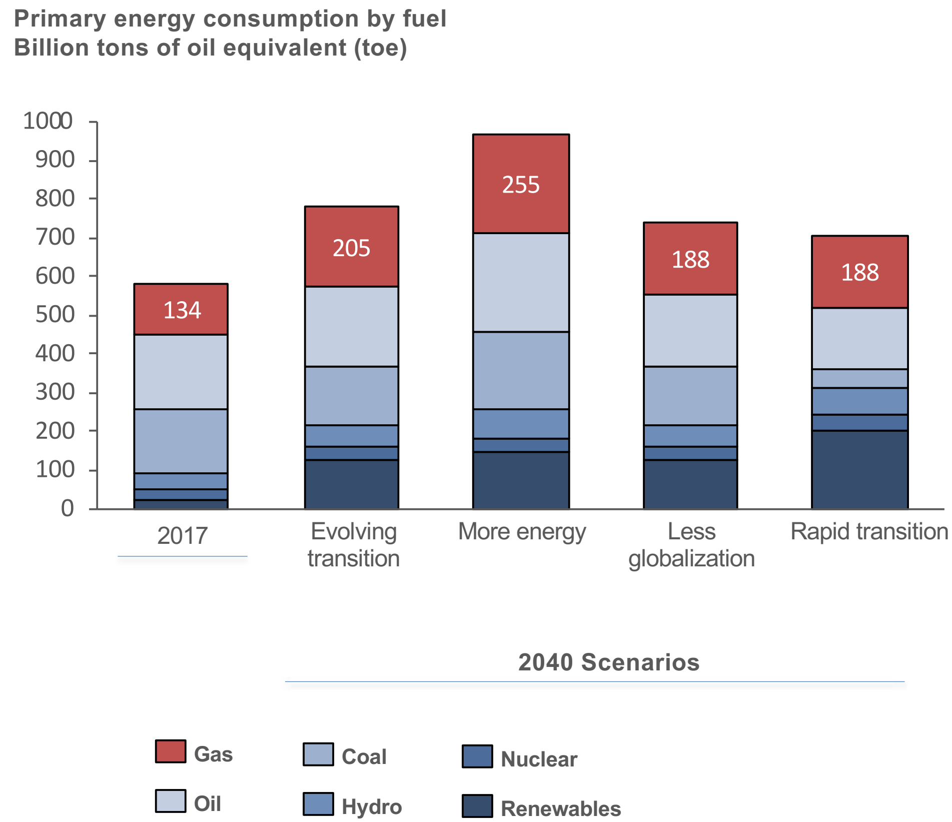
The Role of Gas in the Energy Transition

View from the **Energy Transitions Commission**



Note: Direct zero-carbon electricity generation includes solar, wind hydro, and nuclear.

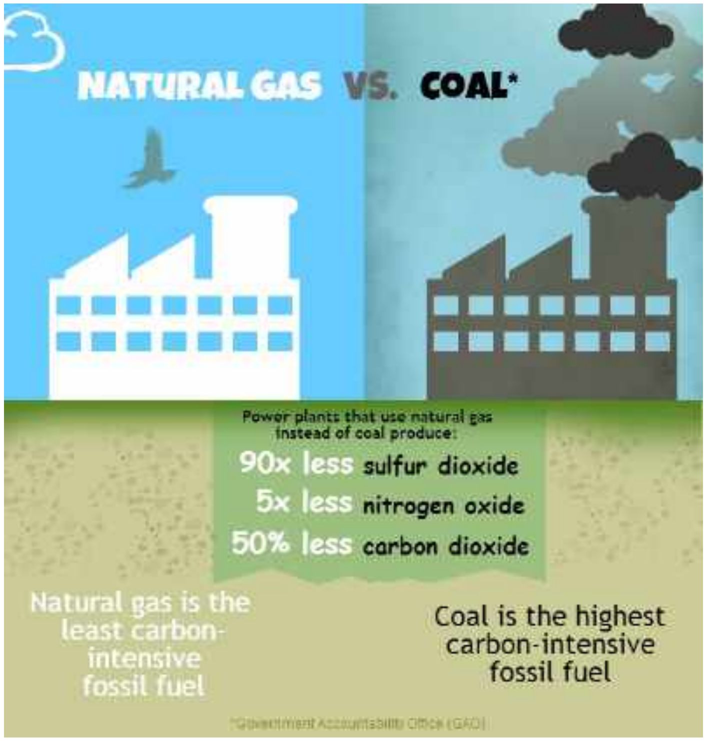
View from BP **Energy Outlook**



Note: Renewables includes wind, solar, geothermal, biomass, and biofuels.

Source: ETC's Mission Possible report. SYSTEMIQ analysis for the Energy Transitions Commission 2018, International Energy Agency (2017), Energy Technology Perspectives
Source: BP World Energy Outlook

Because natural gas is seen
to be “cleaner” than coal …



… Natural gas may play a role in decarbonization, particularly for some hard-to-abate sectors where coal has played a greater role

Residential heating:

For residential heating, where it is inefficient to convert renewables to heat, new technologies take time to deploy, and where gas grids are already in place, certain geographies will continue to rely at least partially on natural gas for two or more decades.

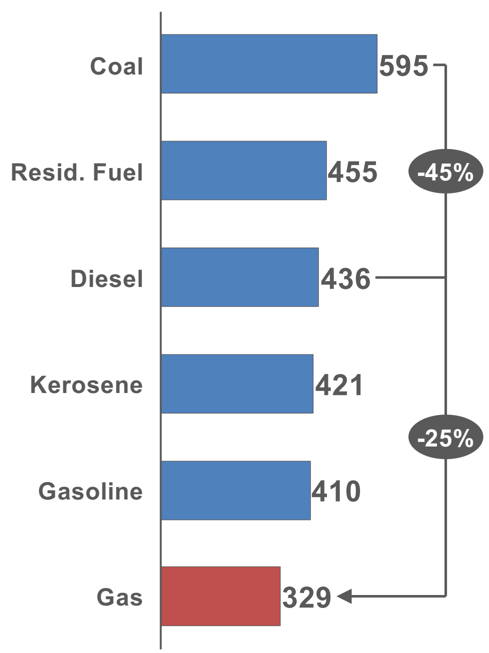
Steel:

In steel, it will be critical to switch the process from traditional basic oxygen furnace (BOF), in which coal is the main power vector, to gas-based direct reduced iron (DRI), with the aim of then transitioning these to hydrogen-based DRI.

Although gas is widely seen as a cleaner transition fuel than other fossil options …

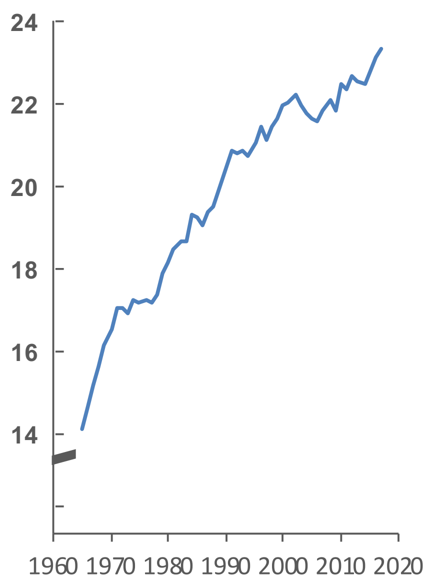
Gas has lower GHG intensity …

Total GHG intensity* (kg CO_2e/boe)



… and the shift to gas …

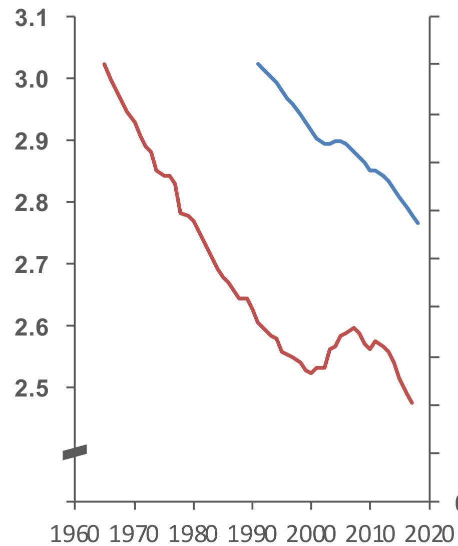
Gas market share (%)



Gas market share has been increasing at 100 bps per decade

… could help decarbonization …

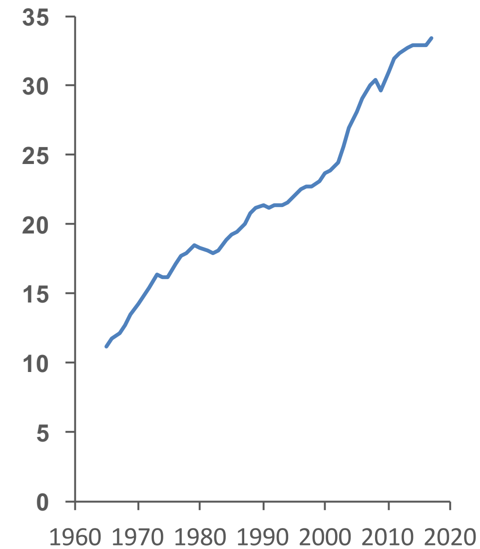
CO_2 intensity (tons/toe)
CO_2 intensity (g CO_2/$ GDP)



Decarbonization has been underway, partly due to gas substitution

… yet emissions are still growing

Billion tons CO_2 from energy



Emissions rose to 33 billion tons of CO_2 in 2017

*We are equally unclear about the exact amount of methane from coal.
Source: BP Statistical Review of World Energy, 2018; IPCC; World Bank (GDP is PPP, 2011)

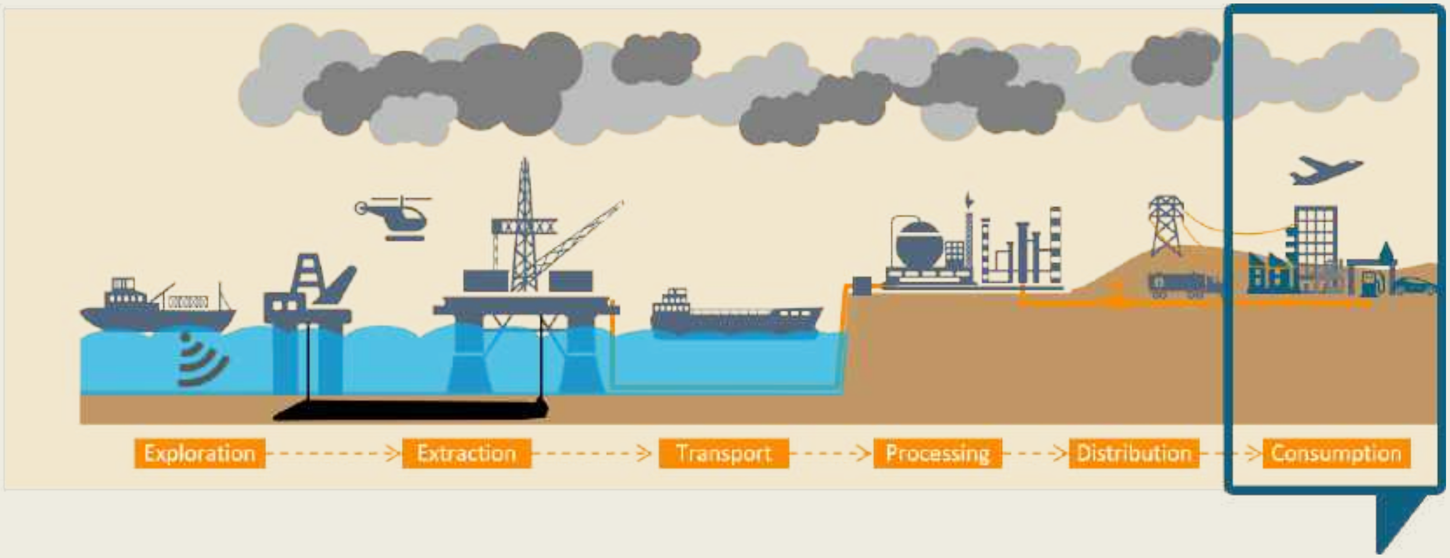
The benefits of switching from coal to gas disappear if end-to-end emissions are greater than 2.7% of all gas produced.

Natural gas is only a lower GHG-impact option as long as methane emissions from the system are less than 2.7% of all gas produced end to end (i.e., over the whole supply chain, from the well to combustion).

If this is not the case, then the benefits of switching from coal to gas no longer hold true.

We must consider full life-cycle emissions from the natural gas system

Natural gas supply chain



Historically, we have considered emissions only from the consumption part of the natural gas value chain. We have to think about the emissions along the entire value chain to retain its advantage versus coal. This is critical for the argument for natural gas as a transition fuel.

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Emissions occur all across the natural gas system, including so-called fugitive emissions

OPERATING:

Gas is often used inefficiently by burning it to power the pumping of more oil or gas out of the ground, or by liquefying natural gas instead of using alternatives, such as solar or hydro energy, which would save gas.

Emits primarily CO_2

FLARING:

Technically from the oil system, this is the deliberate release and burning of methane from associated gas into the atmosphere. During this process, gas is predominantly converted to CO_2, but most flares have a slip of unburnt methane. According to the IEA, this accounts for around 4% of global methane emissions.

Emits primarily CO_2 with some CH_4

VENTING:

This is the deliberate release of methane directly into the atmosphere. According to the IEA, this accounts for around 58% of global methane emissions.

Emits primarily CH_4

LEAKING:

Gas is accidentally released into the atmosphere, often due to suboptimal infrastructure maintenance. According to the IEA, this accounts for around 38% of global methane emissions from the oil and gas sector.

Emits primarily CH_4

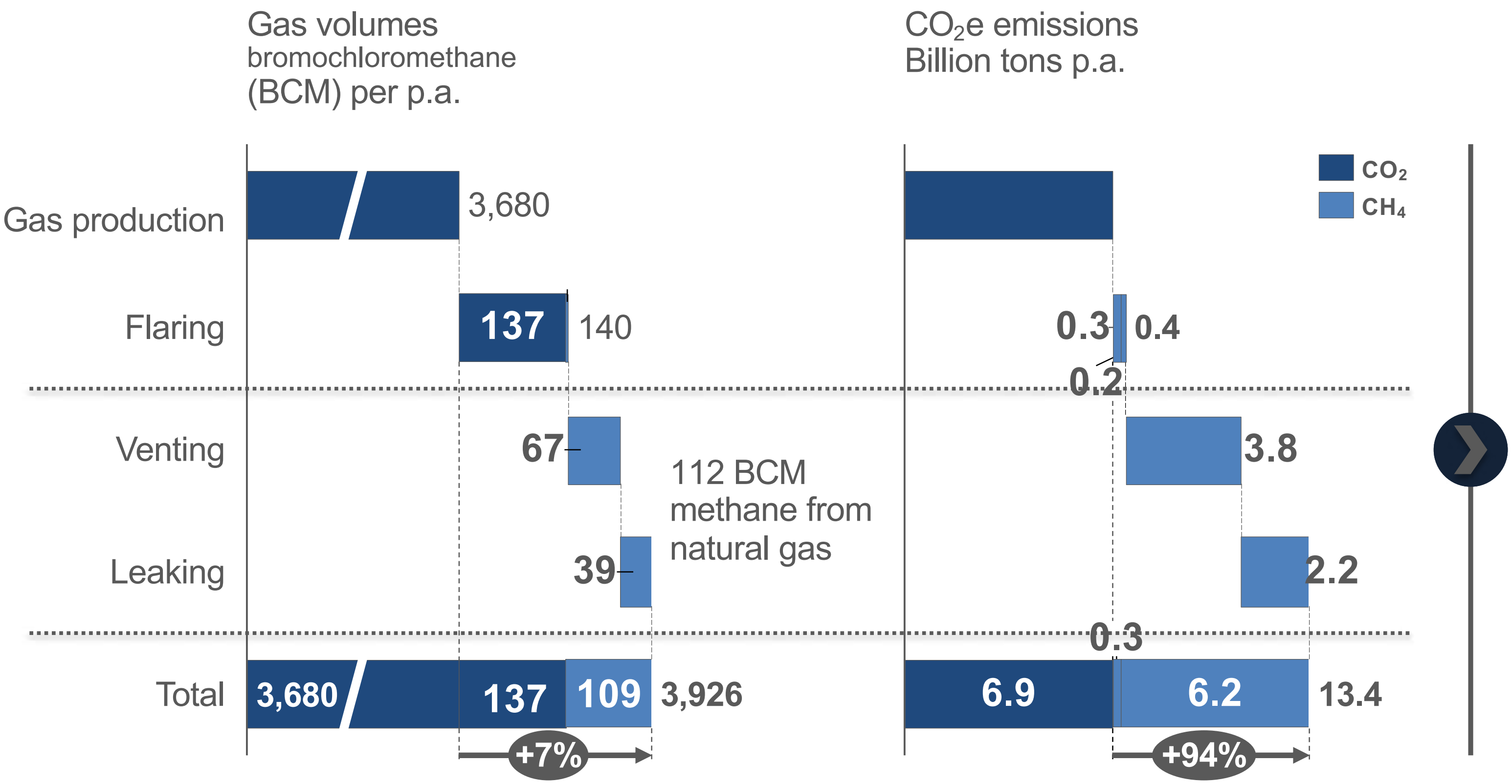
END-POINT COMBUSTION:

This occurs when the gas is combusted and used for power, and thereby converted to CO_2.

Emits primarily CO_2 with some CH_4

Fugitive emissions

Globally, the CO_2 equivalent emissions from oil and gas are 2 times higher when you include methane in those calculations.



- Flaring alone is equivalent to consumption of all of Africa, or 30% of Europe.
- Missed revenue = $35+ billion per year (at $4/MMBTU)—some 5% of total revenue.
- This is a huge GHG impact—the equivalent of more than 2,100 coal-fired power plants!

Note: Gas priced at approx. global average of $4/MMBTU. CO_2e emissions from methane estimated as 84 times of that of CO_2, based on a 20-year timescale. Assumes a typical coal plant produces 6.30 million tons of CO_2 p.a.

Source: BP Statistical Review of World Energy (2018); (1) WB GGRF, 2018; (2) IEA WEO 2017; exact measuring remains a challenge

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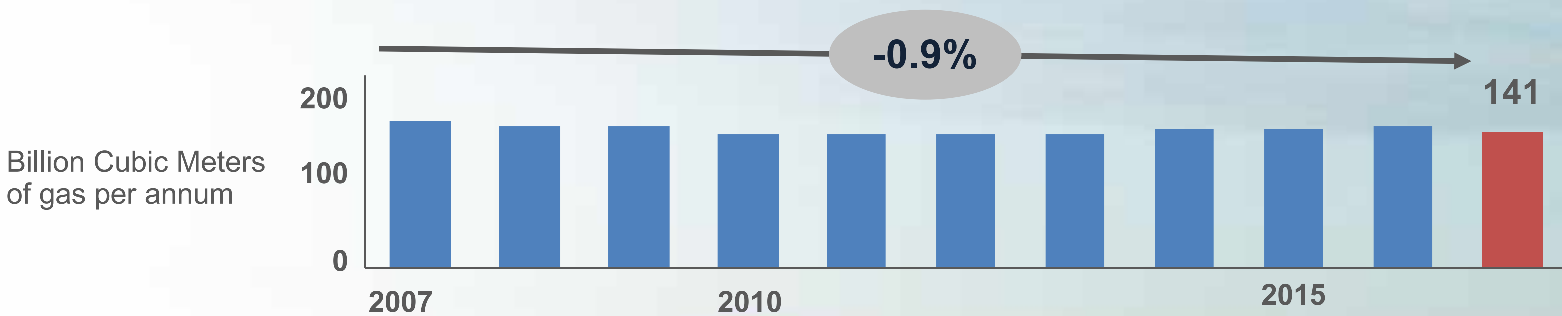
Although we know methane emissions from oil and gas are an ongoing problem, global flared gas has not materially reduced in a decade.



Source: World Bank GGFR, 2018

In 2016, an Environmental Defense Fund (EDF) infrared camera captured images of a natural gas well in California that **spewed more than 100,000 tons** of the harmful greenhouse gas methane into the atmosphere. **The largest methane leak in US history**, the emissions were equivalent to over half a million cars.

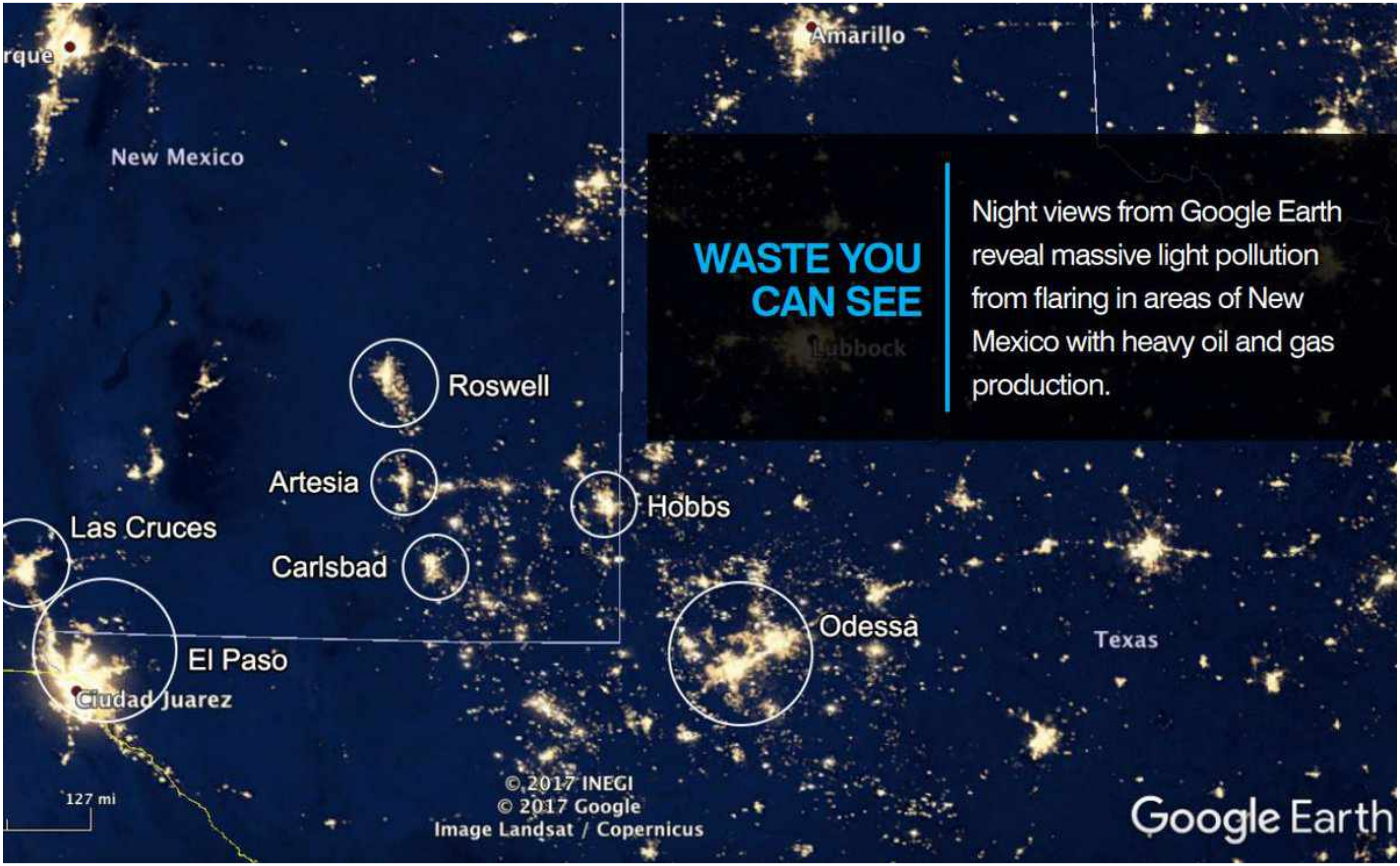

WASTE YOU CAN SEE
Night views from Google Earth reveal massive light pollution from flaring in areas of New Mexico with heavy oil and gas production.
rque
New Mexico
Amarillo
Lubbock
Roswell
Artesia
Hobbs
Las Cruces
Carlsbad
Odessa
El Paso
Ciudad Juarez
Texas
127 mi
© 2017 INEGI
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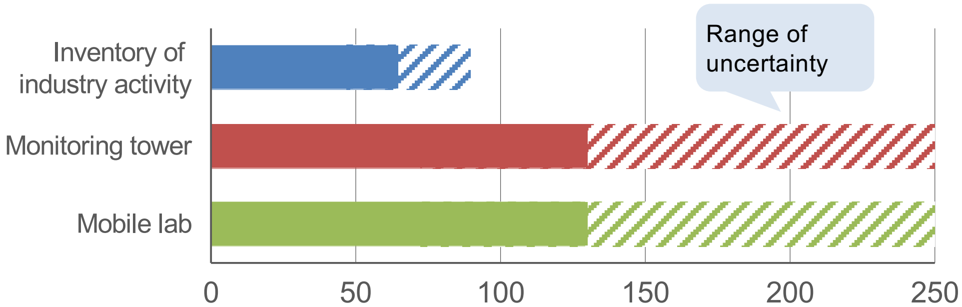
Image Landsat / Copernicus
Google Earth

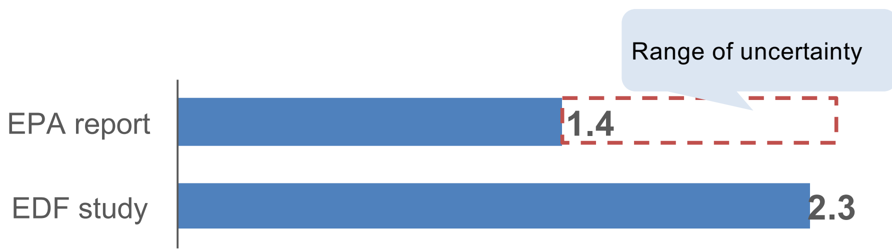
It is unclear precisely how much and where methane emissions are located globally.

Air sampling by NOAA over Colorado finds 4% methane leakage, more than double industry claims

Estimates of methane losses from gas fields near Denver, Colorado, based on air sampling differ considerably from calculations based on industry activity



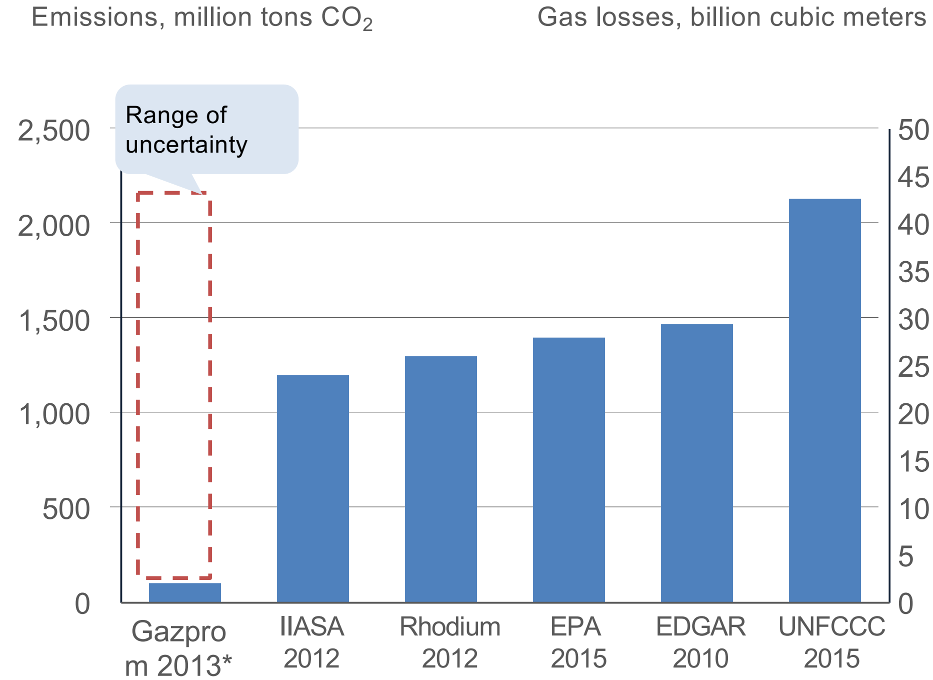
Methane leaked from US oil and gas wells-related infrastructure in 2015, as a percentage of overall US natural gas output



Note: The Environmental Protection Agency (EPA) likely underestimates the emissions because it seeks permission from oil and gas operators to take measurements and workers may avoid errors or fix problems when measurement teams arrive, according to an EDF study. In addition, it relies on reported data and therefore, understandably, misses unintentional and unknown leaks.

Source: EDF

Methane emissions from oil and gas sector in Russia



* Gazprom assessment includes only Gazprom emissions (i.e., not all Russian emissions)

Source: Carbon Limits

New technologies are helping us monitor and measure the emissions, but there is still no perfect option to “see” all emissions.

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Several technologies can helps us measure methane

Satellites can be a powerful and scalable tool that can eventually provide daily global regional GHG emissions data at the facility level; land access permissions are not needed, and airspace restrictions do not apply. Due to the high cost of manned airborne campaigns, the survey area must be defined a priori.

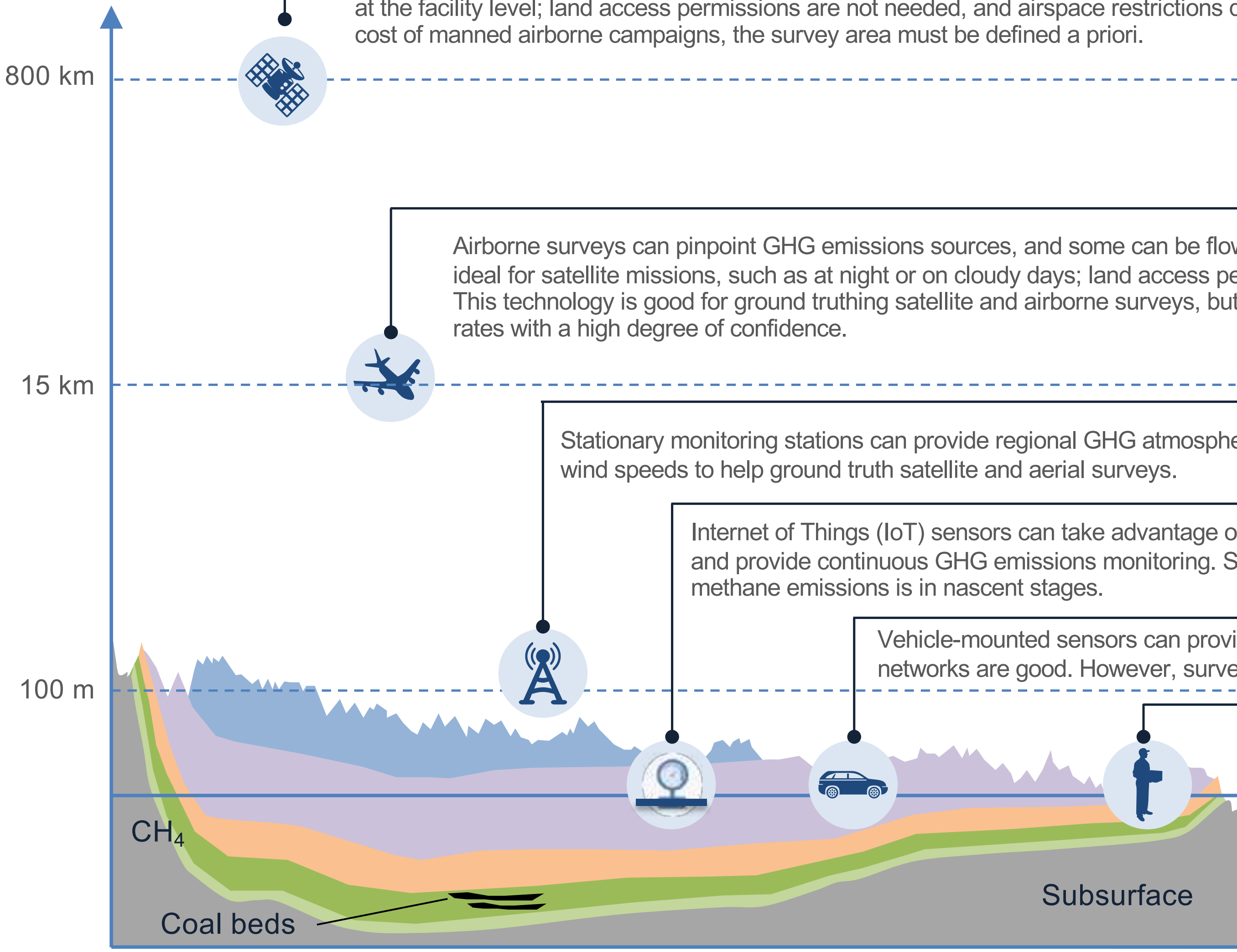
Airborne surveys can pinpoint GHG emissions sources, and some can be flown in conditions that are not ideal for satellite missions, such as at night or on cloudy days; land access permissions are not needed. This technology is good for ground truthing satellite and airborne surveys, but cannot estimate emissions rates with a high degree of confidence.

Stationary monitoring stations can provide regional GHG atmospheric concentration data and wind speeds to help ground truth satellite and aerial surveys.

Internet of Things (IoT) sensors can take advantage of existing infrastructure and provide continuous GHG emissions monitoring. Sensor deployment to quantify methane emissions is in nascent stages.

Vehicle-mounted sensors can provide regional snapshots where road networks are good. However, surveys can be limited by accessibility.

Pedestrian surveys provide highly sensitive and accurate GHG emissions data; these surveys may be added to existing and routine field inspection activities. However, these surveys can take a considerable amount of time, making it hard to scale.



New planned and deployed public satellites will help with this but are not a silver bullet.

TROPOMI (flying today):
- Number of satellites: 1
- Geospatial resolution: 7km x 7km at best (7km x 13km typical)
- Temporal resolution: Daily revisit
- Sensory resolution: 3,600 kg/hr of methane emissions rate detected (?)
- Coverage resolution: Global
- Status: Active

Sentinel 7 (planned):
- Number of satellites: 3
- Geospatial resolution: 2km x 2km
- Temporal resolution: Visits every 2 to 3 days
- Sensory resolution: 3,600 kg/hr of methane emissions
- Coverage: Global
- Status: Planned launch 2025 - 2026

EDF MethaneSat (planned):
- Number of satellites: 1
- Geospatial resolution: 1km x 1km
- Temporal resolution: One a week (?)
- Sensory resolution: 360 to 1,800kg/hr of methane emissions
- Coverage: Sub-global
- Status: Planned launch 2021 (unlikely to meet this deadline)

The Greenhouse Gases Observing Satellite "IBUKI" (GOSAT) (flying today):
- Number of satellites: 1
- Geospatial resolution: 1000km x 1000km
- Temporal resolution: 3 days
- Sensory resolution: TBD
- Coverage: Global
- Status: Active

Go-SAT 2 (flying today):
- Number of satellites: 1
- Geospatial resolution: 500km x 500km
- Temporal resolution: 3 days (may be increased)
- Sensory resolution: TBD
- Coverage: Global
- Status: Active

California satellite – CAL-CEMS (planned):
- Number of satellites: 3 prototype, increasing to 16
- Geospatial resolution: 30m x 30m
- Temporal resolution: monthly at best (with 3), increasing to daily with 16
- Sensory resolution: 50 to 100kg/hr of methane emissions
- Coverage: 10,000 sites of interest chosen a priori
- Status: Planned launch 2024

Does not include: commercial offerings (e.g. GHGSat and Bluefield)

Technically speaking, the overarching emissions problem is largely solvable, often at no net cost.

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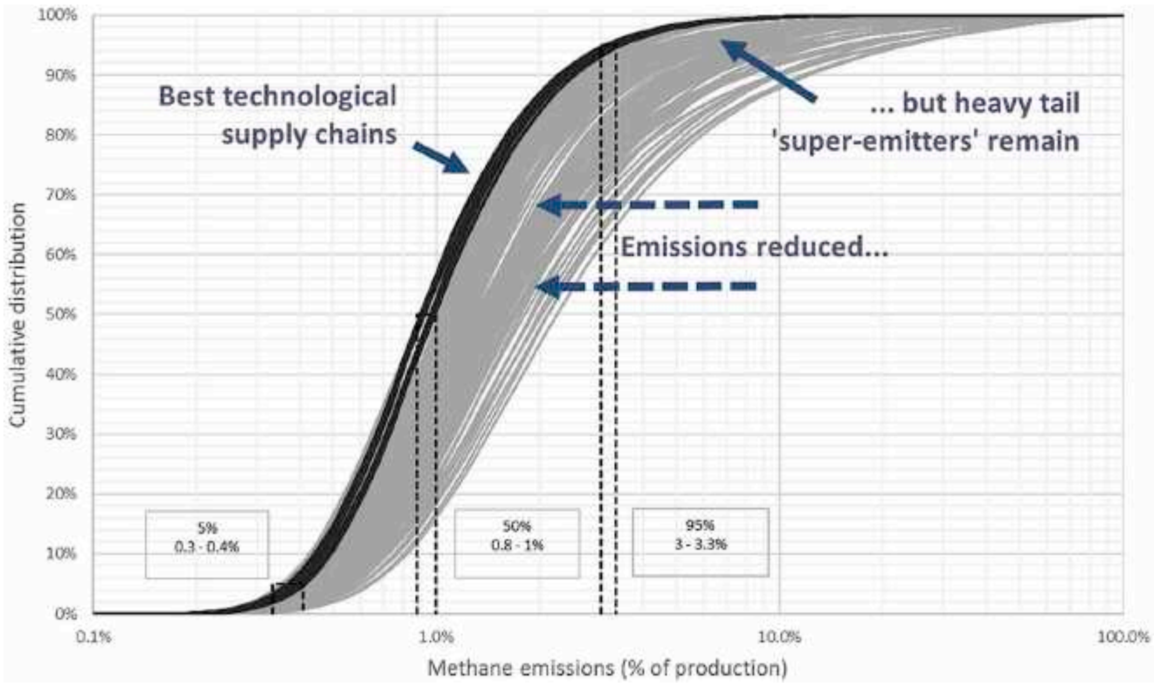
Existing technologies can reduce emissions significantly

Distribution of methane emissions across the
supply chain for various oil and gas players

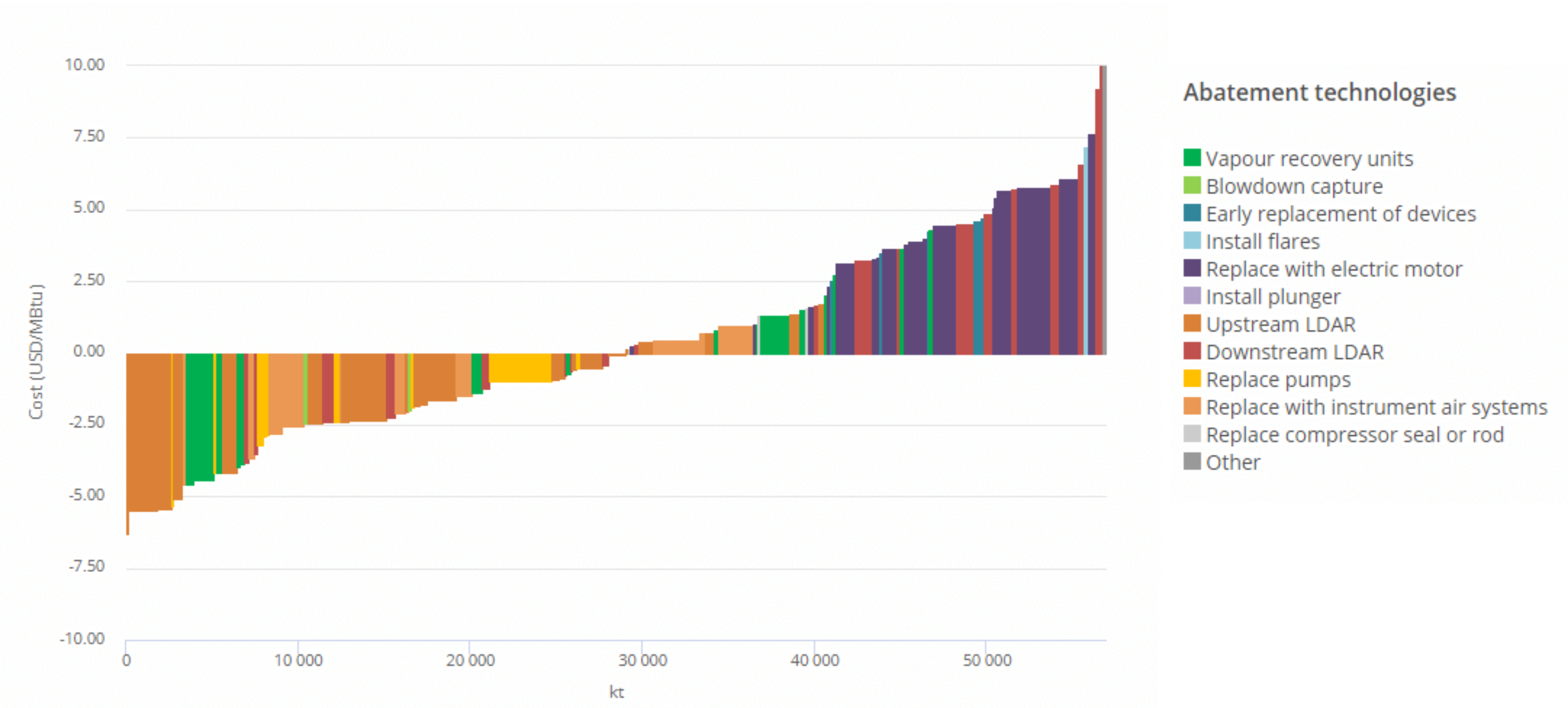


- Median methane emissions are 0.8%–2.2% of total production.
- Technologies can reduce emissions up to 0.9% of production but do not entirely eliminate super-emitters.
- Preventive maintenance and effective detection will reduce super-emitters.
- The most disciplined operators will quickly get there. Others may lag.

Source: https://www.sciencedirect.com/science/article/pii/S0959652617328962#undfig1

Half of current methane emissions could be avoided at no net cost

Marginal abatement cost curve for oil and gas–related methane emissions



- “It is technically possible to avoid around three-quarters of the current 79 Mt of methane emissions.” *
- “Forty to 50 percent of current oil and gas related methane emissions could be avoided at no net cost.” *

*Source: IEA’s World Energy Outlook 2017

However, there are more systemic barriers inhibiting wide-scale methane abatement action.

1 A lack of data and issue awareness

Consumers, asset operators, and market awareness on the issue are lacking, partially because emissions measurement capacity (or standards) is lacking, but also because some operators are in denial about the scale of the issue and their contribution.

2 Solutions are not operationally deliverable

This is a result of lack of funding from venture partners, or operators' focus being usurped by competing priorities, or challenging bureaucracies or country context, or a lack of execution capacity.

3 Solutions are not commercially deliverable

This could be due to low market value of captured gas locally (e.g., from subsidized pricing or poor fiscal terms), a high unit cost of the gas capture infrastructure, difficulty attracting project funding, or a lack of local infrastructure to get captured gas to market.

4 Out-of-date production-sharing agreements in producing countries

National oil companies (NOCs) often invite international oil companies (IOCs) in their country to increase investments, but single operators are typically entitled to only gas or only liquids. Operators with rights over liquids only flare gas as a waste material that cannot be monetized.

Methane emissions are increasingly in the public eye, and many oil and gas industry players have made strong commitments to action.

Methane emissions in global news threaten the "clean alternative" narrative of gas

The Economist

The methane mystery

Scientists struggle to explain a worrying rise in atmospheric methane

Forbes

More Countries Join Coalition To Slash Soot And Methane

Chevron Shareholders Made Methane A Key Priority At Annual General Meeting

REUTERS

California board adopts strictest U.S. methane rules

FINANCIAL TIMES

Climate change

Gas leaks worse for climate than thought, study says

Bloomberg

Business

Insidious Gas Leaks Are (oubts Over Shell's Clean Credentials

The New York Times

An Eye in the Sky Could Detect Planet-Warming Plumes on the Ground

Washington Examiner

Exxon, Shell, BP pledge to reduce methane emissions from natural gas

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Oil and Gas Climate Initiative (OGCI) members target reducing methane intensity from upstream operations to below 0.25%, with the goal to achieve 0.20% by 2025*

*This commitment is for an aggregated average of all members' upstream activities. Currently most oil and gas companies only account for methane from their own operated (i.e., non-join venture) assets.

Several actors are working on various elements of the challenge to try to solve these issues.

Methane Guiding Principles

Geographic focus

- Progress is more advanced in the United States than anywhere else globally.
- However, the current US administration is walking back many of the federal achievements from the past few years.
- New European Commission leadership has expressed intent to explore regulatory levers to bring down emissions in EU and supplying markets.
- Some Asian markets, in particular Japan, are starting to consider methane emissions in their transactions as well.

We believe there are critical gaps in the ecosystem which inhibit the delivery of our joint mission.

Average focus of activities by current oil and gas methane players

- Landscape is heavy on coalitions of industry players
- Most industry-backed initiatives perceived as too conservative
- Not enough activities translating data to actionable insights
- Not enough activities cultivating markets to incentivize methane abatement

Our program seeks to address those gaps. We are partnering with oil and gas companies, governments, and civil society to eliminate fugitive emissions from the oil and gas value chain.

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We will achieve this by showing that:

1 It MUST be done!

We are combining methane emissions data and insights from industry and cutting-edge science to establish a single, publicly accessible data platform that will pinpoint priority areas for action.

2 It CAN be done!

Using insights from our data efforts, we are helping companies take on-the-ground action to reduce their emissions and participate in a market for low-leakage gas.

3 It PAYS to do it!

We are developing a certification pathway for low-leakage natural gas and building demand for this product among consumers. We are demonstrating the environmental and financial value of this product to oil and gas producers.

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