A solution to reduce CO_2 emissions:

CAPTURING FLARED GAS FOR USE IN GE VERNOVA'S AERODERIVATIVE GAS TURBINES

EXECUTIVE SUMMARY

Gas-to-power technologies using associated gas for fuel can help greatly reduce gas flaring – a significant contributor to global warming. Typically, technology choice for such projects is driven by fuel quality, emissions standards, and economies of scale. With their high power density, GE Vernova's efficient and reliable aeroderivative gas turbines are especially well suited as gas-to-power solutions, providing fuel flexibility while meeting stringent emission codes.

ARTICLE:

A significant contributor to global warming could be alleviated with the reduction of gas flaring, and proven technologies are bringing the ability to reduce this practice to the forefront.

Associated natural gas, released when oil is extracted from the ground, often is burned off during the extraction process. Typically a mixture of hydrocarbons such as methane, ethane, propane, and butane, it usually is burned off at the wellhead, creating a tall flame that can be seen for miles.

The use of this valuable resource is hampered by lack of marketplace access, the regulatory environment, and lack of adequate investment in infrastructure and technology. Often, oil producers simply consider it more convenient and cost-effective to burn off the gas than to use it.

However, associated natural gas can be captured and used as a fuel source for power generation, replacing more carbon-intensive fuels such as diesel, residual fuel oil, and coal, or it can be processed into valuable petrochemical products. And, because the captured gas can be sold or used to generate electricity for added revenues, reducing gas flaring actually can provide economic benefits – in addition to the benefits of conserving natural resources and lowering the environmental impact of oil and gas production.

In the face of the dire need to reduce global warming, along with the necessity to provide energy security and economic opportunity to the billions of people who still lack access to electricity, gas flaring clearly represents a significant missed opportunity.

THE PRACTICE OF FLARING

The reasons natural gas is flared during oil production include:

- Technological constraints – The infrastructure required for capturing and transporting the natural gas is not in place or it may be considered of low quality and therefore not usable.
- Economic considerations – In some areas, the marketplace for gas or gas products does not exist.
- Regulatory requirements – In some countries, oil producers do not have the rights to sell gas or gas products based on restrictive production licenses.
- Operational requirements – Flaring may be necessary during certain phases of oil production. For example, gas may be produced as a byproduct during drilling or well testing, and it may be necessary to flare it temporarily to ensure the equipment's safe operation.

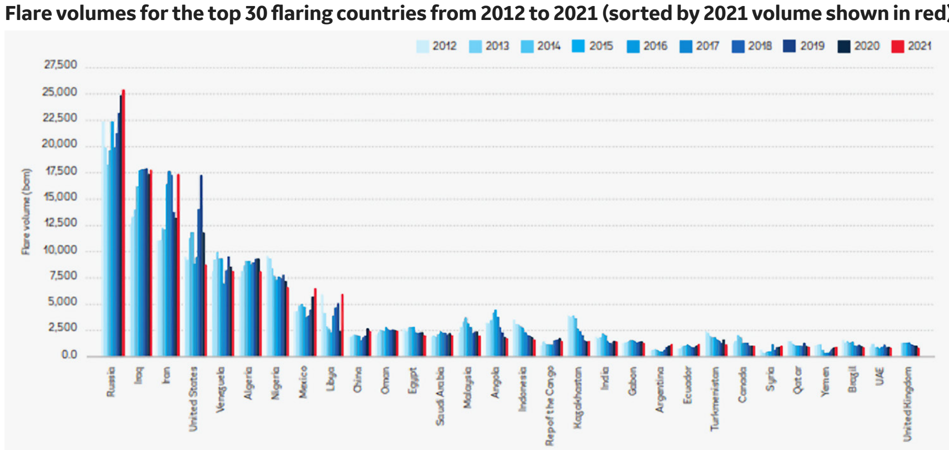
The industry differentiates its flaring practices as "routine" and "non-routine." The difference lies in the frequency and duration of the flaring.

Routine gas flaring refers to the continuous or regular flaring of natural gas that occurs during normal oil production operations. Routine flaring can continue for weeks, months, or even years, and it is responsible for most global gas flaring.

Non-routine gas flaring, on the other hand, refers to the occasional or temporary flaring of natural gas that occurs outside of normal production operations. This can include flaring that occurs during startup or shutdown of oil facilities, as a result of equipment failure or maintenance, or during emergencies such as well blowouts or fires. Non-routine flaring typically lasts for shorter periods of time than routine flaring.

According to the World Bank's recent Global Gas Flaring Tracker Report[1], approximately 144 billion cubic meters (bcm) of natural gas were needlessly flared worldwide in 2021 – similar to the combined gas consumption of Central and South America. This also equates to 400 million tons of carbon dioxide equivalent emissions. According to the report, the flaring activity by volume and flaring intensity (flaring volume per barrel of oil produced) has plateaued over the last 10 years, pointing to a clear need for rejuvenated action and focus.

Flare volumes for the top 30 flaring countries from 2012 to 2021 (sorted by 2021 volume shown in red)



Source: NOAA, Payne Institute and Colorado School of Mines, GGFR

[1] 2022 Global Gas Flaring Tracker Report, World Bank

THE DOWNSIDE TO GAS FLARING

In addition to wasting valuable energy resources, both routine and non-routine gas flaring contribute to greenhouse gas emissions.

Carbon dioxide (CO_2): Gas flaring releases large amounts of CO_2 into the atmosphere. A potent greenhouse gas, CO_2 contributes to climate change, and the inefficient burning of natural gas as a flare is a significant contributor to global carbon emissions.

Methane: Flaring also is estimated to release around 350,000 tons of methane each year. Methane is a more potent greenhouse gas (GHG) than CO_2 on a pound-for-pound basis. According to the Intergovernmental Panel on Climate Change (IPCC), methane has a global warming potential (GWP) 28 times higher than CO_2 over a 100-year time horizon, meaning one unit of methane emissions has the same warming effect as 28 units of CO_2 emissions over a 100-year period.

However, the actual warming effect of methane depends on the time horizon being considered. Over shorter time horizons, such as 20 years, the methane GWP is significantly higher, with estimates ranging from 84 to 87 times that of CO_2. This is because methane has a shorter atmospheric lifetime than CO_2, typically around 12 years, while CO_2 can remain in the atmosphere for centuries or even millennia.

The amount of methane released during gas flaring depends on a number of factors, including the volume and composition of the natural gas being flared, the efficiency of the flaring equipment, and the duration of the flaring.

Other pollutants: Additionally, gas flaring can release other harmful pollutants into the air, such as sulfur dioxide, nitrogen oxides, and particulate matter. These pollutants can cause respiratory problems and other health issues for people living nearby, as well as harm plants and wildlife.

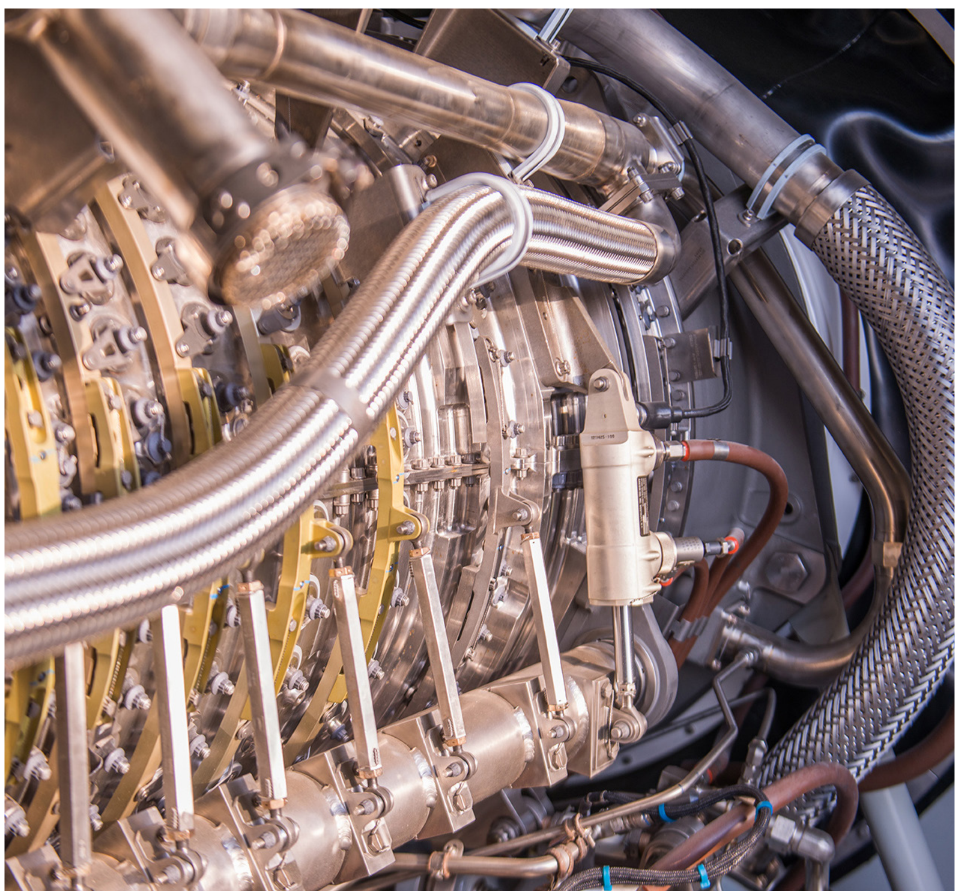
Zero routine gas flaring would have a positive impact towards meeting the COP (Conference of Parties) and Paris Agreement targets for reducing greenhouse gas emissions. The Paris Agreement aims to limit global warming to well below 2 degrees Celsius above pre-industrial levels. Using flare gas for power generation or other industrial applications also can help reduce emissions by displacing more carbon-intensive fossil fuels, such as coal or oil.

Oil producing countries are under a constant spotlight to reduce routine gas flaring. Some countries have enacted regulations that require oil companies to capture and utilize the gas they produce. New technologies such as flare gas recovery systems can help reduce the amount of gas that is flared and increase the amount that is captured and used. Efforts also are being made to reduce the occurrence and duration of non-routine flaring through improved safety and maintenance practices.

FLARE GAS-TO-POWER APPLICATION

Gas-to-power projects using associated gas as fuel for gas turbines or reciprocating engines have been proven as a viable alternative to gas flaring. The electricity produced is not only consumed in the oil exploration and production (E&P) facility for captive power needs but also can support the needs of surrounding communities with minimal investment in grid infrastructure. This model is especially attractive to developing countries like Iraq, Nigeria, Angola, and Libya that have significant electricity shortfall and an active E&P sector.

In addition to the direct benefit of avoiding gas flaring, electricity from flare gas-to-power projects often replaces diesel-based power generation at such remote locations. This further helps significantly reduce the carbon footprint of E&P activity.



Flare gas-to-power potentially reduces the need to build large gas gathering and transmission pipelines. The environmental impacts and challenges associated with securing right of way for pipelines are well known. The cost of building a pipeline versus an electrical transmission line can vary greatly, depending on such factors as the distance between the source and destination, the terrain and geography of the area, the type of materials used, and the size and capacity of the infrastructure. Factors such as the availability of materials and labor, environmental regulations, and political instability also can impact a project's cost and feasibility.

In general, pipelines tend to be more expensive to build than electrical transmission lines, particularly for long distances. Pipelines require specialized materials, such as steel, to withstand the high pressures and temperatures of transporting gas or oil. Additionally, pipelines often require more complex and costly construction techniques, such as trenching and welding, which can add to the overall cost.

On the other hand, electrical transmission lines typically use lower-cost materials, such as aluminum or copper, and are easier to install and maintain. Plus, transmission lines can be designed with higher capacity, allowing them to transmit more energy over longer distances.

Colocation of power generation assets with the E&P assets provides opportunities for capital and operational cost savings.

RECENT TRENDS IN TECHNOLOGY CHOICES

Typically, flare gas-to-power projects are between 50 MW and 200 MW, and technology choice is driven by fuel quality, emissions standards, and economies of scale to justify project development, permitting, and infrastructure costs. Recent trends clearly point toward a preference for the use of gas turbines, especially aeroderivative gas turbines, in such applications for the following reasons:

High power density

GE Vernova's aeroderivative gas turbine technology, which derives its heritage from the aviation industry, is a perfect match for gas-to-power applications using flare gas. GE Vernova's aeroderivative gas turbines, such as LM2500 (18-37MW) and LM6000 (45-57MW), provide a highly modular and scalable solution for flare gas-to-power application. These units can deliver better power density per square meter of footprint and per ton of mass compared to reciprocating engines, allowing developers to optimize for existing space and civil costs.

Fuel flexibility while meeting stringent emission codes

The composition of associated raw gas from wellheads can vary significantly and may include contaminants such as high quantities of water and hydrogen sulfide. The typical composition shows higher C2+ gases and is classified as low to medium heating value (300-450 btu/scf) fuel. GE Vernova's gas turbine technology can operate on a wide variety of gaseous and liquid fuels and has several references of operation on such complex fuels.

GE Vernova's aeroderivative gas turbines offer both Single Annular Combustor (SAC) and Dry Low Nox (DLE) combustor technology, which can achieve as low as 25/15 ppm NOx emissions in compliance with World Bank Emission Standards.

Fast project execution

Highly modular aeroderivative gas turbines require less interface points and interconnections compared to alternatives such as reciprocating engines and larger gas turbines. This presents a significant time and cost saving opportunity for EPC contractors with reduced design and engineering work.

Aeroderivative gas turbine packages and associated skids are fully tested, pre-flushed, and inspected before delivery to the site, reducing the site commissioning schedule. The LM6000 UG3 package, delivering up to 57 MW, can be fully commissioned in less than 90 days[2]. The LM2500XPRESS package was engineered for fast execution on utility-scale projects with just under 14 days for complete installation and commissioning (I&C). The simplicity and speed of execution of the LMXpress package has been acknowledged by customers on utility-scale projects. Similarly, the TM2500 ("Powerplant on Wheels"), which is well known and highly sought after for its quick deployment and mobility, can be installed start-to-finish at the site with minimal infrastructure in as few as 11 days.

High availability and reliability

Remote E&P sites with no or weak grid interconnection require a stable and reliable power supply. Traditionally, these sites relied on reciprocating diesel generator sets, which were cheap and easy to maintain at remote locations. However, in the context of an energy future with less carbon emissions, cleaner and more efficient gas turbine technology is preferable.

Aeroderivative gas turbines offer high availability (>98%) and reliability in even very challenging operating conditions. With over 4,000 units and more than 150 million operating hours, the LM2500 and LM6000 gas turbine families deliver industry-leading reliability performance.

FINANCING FLARE GAS-TO-POWER PROJECTS

With the push to reduce gas flaring activity, a number of financing sources are available:

- Public funding: Governments may provide funding to support projects aimed at reducing gas flaring. This can include grants, loans, or loan guarantees.
- Multilateral development banks and international finance institutions: Institutions such as the World Bank, the International Finance Corporation (IFC), Asian Development Bank, and African Development Bank provide financing and technical assistance to support projects aimed at reducing gas flaring. In addition, these institutions can help to facilitate public-private partnerships and financial incentives.
- Private investment: Private companies, including oil and gas companies and investors, may provide funding for projects that capture and utilize flared gas. This can include equity investments, debt financing, or project financing.
- Carbon credits: Projects that reduce greenhouse gas emissions, such as those aimed at reducing gas flaring, may be eligible for carbon credits under emissions trading schemes. These credits can be sold on carbon markets to generate revenue.

[2] Unit on Foundation to 1st Synchronization

- Philanthropic organizations: Foundations and other philanthropic organizations may provide grants or other funding to support projects aimed at reducing gas flaring.

GAS-TO-POWER REFERENCE PROJECTS

With their unmatched fuel flexibility, their ability to complement renewables, and their fast startup and installation, aeroderivative gas turbines from GE Vernova are an excellent choice for power generation using flare gas.

Many gas-to-power projects are under way around the world. Some recent projects include:

- PetroMasila (Yemen): In 2023 GE Vernova announced an order for fast, and flexible power from Yemeni state-owned Masila Petroleum Exploration and Production Company (PetroMasila), which operates the exploration and production of oil in Yemen. Many oil field operators who flare associated gas - natural gas found in a mixture with crude oil within a reservoir - are making the investments necessary to reduce flaring and lower related emissions. The order includes a trailer-mounted GE TM2500 aeroderivative gas turbine.

  The TM2500, a 34 MW “power plant on wheels” will be powered using previously flared associated gas to support PetroMasila’s oil exploration and extraction processes—creating electricity from excess gas. Once interconnected to the local grid, over half of the electricity produced from the unit will be delivered to the grid, providing electricity needed to power homes in Yemen.
- Eni (Nigeria): This Nigerian project by Eni, an Italian oil and gas company, involves capturing flare gas from an oil field and using it to generate electricity for the local grid. The project has the capacity to generate up to 10 MW of electricity and is expected to reduce emissions by up to 20%.
- Petrobras (Brazil): Petrobras, a Brazilian oil and gas company, has several gas-to-power projects, including capturing flare gas from an offshore oil platform to generate the platform’s electricity. The 2020 project has the capacity to generate up to 2.5 MW of electricity.
- Sultanate of Oman: The Sultanate of Oman has several gas-to-power projects aimed at reducing flare gas. For instance, captured flare gas from an oil field is used to generate electricity for the local grid. The 2020 project has the capacity to generate up to 120 MW of electricity and is expected to reduce emissions by up to 32%.

CONCLUSION

GE Vernova is committed to electrifying the world while simultaneously working to decarbonize it, and using flare gas for power generation is one way to support climate goals. Our portfolio of aeroderivative gas turbines offers industry-leading performance to help you meet today’s challenges—and tomorrow’s.

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