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Reducing black carbon and methane emissions through cost-effective flaring mitigation opportunities in Colombia

Location: Colombia

Region: South America

Sector(s): Short-lived climate pollutants

Date of publication: January 2020

Summary

Flaring at oil and natural gas facilities is a source of black carbon (BC) and methane (CH4) emissions, which are both powerful short-lived climate pollutants (SLCPs). Black carbon influences the climate by directly absorbing light, reducing the reflectivity of snow and ice through deposition, and interacting with clouds. Over a 100-year timeframe, black carbon has 900 times the climate warming impact of carbon dioxide. Flaring also releases GHG emissions (i.e., carbon dioxide and nitrous oxide) and various criteria air contaminants (CACs) (including volatile organic compounds (VOC), PM2.5, carbon monoxide, oxides of nitrogen and potentially sulfur dioxide), as well as air toxics.

In order to reduce emissions from flared associated gas, The Climate and Clean Air Coalition (CCAC) through Clearstone Engineering Ltd conducted a technology demonstration project to help oil and gas companies identify profitable opportunities to recover high-value, condensable liquids from flared associated gas. Recovery of these liquids from associated gas that is high in VOCs can reduce black carbon emissions from the gas when it is flared. At the same time, recovered liquids may be integrated into liquids production and processing infrastructure, potentially adding significant revenues.

Study method

Three flare gas measurement campaigns sponsored by the CCAC were conducted in Colombia between July 2017 and July 2019. Eight flaring oil and gas production facilities were surveyed during these campaigns. A site was selected either because it was known to have large flaring rates, or because it was considered to be representative of highly replicable flaring reduction opportunities.

The flare gas measurements were then evaluated for potential high-impact opportunities to cost-effectively reduce flaring and associated black carbon emissions.

The following mitigation actions were assessed:

- displacement of onsite and field energy purchases
- gas conservation by producing into gas gathering systems
- electricity generation for sale to the electric utility grid and local markets
- recovery of condensable hydrocarbons from the flare-gas
- production of liquefied natural gas
- small-scale gas-to-liquids production
- hybrid (multi-stage) solutions.

The best solutions were determined by analyzing all reasonable options using rigorous process modelling and cost estimations. These techno-economic evaluations include consideration of equipment turn-down ratios, performance capabilities, available size ranges and life expectancy, as well as site-specific production decline rates and local commodity pricing and economic parameters (i.e., discount rate, annual asset depreciation rate, inflation rate, royalty rate, tax rate import duty, and carbon pricing).

The design and operating conditions for each option was optimized to achieve maximum profitability and performance. The assessed environmental impacts include lifetime reductions in black carbon, GHG and CAC emissions. The developed financial results include capital costs, operating costs, net present value (before and after tax), payback period, internal rate of return, and project life.

Researchers from Natural Resources Canada (NRCan) measured the baseline BC emission rates at 6 of the surveyed sites using Sky-LOSA, a state-of-the-art optical technique. Sky-LOSA was developed at Carleton University in collaboration with the National Research Council of Canada with financial support from NRCan.

Results

As shown in the table below, most of the opportunities assessed offer very favourable economics for the sites overall, with payback periods generally less than two years, and net present values after tax as high as USD 291.2 million. [The results below are tentative and subject to change. Final results will be available after the review of the site reports.

Viable lifetime black carbon and GHG emission reductions for individual flares ranged up to 3,080 t and 2,530 kt CO2E, respectively. The small negative BC emission reduction at Site 6 is attributed to the fact the residue gas (i.e., after extracting recoverable hydrocarbon liquids), is used to fuel a reciprocating engine driven power generator, which has a slightly greater BC emission factor than the initial flaring. At least two of these opportunities have led to the development of a business case for consideration by the operator and potential financiers.

Site	Current Flaring Value		CAPEX (10^6 USD)	NPV (10^6 USD)	Payback Period (Years)	IRR (%)	Project Life (Years)	Lifetime Emissions Reduction	
	Energy Basis (10^6 USD)	Commodity Basis (10^6 USD)						BC (t)	GHG (kt CO_2E)
1	25.5	76.1	48.6	291.2	1.1	104.6	10	3,080.8	2,526.9
2	0.342	0.849	0.2	4.5	0.3	347.9	10	45.2	21.9
3	3.882	12.033	1.8	39.9	0.4	315.7	10	607.9	480.9
4	1.005	1.666	1.7	6.3	5.2	22.6	10	93.6	195.3
5	1.931	2.673	1.4	14.4	0.6	172.7	10	37.5	404.5
6	0.123	0.206	0.7	0.4	7.3	18.4	10	-14.8	1.6
7	0.437	0.446	0.1	1.2	0.3	384.9	10	<0.1	85.6
8	0.125	0.126	0.1	0.3	1.2	83.7	10	<0.1	27.3

[CAPEX - Capital Expenditure, NPV – Net Present Value (After tax), IRR – Internal Rate of Return (after tax)]

Key Lessons learned

Some of the common reasons that cost-effective flaring reduction opportunities may exist at oil and natural gas facilities are:

- changes in operating conditions from initial design values.
- capital constraints during the initial facility design and construction resulting in reduced or even no gas conservation.
- progressive deterioration of equipment performance resulting in leakage into flare systems and process system upsets causing flaring events.
- incorrectly sized or unreliable existing flare gas recovery systems (where applicable).
- lack of economic market access for the gas.
- lack of quantitative data to build business cases for flaring mitigation.
- corporate cultures and key performance indicators that favour projects to increase reserves, production and profitability through traditional exploration, drilling and infrastructure projects, rather than through improvements in operational efficiencies.

Challenges

- Developing itemized investment-quality cost estimates to better convince stakeholders of the magnitude and practicability of the assessed opportunities. This requires some initial engineering design work to define and quantify the major equipment and materials required as well as obtaining vendor pricing.

- Developing accurate site-specific assessments of baseline black carbon emission factors for flares and any natural gas fuelled equipment applicable to the assessed mitigation options. There is very limited data available literature on black carbon emission factors for different types of combustion equipment and information on how those values may vary with fuel quality.

- Exploring alternative financing mechanisms to help advance profitable flaring mitigation opportunities to the implementation stage. There is growing push within the investment community to divest from the oil and gas sector due to environmental-social-governance concerns. This, coupled with the sector's typical focus on more conventional projects (i.e., drilling and exploration, and infrastructure projects to tie-in new wells), makes what are often seen as environmental and energy efficiency projects difficult to both develop to a business-case level and fund.

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This case study was developed as part of the "Reducing Short-lived Climate Pollutants in States & Regions" project. The aim of this project is to support member states that are part of the Under2 Coalition to reduce methane emissions from oil and gas operations within their jurisdictions, thereby demonstrating the feasibility of reducing SLCPs at the sub-national level to peers within the Coalition, as well as national governments.