Kenya Air Quality and Emission Reduction Strategy
(Developed for upstream petroleum sector)

REVISED FINAL DRAFT

RACE	Name	Signature	Date
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Contents

Acronyms:

ASTM – American Society for Testing and Materials
API – American Petroleum Institute
BATNEEC - Best Available Technology Not Entailing Excessive Cost
CDM – Clean Development Mechanism
CENELEC – European Committee for Electrotechnical Standardization
CER – Certified emission reductions
CO - Carbon monoxide
CO_2 - Carbon dioxide
DOSHS – Department of Occupational Safety and Health Services
EAC – East African Community
EACCCP – East Africa Climate Change Policy
EIA – Environmental Impact Assessment
EFC -European Federation of Corrosion
EMCA - Environmental Management and Co-ordination Act
EPRC – Energy and Petroleum Regulatory Commission
GHG - Greenhouse gases
H_2S - Hydrogen sulfide
ISO- International Standard Organization
IEC – International Electrotechnical Commission
MoPM– Ministry of Petroleum and Mining (Kenya)
LDAR - leak detection and repair
NACE - National Association of Corrosion Engineers
NDC – Nationally determined contributions
NEMA – National Environment Management Authority (of Kenya)
NO - Nitric oxide
N_2O - Nitrous oxide
NO_2 - Nitrogen dioxide
NO_5 – Nitrogen Pentoxide
O^3 – Ozone
PM – Particulate Matter
SO_2 – Sulphur Dioxide
SOx – Sulphur Oxide
VOCs – Volatile Organic Compounds
WHO – World Health Organisation

1. Introduction

1.1 Objective

The discovery of substantial oil and gas reserves in Kenya provides significant development opportunities for the country and increased the national and private sector interest in onshore and offshore exploration of oil and gas, triggering new developments which required reform of the petroleum sector necessary to manage associated environmental and health risks.

One of the significant environmental impacts of petroleum operations are air emissions and potential worsening of ambient air quality. To address such impacts Kenyan government is committed to put in place necessary safeguards to address any negative impacts of such upstream petroleum operations. One of the safeguards is this Air Quality and Emission Reduction Strategy (further referred as the Strategy).

This Strategy assesses the current level of upstream petroleum operations in Kenya and its impact on air quality, defines strategic goals aimed at reducing potential emission reduction, and provides an action plan and implementation matrix that defines the list of short-, medium- and long-term actions required to be undertaken to achieve strategic national goals.

The Strategy aims to protect and improve the air quality in Kenya while supporting sustainable development of its natural resources, including oil and gas.

1.2 Scope

This document establishes strategic goals and defines an action plan to monitor and reduce the air emissions derived specifically from the upstream oil and gas exploration, development, production and decommissioning operations in Kenya and to improve air quality.

2. Situation Analysis

2.1 Overview of Upstream Oil and Gas Industry of Kenya

The main purpose of the petroleum sector is to find and bring above ground natural gas and crude oil, to process it into products and to distribute petroleum derivatives to customers. A major factor, which determines the importance, ease of processing, quality of final products, and the environmental impact of the petroleum sector, is the composition of crude oil and natural gas. The oil and gas industry is usually divided into three major sectors: upstream (exploration and production - E&P), midstream and downstream. It should however be noted that some authors categorise midstream either as part of the upstream or downstream operations.

Kenya Exploration and Production Data Profile

Kenya has four (4) petroleum exploration basins and these are:

- Lamu Basin,
- Anza Basin,
- Mandera Basin and
- Tertiary Rift Basin.

Oil and gas exploration in the country began in 1956 and the breakthrough came in March 2012 with the discovery well – Ngamia 1 Well, in Lokichar Basin in Turkana County. As of December 2015, seventy-four (74) wells had been drilled with twelve (12) hydrocarbon

discoveries to date, nine (9) of which are in Turkana County. The other three are in Anza Basin and Offshore Lamu.

Reserves

As of year-end 2018, Kenya's total recoverable reserves were estimated at 1.3 billion cubic feet (Bcf) of natural gas and 870 million barrels (MMbbl) of oil (totaling 1 billion barrels of oil equivalent [Bboe]) in 21 undeveloped discoveries in the Lamu Basin, the Lokichar Trough (East Africa Rift System) and the Anza Basin.

Field Development

In November 2019, Tullow confirmed that the Final Investment Decision (FID) for the Ngamia, Amosing and Twiga fields development project in the Block 10BB and Block 13T is not expected before 2H 2020. The Environmental and Social Impact Assessment (ESIA) has been submitted to the National Environment Management Authority (NEMA) with approval expected in Q1 2020. The fields are situated in the South Lokichar Basin. First oil is expected three years after FID is taken.

In June 2019, several agreements around fiscal and commercial terms were signed between joint-venture partners and the government. In addition, FEED studies for the upstream and midstream project were also completed. In February 2018, Tullow suggested to the Kenyan government to start the development phase with the Ngamia and Amosing fields. The Twiga fields - added to the project in February 2019 - will bring significant benefits, according to Tullow. The development of the Foundation Stage will include the construction of a 60,000 to 80,000 barrels per day (b/d) central processing facility (CPF) and an export pipeline to Lamu. In addition, 120 wells at 18 well pads for the Ngamia field will be involved and 70 wells at seven well pads for the Amosing field. The Foundation Stage is expected to produce about 38% of the 2C resources (1P (proven reserves) + probable reserves) (210 MMbo out of 560 MMbo) with a plateau production between 60,000 and 80,000 b/d. The plateau production could be increased to 100,000 b/d with the development of the upside potential and the production of the remaining 2C resources. P(mean) for the whole Lokichar Trough are estimated at 750 MMbbl. Tullow estimates total gross capex is expected to reach USD 2.9 billion (USD 1.8 billion for upstream and USD 1.1 billion for the pipeline). Interest in the licences is held by Tullow Kenya BV (50% + operator), Africa Oil BV (25%) and Total E&P Danmark A/S (25%).

Production

The Early Oil Pilot Scheme (EOPS) was finally launched in June 2018 and some 600 bo/d was trucked to Mombasa. The oil will be stored in the Mombasa refinery before being shipped to specialized refineries in East Asia. As of January 2019, some 60,000 barrels were stored in Mombasa, followed by the first lifting of oil in August 2019. The project aimed to transport oil from South Lokichar to Mombasa using road and rail roads. The EOPS represents an immediate step on the road to the full commercialisation of the oil resources and it will be followed by a full field development project. The first step is to truck the stored crude oil that was produced during various extended well tests. The second phase will involve production of 2,000 b/d from the Ngamia and Amosing fields

Pipelines

The KPC pipeline is the backbone of oil product distribution, both locally and regionally. The vast majority of oil products are imported into Kenya via the Kipevu Oil Jetty in Mombasa and are then evacuated via the KPC pipeline network. Residual volumes are imported via the Shimanzi oil terminal in Mombasa. Transporting some three-quarters of all domestic oil products, the government-owned KPC pipeline dominates oil product transportation inland. Pipeline capacity is reserved at roughly 40% for gasoil, 30% for gasoline, and the remaining 30% for jet fuel and kerosene.

By 2015, the destination of oil products transported by the pipeline was split roughly equally between the domestic market and export markets, which include Uganda, South Sudan, DR Congo, Rwanda, Burundi and Northern Tanzania. Therefore, the KPC pipeline is of strategic importance in delivering oil products to Kenya's landlocked neighbors.

Rail is used to transport a small proportion of oil products from Mombasa to inland demand centers; however, oil marketing companies are increasingly relying upon this mode of transportation. Rift Valley Railways, a Kenyan Railways concessionaire, refurbished over 250 fuel ferrying tanks in 2014, resulting in Vivo Energy signing contracts to distribute gasoil via rail.

In late October 2017, a Joint Development Agreement (JDA) was signed between the Kenyan Government and the Joint Venture partners. The JDA sets out the structure to progress with the development of the new crude oil pipeline from the South Lokichar fields to the Lamu port. The export pipeline was expected to be completed by 2020, (but most likely will be delayed) and will cost around USD 2.1 billion. The pipeline will extend for 891 km from Lokichar in Turkana to a projected port in Lamu, and it will be heated/insulated (to 80°C), given the waxy nature of the Lokichar oil. In May 2018, the Kenyan Government awarded the FEED contract to Wood Group and the Environmental and Social Impact Assessments (ESIA) to Golder and Associates.

2.2 Status of air quality and air quality management in Kenya

Air pollution is a leading cause of respiratory diseases such as chronic obstructive pulmonary disease (COPD), lung cancer, pulmonary heart disease and bronchitis in Kenya. The effects of outdoor air pollution are compounded by those of indoor air pollution. Most households use charcoal and firewood for domestic cooking. Indoor air pollution affects both urban and rural populations[1].

According with UNEP Air Quality Catalogue[2], the overall situation with air quality in Kenya, includes the following key challenges:

- Traffic emissions have been identified as the leading cause of air pollution in major cities in Kenya
- Traffic related emissions are exacerbated by the importation of second-hand vehicles
- Poor solid waste management is also an important source of air pollution
- Majority of the households use kerosene and biomass-based fuel (charcoal) for domestic cooking leading to substantial indoor exposure to air pollution

[1] National Environment Policy of Kenya 2013 http://www.environment.go.ke/wp-content/uploads/2014/01/NATIONAL-ENVIRONMENT-POLICY-20131.pdf

[2] https://wedocs.unep.org/bitstream/handle/20.500.11822/17228/Kenya.pdf?sequence=1&isAllowed=y

Furthermore, specific deficiencies were identified with respect to the air quality monitoring system in the country[3]:

- Currently air quality monitoring is limited (any ad hoc monitoring is a response to air pollution complaints; short-term research for academic requirements and currently, no National Air Quality Monitoring Program is in place)
- Ambient Air Quality levels exceed the limits stipulated under the WHO guidelines for some parameters
- Major causes of air pollution are activities in the industrial sector, transport sector, energy sector, waste disposal operations and domestic cooking activities.

A climate-resilient, low carbon development was established as a national priority for Kenya since it will support Kenya's goal to absorb disturbances and build capacity to adapt to additional stress and change. By pursuing a green economy path and minimising carbon footprints, the country will better deliver constitutional rights to a clean and healthy environment while minimising the country's contribution to global climate change. Measures to address existing climate variability and achieve national development goals should not be at the expense of preparing for future climate change. Measures to address climate change through mitigation and adaptation actions should not compromise the ability of today's generation to achieve people-centered sustainable development[4].

According to the Strategic Environmental and Social Assessment of the Petroleum Sector in Kenya,[5] all reasonable attempts should be made to maximize energy efficiency and design facilities to minimize energy use. The overall objective should be to reduce air emissions and evaluate cost-effective options for reducing emissions that are technically feasible. In Kenya, there is no industry specific regulation governing air emissions; however, the Environmental Management and Co-ordination (Air Quality) Regulations, 2014 are applicable. The provisions in the regulations include: general prohibitions, permissible levels, controlled areas, stationary sources, mobile sources, occupational air quality limits, licensing, methods of measurement, analysis and laboratories, inspection and monitoring and reporting.

The responsibility to measure noise levels and air quality rests with the Safety and Health Advisors registered by DOSHS[6]. However, there is no clear mechanism on how these officers should share their findings with NEMA or how to incorporate the Safety and Health audit reports in the environmental audit reports and vice versa. For this reason, NEMA environmental inspectors and Occupational Safety and Health Officers end up duplicating efforts or demanding the same legal requirements in a particular facility[7]. The role of County governments in air pollution control in accordance with the constitution also poses an area of conflict, although air quality regulation is yet to be devolved[8].

The following gaps were identified in the Air Quality Standards: *"There is a lack of environmental standards and guidelines for upstream oil drilling and mid-stream processing activities to meet international air quality thresholds."* The following recommendations were

[3] Ibid

[4] National Environment Policy of Kenya 2013 http://www.environment.go.ke/wp-content/uploads/2014/01/NATIONAL-ENVIRONMENT-POLICY-20131.pdf

[5] Ministry of Energy and Petroleum of Kenya, *Strategic Environmental and Social Assessment of the Petroleum Sector in Kenya*, 2016, http://documents.worldbank.org/curated/en/186991495657679496/pdf/SFG2851-V2-EA-P145234-Box402910B-PUBLIC-Disclosed-5-24-2017.pdf

[6] Ibid

[7] Ibid

8 Ibid

provided as a result with the emphasis on enforcement and implementation of the following specific regulations to enhance air quality management practices:

- Point Source Air Emissions Prevention and Control Technologies to be adopted by the industry, i.e. on Particulate Matter, SO2, NOx, Ozone depleting substances and Green House Gases.
- Implementation of carbon capture and storage technologies, or installation of protection and enhancement sinks and reservoirs to cut down greenhouse gas emissions.
- Strict implementation and maintenance of a buffer zone between a petroleum facility and residential dwellings and the storage of highly flammable products based on the current regulations.

2.3 Overview of Emission Sources and Air Pollutants in the Upstream Oil and Gas industry

2.3.1 Emission Sources

Each hydrocarbon reservoir is unique with regard to both its geological and petrophysical characteristics and its hydrocarbon composition. Depending on the particular field, quantities of both oil and gas may be mixed with other hydrocarbons - such as ethane, butane, propane, benzene, and hexane – as well as water and CO_2 or other contaminants. These pollutants must be removed prior to transportation or sale in the market. Some are marketable individually. Release of pollutants, including air emissions, may arise throughout the myriad of different industrial activities associated with hydrocarbon extraction, processing, transportation, storage and marketing processes.

The main air emissions (continuous or intermittent) from petroleum sector include:

- combustion emissions (stationary and mobile, including flaring and venting, continuous and intermittent emissions (e.g., well-testing emissions, safety flaring, engine exhaust, etc.);
- fugitive emissions (from pipes, valves, seals, tanks, and other infrastructure components, evaporation ponds and pits, windblown dust (from truck and construction activity));
- process emissions;
- auxiliary emissions storage tanks.

While statutory and mobile combustion and fugitive sources of emissions are typical for upstream petroleum operations, process and auxiliary emissions are common for mid- and downstream petroleum operations.

Stationary combustion sources include boilers, turbines, steamers, flares, thermal oxidizers, dryers, and any other equipment or machinery that combusts carbon bearing fuels or waste stream materials (like the use of compressors, pumps, and reciprocating and other engines on offshore and onshore facilities).

Mobile combustion sources include support and supply vessels and helicopters, highway vehicles, construction equipment, freight trains, upstream/downstream third-party transportation emissions, such as those associated with transporting material inputs or product distribution, are considered optional indirect emissions.

Fugitive emissions include sudden leaks of vapors from equipment or pipelines, as well as continuous small leaks from seals on equipment. These emissions are not released from vents and flares but may occur at any location within a facility. At the upstream petroleum facilities fugitive emissions may be associated with cold vents (collected gaseous stream that is directly released to the atmosphere without burning in flare), leaking tubing, valves, connections, flanges, packings, open-ended lines, pump seals, compressor seals, pressure relief valves, open tanks for Non-Aqueous Drilling Fluids (NADF) (generating diffuse emissions), and hydrocarbon loading and unloading operations . In petroleum-refining facilities fugitive emissions may occur from leaking tubing, valves, connections, flanges, gaskets, steam traps, packing, open-ended lines, floating roof storage tanks and pump seals, gas conveyance systems, compressor seals, pressure relief valves, breathing valves, tanks or open pits/containments, oil-water separators, and in the storage, loading, and unloading operations of hydrocarbons.

The summary table below classifies different upstream oil and gas activities, the associated pollution potential and examples of the remedial actions that can be undertaken to reduce the impact.

Phase	Activity	Issue	Level of Impact
Exploration	Surveys	Aircraft emissions	Short-term, transient
Exploration	Seismic - onshore	Noise from seismic activities (explosions, vibrations)	Short-term
Exploration	Seismic - onshore	Emissions from power generation or transportation equipment	Short-term
Exploration	Seismic – offshore	Emissions from vessels	Short-term, transient
Exploration/ Appraisal Drilling - Onshore	Site Preparation	Dust from construction equipment and transportation	Short-term, transient
Exploration/ Appraisal Drilling - Onshore	Operations	Emissions from equipment during drilling and transport	Short-term, transient
Development – onshore/offshore	Operations	Flaring and venting during testing	Intermittent
Development – onshore/offshore	Operations	Emissions from transport	Moderate
Production	Operations	Flaring and venting during start-up, maintenance, and emergency situations	Periodic, but brief

Production	Operations	Leaks from equipment	Minor, but will increase as equipment ages
Production	Operations	Emissions from equipment and plant processes	Moderate

2.3.2 Air Pollutants

Pollutants typically emitted by petroleum sector include the following:

Principal Pollutants	Additional Pollutants	Greenhouse Gases
Nitrogen oxides (NOx),	Hydrogen sulphide (H2S);	Carbon dioxide (CO2)
Sulphur oxides (SOx),	Volatile organic compounds (VOC);	Methane (CH4) and Ethane (C2H6)
Carbon monoxide, (CO)	Benzene, ethyl benzene, toluene, and xylenes (BTEX)	Nitrous oxide (N2O)
Particulate Matter (PM)	Polycyclic aromatic hydrocarbons (PAHs)	Global warming potential (GWP) gases - all of the above in this column, and Chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF6)9)
	Mercaptans and mercury	
	Halon and other Chlorofluorocarbon (CFC) gases from fire-fighting and refrigeration systems	

Volatile Organic Compounds (VOCs)

Oil and gas production areas may have high levels of volatile organic compounds (VOCs) which contribute to the formation of ozone in the lower atmosphere. VOCs also may evaporate from the oil and gas being extracted, stored and transported. Furthermore, VOC emissions may arise from vehicles and equipment used in the oil and gas operations. Quantification of VOCs in oil and gas production areas can be challenging to identify and link directly to a source.

Greenhouse Gases

CO_2 and methane are the most common greenhouse gases emitted during the production of oil and gas.

CO_2 occurs in varying proportions in natural gas and is removed at processing plants to improve the quality of the gas. Historically, most CO_2 was vented into the atmosphere, and accounted for a significant proportion of GHG emissions at the oil and gas processing site. At present it is accepted practice for CO_2 to be injected into the reservoir as part of enhanced oil recovery (EOR) operations, where the injection of CO_2 helps to improve the productivity at declining fields.

[9] https://www.epa.gov/ghgemissions/understanding-global-warming-potentials

Depending on the characteristics of the reservoir, the composition of hydrocarbons produced will vary. Oil and gas will be mixed with other hydrocarbons—such as ethane, butane, propane, benzene, and hexane – as well as water, CO_2 and other contaminants, such as H_2S. Some of these components are termed "natural gas liquids" and can be sold separately at a higher value to the petrochemical industry. In order to transport methane by pipeline to market, the methane must be processed to remove these substances, some of which are marketable individually.

Oil and gas production accounts for 72% of the methane emissions from the oil and gas industry[10].

During drilling, emergency situations, well testing, and startup operations, it may be necessary to vent or flare methane into the environment. Historically, operators globally have flared natural gas at the well site when there was insufficient local market or pipeline capacity to monetise the natural gas. However, industry best practices now encourage the reinjection of natural gas back into the reservoir, use of the gas as on-site fuel, or the creation of a local natural gas market to limit flaring.

Methane may also leak from pipelines or other equipment during storage or transportation. Leaks occur from storage tanks, seals, valves, or during loading and unloading operations. Regular maintenance and inspection programs can limit the leaks. Operators and jurisdictions are beginning to use stationary and mobile sensors and cameras to detect leaks.[11]

Hydrogen Sulphide

Hydrogen sulphide (H_2S) is a colourless gas, soluble in various liquids including water and alcohol. It can be formed under conditions of deficient oxygen, in the presence of organic material and sulphate. H_2S is colorless, flammable, highly toxic, and corrosive gas. H_2S is identified in the reservoir during the drilling phase and may be predicted when certain geological conditions are in place – i.e., a high pressure/high temperature reservoir or limestone source rock. Gas with H_2S content is called a "sour gas".

H_2S may be contained in gas found in petroleum reservoirs but has not been discovered in Kenya at this time. Precautions should be in place for the discovery of H_2S during drilling operations.

Where H_2S is present in the reservoirs, operators must take additional measures to protect workers, communities and the environment, remove it from the gas stream and also to prevent corrosion to equipment. Because H_2S is heavier than air, it may accumulate in enclosed, poorly-ventilated, and low-lying areas, and thus, presents a significant danger to workers.

While there are regions of the world where gas with significant H_2S content is managed safely, additional precautions must be undertaken, such as the use of wearable sensors, use of protective equipment and the protection of equipment against corrosion.

The World Health Organization (WHO) states that the lowest-adverse-effect level of hydrogen sulfide is 15 mg/m^3, when eye irritation is caused. It recommends that H_2S concentrations should not be allowed to exceed 7 mg/m^3, with a 30-minute averaging period. When setting

[10] https://www.epa.gov/natural-gas-star-program/estimates-methane-emissions-sector-united-states
[11] https://www.atsdr.cdc.gov/MHMI/mmg114.pdf

concentration limits in ambient air, it should be noted that hydrogen sulfide is emitted from natural sources in many places.[12]

Priority Air Pollutants

The WHO identifies ambient air quality thresholds and limits for four key air pollutants – Particulate matter, ozone, nitrogen dioxide, and sulphur dioxide. WHO is in the process of revising its guidelines and anticipates releasing revised guidelines in 2020.

Particulate matter (PM)

Particulate matter consists of a complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air that may include sulphate, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water. It is measured by the size of the particles (in microns) and is typically grouped in particulate matter with diameter of less than or equal to 2.5 microns ($PM_{2.5}$) and particulate matter with diameter of less than or equal to 10 microns (PM_{10}). Chronic exposure contributes to the risk of developing cardiovascular and respiratory diseases. $PM_{2.5}$ is small enough to penetrate the lung barrier and enter the blood system. PM can come from household combustion of fuels, construction sites, internal combustion engines. In addition to health effects, PM contributes to reduced visibility and may impact ecosystems.

Ozone (O3)

Ozone located at ground level is a major constituent of photochemical smog. It is formed when pollutants such as nitrogen oxides (NO_x) or VOCs react with sunlight. Sources of NO_x and VOCs include vehicle and industrial emissions. Ozone can trigger lung issues such as asthma.

Oxides of Nitrogen

Oxides of Nitrogen are a mixture of gases that are composed of nitrogen and oxygen -- nitric oxide (NO), nitrogen dioxide (NO_2), nitrous oxide, N_2O, and nitrogen pentoxide (NO_5). Excessive levels can damage crops, increase the acidity of rain, and cause respiratory issues and skin irritation, even at low levels. Sources include oil and gas extraction, petroleum manufacturing, internal combustion engines, and fuel burning.

Nitrogen Dioxide

Nitrogen Dioxide (NO_2) specifically may cause inflammation in the airways in high concentrations in the short term, cause reduced lung function in the long term, promote the development of ozone, and may be found in $PM_{2.5}$. Sources of NO_2 include combustion processes such as heating, power generation, and engines.

Sulphur Dioxide

Sulphur Dioxide (SO_2) can cause respiratory inflammation and is a component of acid rain when combined with water. Sources of SO_2 include the burning of fossil fuels for domestic heating, power generation, and motor vehicles.

Carbon Monoxide

Carbon Monoxide (CO) can be harmful to humans in high levels by impeding oxygen transport in the body. High concentrations are most common indoors. Long term exposure may also

[12] http://www.euro.who.int/__data/assets/pdf_file/0019/123076/AQG2ndEd_6_6Hydrogensulfide.PDF

cause health effects. Sources of CO include motor vehicle exhaust and machinery that burns fossil fuels.

Lead

Lead pollution has been on the decline in developed countries since it has been removed from gasoline. Other sources include waste incineration, utilities, and smelters. Lead can cause significant health issues and is persistent in the environment if deposited in the soil through air or water pollution.

Other Air Pollutants

Other air pollutants may also be found at the upstream sites, but emissions will be mostly due to equipment or combustion engines rather than emissions from the reservoir specifically. Up to date regulations for mobile sources, stationary sources, or occupational health are sufficient typically to manage these pollutants.

2.4 Summary of International Good Practice of Potential Remediation Actions to address emissions deriving from Upstream Petroleum Operations

The generic high-level list of actions to be reviewed and applied by petroleum companies consists of the following[13]:

- Design and operate to minimize air emissions.
- Use regular preventative maintenance and monitoring procedures.
- Install and maintain catalytic converters.
- Use low NOx burners.
- Convert engines to lean-burn.
- Maintain and run all engines to be the most fuel efficient.
- Install pre-combustion chambers on engines.
- Install electronic ignition systems on engines.
- Use natural gas engines instead of engines fueled by diesel or other fuels.
- Tighten connections and replace packing to minimize leaks and fugitive emissions.
- Reduce emissions of unburned hydrocarbons in new facility design (e.g., route emissions to flare, route dehydrator still emissions to first stage compression, use electric drivers for compressors, use shorter piping runs with fewer flanges, use welded rather than screwed or bolted fittings).
- Reduce horsepower demands to reduce emissions.
- Maintain tank thief hatch seals.
- Route dehydrator still emissions to reboiler, firebox, first stage compression, or flare.
- Lower glycol circulation rate - avoid over dehydrating (vapor recovery).
- Eliminate use of sparge or stripping gas in dehydrators.
- Buy solvents and liquid chemical in bulk and keep containers covered.
- Buy less volatile solvents and liquid chemicals.
- Use dust control techniques at facilities.
- Eliminate the use of halon fire extinguishing materials.
- Revise test procedures so halon is not released.
- Use waste heat recovery opportunities where possible.

IFC Environmental, Health, and Safety Guidelines, https://www.ifc.org/wps/wcm/connect/532ff4804886583ab4d6f66a6515bb18/1-1%2BAir%2BEmissions%2Band%2BAmbient%2BAir%2BQuality.pdf?MOD=AJPERES

- Use vented or flared gas as fuel.
- Collect vented or flared gas, compress, and sell as product

A specific list of techniques aimed at reducing emissions in the upstream oil and gas industry is provided in Annex 1.

3. Legal Framework - Key Drivers and Policy

3.1 Overview of Kenya policies, laws and regulations related to air quality and air emissions as it relates to upstream oil and gas industry

Kenya National Priorities & International Commitments

Kenya Vision 2030

Kenya's Vision 2030 defines priorities to establish Kenya as a middle-income economy by 2030. The strategy divides the policy targets into pillars – Economic, Social, and Political. A part of this national strategy, economic development and sustainable use of natural resources target the growth of an oil and gas sector.

Kenya Vision 2030 identifies the development of the oil and gas sector in Kenya as a priority under the Economic and Macro Pillars of the overall plan. Specifically, the plan also identifies "effective management of the environment and social footprints" as a flagship project in the Second Medium Term Plan.[14]

Furthermore, Kenya's Vision 2030's Second Medium Term Plan identifies a goal of attaining a "***clean, secure, and sustainable environment"*** in the Social Pillar. As a part of this, ***the development of Kenya as a carbon credit trading hub is identified as a flagship project***. This would require the development of a carbon trading platform for the East African Community and potentially the entirety of Africa.[15]

The Second Medium Term Plan (2013-2017) also identified the establishment of a Carbon Credit Trading hub for East Africa. As part of this plan, carbon trading schemes and a regional framework for carbon trading throughout the East African Community will be established. It also identified the implementation of the ***National Climate Change Action Plan*** during this period.

The Third Medium Term Plan (2018-2022) specifically identified projects of importance to the upstream oil and gas industry. It identified the ***construction of Lokichar-Lamu crude oil pipeline, commercialization of the oil and gas discoveries, and the strengthening of climate change governance and monitoring programs***. It specifically assigned priority to the development of infrastructure.

Kyoto Protocol

The Kyoto Protocol (the Protocol) is an international treaty which expounds the 1992 United Nations Framework Conventions on Climate Change and was ratified by Kenya in 2005. The main goal of the Kyoto Protocol is to control emissions of the main anthropogenic (human-emitted) greenhouse gases (GHGs) in ways that reflect fundamental national differences in GHG emissions, wealth, and capacity to make the reductions.

[14] https://vision2030.go.ke/economic-pillar/#93 and http://vision2030.go.ke/inc/uploads/2018/06/Second-Medium-Term-Plan-2013-2017.pdf page 69
[15] http://vision2030.go.ke/inc/uploads/2018/06/Second-Medium-Term-Plan-2013-2017.pdf page 84

The Protocol obligates its parties to follow certain requirements. ***The Clean Development Mechanism*** (CDM) allows emission reduction (or emission removal) projects in developing countries to earn certified emission reductions (CERs), each equivalent to one tonne of CO_2. These CERs can be traded and sold,and used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol. It is expected for parties to work together to achieve lower emissions. If the emissions of a party included in the Protocol are less than an assigned amount, the difference can be added to another party's amount for subsequent commitment periods.

Kenya has already prepared a Climate Change Response Strategy which spells out the priority areas for both adaptation and mitigation activities in the country. Kenya has registered Clean Development Mechanism (CDM) projects. This mechanism is further described in the Kyoto Protocol. CDM spells out the priority areas for both adaptation and mitigation activities in the country.

Paris Agreement

The Paris Agreement entered into force in November 2016 and builds upon prior global climate agreements, such as the Kyoto Protocol. As of early 2020, 187 countries have ratified this agreement including Kenya.

The Paris Agreement aims to keep a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.

The agreement aims to increase the ability of countries to deal with the impacts of climate change, and at making finance flows consistent with a low GHG emissions and climate-resilient pathway. Focus was given to support action by developing countries and the most vulnerable countries through appropriate mobilization and provision of financial resources, a new technology framework, and enhanced capacity-building.

The Paris Agreement requires all Parties to put forward their best efforts through "nationally determined contributions" (NDCs) and to strengthen these efforts in the years ahead. All parties must report regularly on their emissions and on their implementation efforts. Every 5 years, there will also be a global stock taken to assess the collective progress towards achieving the purpose of the agreement and to inform further individual actions by Parties. The Agreement provides for an enhanced transparency framework for action and support.

East Africa Climate Change Policy

The goal of the East Africa Climate Change Policy (EACCCP) is to help Partner States on the preparations and implementation of collective measures to address climate change while assuring sustainable social and economic development in the region. The document evaluates the challenges faced by developing nations and special sensitivities that will impact the East African Community (EAC) member states. The document sets out policy provisions addressing the major sectors impacted by climate change and offers guidance on implementation plans.

EAC encourages the development and implementation of National, as well as regional, plans of action. The Partner States are under the obligation and have a right to promote sustainable development. Policies and measures to address effects of Climate Change against human development should be appropriate for the specific conditions of each Partner State.

The Policy charges the individual partner states with the development of country-specific policies, strategies, plans of action, legislation, and institutional relationships. Implementation should be through sustainable financing, capacity building, technology development and transfer. The EAC Secretariat will develop monitoring and evaluation guidelines and regularly review the EACCP every three years.

The EAC shall focus on adapting to climate change through disaster reduction and planning, building economic and social resilience, and various planning activities focused by sector.

Kenya legislation and regulations

The Constitution of Kenya, 2010

The Constitution of Kenya establishes the rights of Kenyan citizens, including the rights to a clean and healthy environment, access to information held by the State, and the protection and sustainable development of the natural resources of Kenya. Furthermore, the Constitution specifically charges the state with the establishment of "systems of environmental impact assessment, environmental audit and monitoring of the environment" and to "eliminate processes and activities that are likely to endanger the environment."[16]

Environmental Management and Co-ordination Act, 1999 rev 2018

The Environmental Management and Co-ordination Act establishes the National Environmental Council, which has responsibility for policy formulation and cooperation between various authorities and the public. It also establishes the authority of the National Environmental Management Authority (NEMA) to exercise general supervision and co-ordination over all matters relating to the environment and to be the principal instrument of the Government in the implementation of all policies relating to the environment. NEMA is charged with environmental monitoring activities which must assess any possible changes in the environment and their possible impacts as well as the operation of industry and its immediate and long-term impacts on the environment. NEMA is charged with the setting of air quality standards, determination of measures to reduce air emissions, and undertaking the monitoring and enforcement activities.

EMCA also establishes the County Environmental Committees that are responsible for the proper management of the environment within the respective county, required to develop strategic environmental action plans every five years, and perform other environmentally related activities in the county. The National Environmental Complaints Committee is charged with the management of complaints regarding the environment, represent the public interest in any litigation, and undertake any investigation.

Petroleum (Exploration, Development and Production) Act, 2019

The Petroleum (Exploration, Development and Production) Act, 2019 (Petroleum Act) is the main law governing upstream petroleum operations in Kenya. It provides the legal and institutional framework applicable to the industry and created an industry regulator – Energy and Petroleum Regulatory Commission (EPRC). The purpose of EPRC is to exercise general supervision and co-ordination over all matters relating to the petroleum and electricity sectors, and to be the principal instrument of the government in the implementation of all applicable policies.

[16] Constitution of Kenya, §69.1(f)-(g).

The Petroleum Act contains a broad spectrum of provisions, including licensing and permitting; revenue sharing; contractual matters; decommissioning; monitoring and enforcement; as well as environment, health and safety-related issues, e.g., waste management, damage compensation, and emergency preparedness.

The Petroleum Act is a parent act that was passed in early 2019 and will require a number of subordinate regulations to give full force to its provisions.

Energy Act, 2019

The Energy Act, 2019 is the main law governing the energy sector outside of the upstream petroleum operations. It has five main functions: to regulate the energy sector by delineating the sectorial functions of the National and County Government; to provide for the promotion of renewable energy; to regulate geothermal energy; to regulate the midstream and downstream operation of the coal and petroleum sectors; and to regulate the production and supply of electricity.

Climate Change Act, 2016

The Climate Change Act establishes a framework to respond to climate change. It establishes the National Climate Change Council as the coordinate and develop national climate change mechanisms, advise on climate change policies, administer the Climate Change Fund, and set targets for the regulation of greenhouse gases.

The Act requires public agencies to integrate the National Climate Change Action Plan in its activities, report on sectoral greenhouse gas emissions for the national inventory, put in place and implement sustainability measures, and to report annually all climate change related duties and functions. This Act grants NEMA the authority to monitor, investigate, and report on climate change compliance activities. NEMA is required to report annually on these compliance activities. The Act also creates a Climate Change Fund that will help promote and incentivize actions to prevent and limit climate change.

Environmental Management and Co-ordination Act (Air Quality Regulations), 2014

The EMCA (Air Quality Regulations) expounds upon the EMCA with specific details on air pollution prevention, controls, and abatement. The regulations establish NEMA's authority for identifying priority air pollutants, establishing ambient air quality standards, and prescribing permissible standards. On a procedural front, the regulations establish the process for obtaining emissions licenses, determining the methods of measurement and analysis of emissions data, inspection and monitoring programs, and reporting requirements. The regulations establish the emissions requirements for stationary sources, mobile sources, and occupational air quality. Schedules to the regulations specify requirements for different pollutants. The First Schedule establishes Ambient Air Quality Tolerance Limits and limits at property boundaries. The Third Schedule establishes emissions limits for priority pollutants from point sources and identifies the permissible levels by the type of facility. The Fourth Schedule of the regulations sets out the air pollution monitoring parameters from stationary sources. The Fifth Schedule establishes general guidelines on air quality. The Seventh and Twelfth Schedules present acceptable emissions control technologies for stationary and mobile sources. Other schedules provide relevant forms, licenses, approved standards, and fees. ***The schedules as currently written do not address air emissions from oil and gas exploration and production activities, although some components included, such as engines and boilers, which may be used at oil and gas well sites.***

Environmental Management and Co-Ordination Act (Impact Assessment and Audit) Regulations, 2003

The EMCA Impact Assessment and Audit regulations establish the process for Environmental Impact Assessments, environmental audits, and monitoring programs. The Schedules to the regulation have details on the required EIA contents, general guidelines for EIAs, criteria for EIA experts, and required fees.

Draft Kenya Legislation (as of February 2019)

Environmental Management and Co-ordination (Strategic Assessment, Integrated Environmental Impact Assessment and Audit) Regulations, 2018

The draft Regulations establish the process and procedures for strategic environmental assessments, environmental impact assessments, and environmental audits. An Environmental Management Plan must be included in every EIA followed by a biannual monitoring report submitted to NEMA in the format detailed in this regulation. Oil and gas exploration and production activities require an EIA. This regulation is intended to repeal the Environmental (Impact Assessment and Audit) Regulations, 2003.

3.2 Key air quality and air emission gaps identified in Kenya policies, laws and regulations as they relate to upstream oil and gas industry

Gaps identified in Kenyan regulations that affect regulation of air emissions includes the following:

- **Emissions and Emission Sources Specific to Petroleum sector:** Since the Air Quality Regulation is of a generic nature, sources of air pollution applicable to petroleum sector are not covered by the regulation explicitly. The main air emissions (continuous or intermittent) from petroleum activities include:
    - combustion emissions, stationary and mobile, including flaring and venting, continuous and intermittent emissions (e.g., well-testing emissions, safety flaring, engine exhaust, etc.);
    - fugitive emissions (from pipes, valves, seals, tanks, and other infrastructure components, evaporation ponds and pits and windblown dust from truck and construction activity);
    - process emissions (more relevant for mid- and down-stream);
    - auxiliary emissions (more relevant for mid- and down-stream).

  Such classification of petroleum sector air emission sources should/can be incorporated into Kenyan Air Quality Management Guidelines developed specifically for petroleum sector. Furthermore, it can used for the purpose of permitting, measurement and monitoring of emissions from petroleum Ooperations.

- **Air Quality Standards**: The First Schedule of the Air Quality Regulations establishes ambient air quality tolerance limits. It is observed that some pollutants' limits do not correspond to current standards stipulated in WHO, IFC guidelines and US National Ambient Air Quality Standards. For example, international standards for Sulphur Oxides (SOX), Nitrogen Dioxide, PM10, PM2.5, Lead (Pb), Carbon Monoxide (CO)/Carbon Dioxide (CO2), Hydrogen Sulphide (H2S) and Ozone establish more stringent levels. It is recommended that Kenya's air quality standards are aligned with limits established in WHO, IFC guidelines. Further assessment on the impact of these changes on other

industries might be required, as such standards will apply to all industries due to generic nature of Air Quality Regulations.

- **Petroleum sector Air Pollutants:** The Second Schedule of the Air Quality Regulations provides a list of priority air pollutants. This list is extensive and covers all primary pollutants and greenhouse pollutants. However, some additional pollutants specific to the petroleum sector are not covered in this schedule. Therefore, it is recommended to consider addressing additional pollutants, such as Benzene, ethyl benzene, toluene, and xylenes (BTEX), Polycyclic aromatic hydrocarbons (PAHs), Mercaptans and Nitrogen trifluoride (NF3). Potentially, this could be done by adding a separate sub-section to the Second Schedule entitled "Petroleum Emissions", should NEMA consider addressing them.
- **Air Emission Limits for Upstream and Midstream Facilities:** The Thirteenth Schedule of the Air Quality Regulation establishes emission limits for pollutants emitted from Controlled and Non-Controlled Facilities. It is understood that such limits will be applicable to facilities/equipment routinely used in petroleum operations and in petroleum refineries. This is consistent with regulations of the jurisdictions that were used for benchmarking purposes. However, as a potential long-term objective it is recommended that the approach implemented in the US is considered in order to establish New Source Performance Standards. This provides a mechanism to determine emission limits for new sources taking into account ambient local/regional conditions.
- **Controlled Facilities and Emission License**: It is recommended that the list of controlled facilities in the Fourteenth Schedule of the Air Quality Regulations is amended to include upstream oil and gas facilities required for exploration, development, production, transportation and decommissioning. By introducing this change such facilities will be required to obtain an Emissions' License and will be subject to requirements applicable to such controlled facilities, such as planning, reporting, measurements and monitoring. Such Emissions' Licenses must cover the priority pollutants established in the Air Quality Regulations.
- **Record Keeping Period:** The record keeping requirement for controlled facilities is only for a two-year period, which is shorter than what is established in the benchmarked jurisdictions. Furthermore, only petroleum refineries and depots are required to keep records under the regulation, as upstream and midstream facilities are not included to the list of controlled facilities under the Fourteenth Schedule. Consideration should be given to requiring upstream and midstream operators to keep records for a period of five years. It is assumed that petroleum facilities would fall under the category of controlled facilities as per above.
- **Environmental Monitoring of Stationary Sources:** Continuous monitoring is required to be performed by a licensee. However, as indicated above it would appear that an emission license is only required for controlled facilities that are included in the Fourteenth Schedule. It is recommended that the Fourteen Schedule of the Air Quality Regulations is amended to include upstream oil and gas facilities required for petroleum exploration, development, production, transportation and decommissioning. By introducing this change such facilities will be required to obtain an Emission License and carry out continuous monitoring activities.

- **Sources of Fugitive Emissions from Petroleum sector:** Part VIII of the Fifth Schedule of the General Guidelines of the Air Quality Regulations lists sources of fugitive air pollutants. However, this list does not identify fugitive emissions specific to upstream and midstream petroleum sector. It is recommended to add sources of fugitive emissions derived from the petroleum sector to Part VIII of the Fifth Schedule. Such specific fugitive emissions from the petroleum sector include, for example, sudden leaks of vapors from equipment or pipelines, continuous small leaks from seals on equipment, cold vents, leaking tubing, valves, connections, flanges, packings, open-ended lines, pump seals, compressor seals, pressure relief valves as specified in more detail in the body of the report. Such emissions should be subject to a Fugitive Emissions Control Plan.
- **Acceptable Emission Control Technologies:** The Seventh Schedule of the Air Quality Regulations lists acceptable emission control technologies. However, this list is not up to date and is not representative of best emission control technologies applicable to petroleum sector. It is recommended to expand the list or develop more flexible provisions to keep the list up to date. A list of best emission reduction and control technologies is provided in the report, see Annex 2.
- **Pollution Measurement:** Article 32 of the Air Quality Regulation requires that measurements of pollutants at the controlled facilities are carried out by a laboratory designated by the Authority in order to determine compliance with the prevailing allowed levels of exposure. If upstream and midstream facilities are included in the list of controlled facilities, this method of determining compliance by a designated laboratory may not always be effective. As a wide range of instruments are allowed globally for compliance checking purposes, a wider approach to accepting compliance is recommended such as, for example, acceptance of monitoring data collected by companies.
- **Test and Measurement Methods of Air Pollutants:** The Eleventh Schedule of the Air Quality Regulation list the standards that establish methods of test and measurement of air pollutants. This list might not be up to date or representative of test methods suitable for the petroleum sector. As such, flexibility is recommended and to permit alternative test and measurement methods and standards that are more suitable for petroleum sector, provided that they represent best practices. Therefore, it is recommended to add a provision stipulating that other methods may be approved by NEMA subject to substantiated justifications. Detailed methods for test and measurement are provided in the Inspection Manual.
- **Greenhouse Gas Standards Emitted by Petroleum sector:** The Climate Change Act of 2016 provides for the regulation of greenhouse gases (GHG), although it establishes no standards or emissions limits for all GHG. Some standards are established for CO2 and hydrocarbons under the Air Quality Regulations, but not all other GHGs. It is recommended to encourage and incentivize the reduction of methane emissions through leak detection and repair programs or other monitoring programs. As a long-term target, Kenya may consider adopting an approach of developing and enforcing Greenhouse Gas Emission Standards based on international practice, such as those established in California, US, or Alberta in Canada, for example. However, this approach shall be fully assessed prior to implementation.

- **Upstream Flaring and Venting**: Under the Petroleum Law, upstream operators are prohibited from flaring or venting, except in cases of emergency or when expressly authorized by the Authority in consultation with NEMA. At the same time, it would appear that current Kenya legislation and regulations do not provide for much details beyond this requirement. Secondary requirements applicable to flaring addressing various aspects of flaring, environmental among others, such as technical, safety and health requirements should be developed and adopted in Kenya via secondary regulations and/or guidelines and standards. Such environmental requirement can cover measures among other, including: application and review process for issue of flaring/venting permits (for different phases: commissioning vs production), pollution prevention and control measures; emergency flaring, well testing, flaring and venting gas volumes, greenhouse gas emissions estimates flaring and venting monitoring and reporting requirements.

4. SWOT analysis

The SWOT analytical framework provides a scan of areas of strengths, weaknesses that require addressing as well as potential opportunities and threats posed within the operating environment with adoption of this Strategy.

Strengths	**Weaknesses**
• Political commitment through the ratification and adoption of relevant policies, laws and international conventions • Existence of enabling environment at national level such as EMCA Act, Climate Change Act and Petroleum Act that have a framework for emission control and management • Petroleum Operations conducted predominantly by experienced International Oil Companies which are aware of and have comprehensive HSE management systems and aware of best practices required to comply with aimed at emission reductions	• Lack of regulatory framework for upstream petroleum oil and gas industry in current Kenyan environmental regulations; • Lack of secondary regulations developed under Petroleum Act which specify techniques and technologies which will deliver emission reduction and control; • Lack of institutional capacity of regulators and inspectors to monitor compliance with yet to be established regulations, adopted standards and guidelines; • Local community lacks understanding of upstream oil and gas operations and what threats and opportunities it brings
Opportunities	**Threats**
• International push on improving air quality and combat climate change • Local content development • Developing a system for incentivization for complying with	• Establishing unreasonably strict requirements which may become an impediment for developing natural resources in Kenya. Country may

requirements and self-discovery which can reduce burden of regulatory authorities • Emission reduction and improvement of air quality • Establishing flexible system which can be adopted to current and future needs of upstream petroleum indsutry	become less competitive compared to its peers. • Strict requirements may lead to more costly petroleum operations, therefore, reducing company's taxable income / • Inadequate requirements may lead to worthening of health problems of local communities and withdrawal of "social permit" for petroleum operations • Lack of capacity/capabilities to implement requirements

5. Air Quality and Emission Reduction Strategy for Kenya's Upstream Petroleum sector

Based on the situational analysis the following key strategic initiatives are proposed to be n in Kenya aimed at emission reduction and improvement of air quality development of the upstream petroleum sector in a safe and prudent manner.

When revising and establishing new requirements, the government shall take into account the types of companies currently operating in the country, as well as those that may operate in the future.

As of 2020, upstream oil and gas operations in Kenya are limited to larger international oil companies which may have extensive resources and processes in place to implement such requirements. However, adoption of very stringent requirements may deter local Kenyan companies from entering into potential exploration and development activities.

The key strategic initiatives defined based on the situational analysis include:

- Balancing environmental protection priorities with priorities for development of upstream petroleum sector
- Addressing gaps in Kenyan legislation and regulations applicable to upstream petroleum operations
- Adopting best environmental management practices for petroleum sector
- Requiring use of best available technologies not entailing excessive costs (BATNEEC) by petroleum sector players
- Revision and establishment of realistic emission targets set by international organizations
- Development of fiscal and other incentives aimed at emission reduction
- Reduction of greenhouse gas emissions

Balancing environmental protection priorities with priorities of development of upstream petroleum sector

Kenya's National Environmental Policy identifies air quality as a topic to be addressed. The focus in the strategy is to improve enforcement and compliance with air quality standards, reduce emissions in the transportation sector and by households.

However, at the same time Kenya aims to become a middle-income economy by 2030, and creation of an oil and gas industry, including the upstream sector, was specifically identified.

This may bring certain challenges related to environmental protection. Such challenges among others include balancing the growth of the economy with the protection of Kenya's environment, natural resources, and community needs. These challenges will be addressed through the action plan specified in S.5 of this strategy to achieve an optimal balance of delivering two goals.

Addressing gaps in Kenya legislation and regulations applicable to upstream petroleum operations

Existing gaps in regulations specific to oil and gas exploration and development activities shall be addressed prior to the commencement of production. As a minimum this shall include but not be limited to:

- establishing clear provisions for flaring and venting of natural gas,
- defining emissions limits specifically related to exploration and production activities,
- requiring energy efficient machinery and equipment,
- limiting leaks from tanks, valves, or other equipment, and
- limiting emissions during the construction phase.

Adopting best environmental management practices for petroleum sector

Given that Kenya has limited existing oil and gas exploration and development activities, it has a unique opportunity to establish policies for this sector that implement and take into account best environmental practices learned from other nations. Capacity of regulators to identify and regularly update best environmental practices may be difficult at this time.

Regulators should work with industry associations and reach out to mature oil producing jurisdictions for guidance on best practices.

Requiring use of best available technologies not entailing excessive costs (BATNEEC) by upstream petroleum sector players

Modern equipment used in oil and gas operations is energy efficient and less polluting. As such NEMA and the Ministry of Petroleum and Mining via establishment of regulations and permitting process shall require operators to choose efficient equipment and machinery with modern pollution controls.

Regular maintenance programs shall be required to reduce overall pollution and limit any major accidents or releases. Maintenance programs will go hand in hand with inspections.

Revision and establishment of realistic emission targets set by international organizations

Emissions targets for ambient air quality should follow established targets set by international organizations, such as:

- World Health Organization (WHO),
- World Bank,
- Ratified international agreements, such as, for example, United Nations Framework Convention on Climate Change.

All targets are to be set with realistic expectations while still allowing for sustainable development of the economy. Prior to establishing limits for specific oil and gas activities or equipment, existing norms established globally for the petroleum sector shall be taken into account. Equipment in the upstream oil and gas industry is manufactured for a global market and will generally meet uniform standards.

Development of fiscal and other incentives aimed at emission reduction

Such incentives shall be developed to encourage reduction of routine flaring and venting in the upstream oil and gas and incentives promoting use of natural gas in Kenya.

Reduction of greenhouse gas emissions

Reduction of greenhouse gas emissions is a priority goal for Kenya as climate change is anticipated to have impacts on wildlife, agriculture, and land use due to changes in meteorological conditions. Kenya has committed to participate with other nations in East Africa to work to prevent and limit the impacts of climate change on the region and its ecosystems. This strategic goal will be achieved through implementation of plans derived from Kenya Vision 2030.

6. Action Plan for implementation of the Air Quality and Emissions Reduction Strategy for Kenya's Oil and Gas Industry

This plan specifies actions to be taken to deliver the air emission reductions strategy for upstream petroleum sector.

Initial focus will be on actions aimed at establishing a framework, or those that are mandatory for the development of the industry, or that can be implemented quickly.

The action plan is broken down into short-, medium- and long-term initiatives to be implemented in Kenya:

- Short term initiatives focus on actions that can be achieved within a period of 3 years.
- Medium term initiatives should be achieved within 3-5 years.
- Long-term initiatives should target actions to be implemented within a period of over 5 years.

Short Term Initiatives

Initiatives requiring revision of existing or adoption of new environmental regulations in Kenya

Development and promulgation of changes into environmental regulation to address current gaps so that they apply to the upstream oil and gas industry.

- Revise the Third Schedule of the EMCA (Air Quality) Regulations to include a category for the upstream oil and gas industry. Develop air emissions guidelines for the Priority Air Pollutants identified in the Second Schedule of the Regulations.

a. The existing regulations establish emissions levels for specific items of equipment, such as turbines or engines, that may be used during operations. Emissions from equipment should be limited as much as practicable and within manufacturers guidelines.
b. Contaminants released naturally during drilling, development, and production activities, such as hydrocarbons, carbon dioxide, or hydrogen sulphide, should also have established emissions levels. Regulators should require monitoring and capture of these contaminants.

- Develop requirements for other air pollutants that may be released during upstream oil and gas operations. These chemicals include benzene, toluene, ethylbenzene and xylene, which are often called BTEX chemicals. These compounds occur naturally in crude oil and can be found in sea water in the vicinity of natural gas and petroleum deposits.

- Develop regulations to limit flaring to emergency situations only or if approved by the regulator. Other instances of routine flaring should be limited as much as practicable and only with regulator approval. Flaring should be allowed only for safety reasons, this includes during start up, shut down, during maintenance activities, or to prevent a potential accident. Under the Petroleum Law, upstream operators are prohibited from routine flaring or venting, except in cases of emergency or when expressly authorized by the Energy & Petroleum Regulatory Authority in consultation with NEMA.

- Finalize and approve draft EMCA (Strategic Assessment, Integrated Environmental Impact Assessment and Audit) Regulations. The EIA forms the basis of the environmental plan and air quality monitoring at facilities. While the existing regulations have an established process in place, operators may have concerns about changing requirements until the new regulations have been passed.

Initiatives Requiring NEMA Actions

- Identify potential organizations capable to provide training programs on environmental monitoring systems, manage data collected, and evaluate successful application specific to oil and gas exploration and production. These organizations could be universities, government agencies, and environmental and stakeholder organizations. Training shall assist NEMA officials, inspectors, policymakers and other parties engaged in the process on appropriate measures for EIAs, audits, and potential legislation.

- NEMA and upstream operators should undertake baseline assessments of air quality in regions with oil and gas potential. Establishing a baseline for air quality will provide NEMA officials with understanding of the air quality in the region prior to the start of oil and gas operations. This should help in future regulatory initiatives and to identify and evaluate any potential violations.

Medium Term Initiatives (3-5 years)

Initiatives aimed at reducing emissions from upstream petroleum operations in Kenya

- Implement changes to the air quality regulations or other regulations to ensure applicability to oil and gas exploration. Revise guidelines and other documents to reflect these changes.
- Establish a plan to encourage development of a natural gas market (for both associated and non-associated gas). The plan may include actions such as support for gas pipeline developments to bring gas to the market, development of gas infrastructure for domestic use, incentives for industry to use natural gas as a fuel, etc., where technologically and economically feasible.
- Promote pipelines over the use of truck or rail transport to reduce emissions from transport. Pipeline transport is a more efficient method to transport crude oil and is essential for the transportation of natural gas. Pipelines eliminate emissions generated by mobile sources such as trucks and rail, as well as reduce the risk of spills when transporting to market.
- Develop energy efficiency programs. Use of energy efficient equipment during the production phase can lower the emissions footprint. Solar panels, use of associated gas for fuel, or other efficiency measures limit the diesel or electricity demand of the site.
- Encourage reduction of traffic congestion and pollution in the region. Policies that limit truck idling, encourage more efficient transportation (i.e., rail or barge), or require increased fuel efficiency for trucking are encouraged.

Initiatives Requiring NEMA Action

- Adopt recognized industry standards as Kenya Standards for equipment used in the oil and gas exploration activities. The American Petroleum Institute (API) has developed and published extensive Standards and Recommended Practices specific to the oil and gas industry. ISO – International Standards Organisation, IEC – International Electrical Commission, NACE - National Association of Corrosion Engineers , IFC – International Financial Corporation, CENELEC - European Committee for Electrotechnical Standardization, ASTM - American Society for Testing and Materials have also developed de-facto standards widely used by the oil and gas industry that are accepted as international best practices.
- Develop incentives to reduce flaring of natural gas. Financial incentives to reduce flaring could include high permit costs for flaring or high penalties for excess flaring.
- Provide incentives to encourage the reinjection of natural gas or the use during on-site operations. Equipment that uses natural gas as a fuel typically burns cleaner than diesel-powered equipment, which will limit the levels of NOx, SOx, or other contaminants. Some well sites may be in remote locations where use of electrical power is limited. Some equipment, such as those used for monitoring or metering, could also be battery or solar-powered. By using zero or low emissions for these

routine tasks, any emissions generated on site could be limited to larger equipment or shorter-term activities where emissions reductions may be more difficult. The government should establish policies to promote these activities.

- Identify opportunities to expand training and local capacity on the oil and gas exploration activities and related environmental issues to relevant government agency personnel. Relevant agencies include but are not limited to NEMA, DOSHS, EPRA, and Ministry of Petroleum and Mining.
- Develop programs to provide training programs on environmental monitoring systems for government regulators, environmental data collection, and evaluation of data specific to oil and gas exploration and production. Organizations involved should be universities, government agencies, and environmental and stakeholder organizations.
- Develop a community relations program for the oil and gas industry. The program should require companies operating in the country to participate as well as the local county governments. NEMA officials should provide a mechanism for communities to report incidents or inquire about air pollution in the region.
- Develop a Leak Detection and Reduction (LDAR) program and require them at all new well sites and gathering systems. These provisions should be required as a part of the environmental management plan submitted as a part of the EIA licensing process and aim to limit fugitive emissions from equipment, tanks, or during loading and unloading activities. These programs should require appropriate training for employees. Regulations should not prescribe specific equipment to be used but should require prompt repairs (usually within 15 days). Records should be kept of all maintenance activities.
- Develop capabilities of NEMA inspectors to evaluate regular inspection and monitoring programs.

Initiatives Requiring Operator Actions

- Require operators to develop and gradually implement a Leak Detection and Reduction (LDAR) program for implementation. The program should include self-auditing programs, employee training, and recordkeeping.
- Regular maintenance programs should be developed as a part of the environmental management plans. Maintenance programs should be undertaken regularly to identify any issues promptly. All leaks should be repaired within 15 days of discovery.
- Operators should develop community relations programs to inform the local communities of their activities and operations.

Long term Initiatives (>5 years)

Initiatives aimed at reducing emissions from upstream petroleum operations in Kenya

- Develop a market for any associated or non-associated natural gas that is produced. Other uses for natural gas have been fertilizer, power generation, industrial fuel, or for domestic uses. The government may need to provide assistance to develop

pipelines to bring the gas to market, support the development of new industrial facilities to utilize the gas, or help develop local power generation or local use of the gas.

- Include requirements for the upstream oil and gas industry in any greenhouse gas monitoring or climate change monitoring regulations. Targets should be realistic and in line with international best practices. Requirements should not be so onerous as to deter potential investments in oil and gas exploration activity. Acknowledgement of the benefits associated with fossil fuels should be recognized.

Initiatives Requiring NEMA Actions

- Require Leak Detection and Reduction (LDAR) programs in the environmental management plan submitted during EIA. As Kenya has limited existing upstream oil and gas production, the implementation of an LDAR program should be easier than in more mature oil and gas jurisdictions where older and less efficient oil and gas production and infrastructure is already in place. Newer, more efficient valves, processes, and equipment should be required at new exploration and production facilities.
    a. Fugitive emissions from equipment, tanks, or during loading and unloading activities should be reduced. Regulations should not prescribe specific equipment to be used, but should establish a program to detect leaks quickly and requires them to be repaired promptly (usually within 15 days). For equipment that remains on-site, leaks will develop more as the equipment ages and regular maintenance is essential to detect and replace faulty equipment.
    b. Regular inspection and monitoring programs must be in place to properly identify leaks early with appropriate training for employees. Records should be kept of all maintenance.
    c. Develop monitoring program for volatile organic compounds at oil and gas well sites. Establishing a program to monitor and limit VOCs at well sites will help to limit the formation of ground level ozone.
- Establish a system to regularly evaluate and revise air emissions programs and requirements at oil and gas well sites. Monitoring programs should ensure that emissions levels follow existing Kenyan policy goals and follow global, regional, and national targets. Regular evaluations should occur every five years.
    a. Revisions should follow changes in international best practices and any revisions to guidelines, such as those released by WHO.
    b. Revisions should take into account air quality data gathered in Kenya and compared against established policies and targets.
- Develop a register for monitoring emissions to be reviewed and analyzed by the general public. Revision to the air quality regulations may be required, or NEMA can voluntarily provide this information. A feedback loop to the communities should be established to address their concerns and provide them with information on the air quality related to oil and gas operations in the vicinity of their communities. Under

current regulations. NEMA is only required to maintain a register of air emissions licenses which must be accessible by the public.

Annex 1 Emission reduction techniques for upstream oil and gas

The following table provides a summary of techniques aimed at reducing emissions in the upstream oil and gas industry[17].

These techniques shall be considered and implemented where relevant and practical by petroleum companies and their contractors to mitigate risks of air pollution in Kenya.

No	Emission Reduction Technique	Emissions reduced	Benefits:	Application	Limitations
Transportation					
1	**Traffic Reduction** - reducing trucking and service traffic can reduce associated dust and tailpipe emissions.	• NO from tailpipe emissions. • VOC, CO, and CO2 from tailpipe emissions. • PM10 and PM2.5 from road dust and construction activities.	• Reduces on-road emissions from exhaust. • Reduces entrained particulate matter as road dust. • Reduced road wear. • Improved safety.	• At least to some extent, to most projects. • During development when coordinated crews are working rotating shifts.	• Requires administrative authority otherwise will be limited as a voluntary program. • Limits to the minimum number of trips required for tasks including safety-related activities and essential maintenance.
2	**Directional Drilling of Multiple Wells Per Pad** - to drill multiple wells from a well pad, although directional drilling can also occur on a single-well pad	• NO from tailpipe emissions. • VOC, CO, and CO2 from tailpipe emissions • PM10 and PM2.5 from road dust and construction activities. • Future reduction of VOC due to consolidated production facilities by making the	• May decrease vehicle traffic; i.e., reduce road and pad construction related dust and emissions, • Reduces road network. • May reduce truck traffic dust and emissions during production. • Facilitates use of consolidated production	• In most development scenarios, though it is sometimes used in exploratory developments where access is limited due to terrain or minimal ground disturbance is desired	• NO, CO, and CO2 and other engine emissions from drill rigs are much larger per engine than those associated with vehicle traffic. Hence, increase in drill time from directional drilling may result in a short-term emissions increase, even if emissions from vehicle traffic

[17] Emission Reduction Techniques for Oil and Gas Activities https://www.fs.fed.us/air/documents/EmissionReduction-072011x.pdf

		capture of VOC and CH4 more economically viable.	facilities, making controls more efficient and cost-effective on VOC and NO emissions. • Less disturbance of wildlife		decrease in the long term. This may not work in exploration phase of development, because the field has not yet been delineated. • In some areas, the geologic structures are not suited to directional drilling. • Total air emissions might actually increase as a result of directional drilling due to the increase in true depth, i.e., greater distances drilled, greater drill times, and increased overall energy use. • Technical, down-hole limits on directional drilling remain in spite of tremendous advances.
3	**Centralized Water Storage and Delivery** - centrally stored water piped to the well pads and fracturing facilities through a	• NO from tailpipe emissions. • VOC, CO, and CO2 from tailpipe emissions. • PM10 and PM2.5 from road dust.	• Reduces number of truck trips for hauling water. • Decreases dust from road traffic. • Reduced tailpipe emissions.	• Can be used for developed and producing wells. • Can be applied to individual or consolidated facilities	• May not be feasible in some terrain. • May not be feasible if wells are too far apart. • Emissions occur during construction of

	temporary, plastic, surface line		• Less disturbance of wildlife		centralized facility. • May not be feasible if the collection point is too far away.
4	**Offsite Centralization of Production & Use of Liquids Gathering Systems** - collect and pipe produced fluids from remote well location to a centralized production and collection facility situated more closely to a major county or state highway	• NO from tailpipe emissions. • VOC, CO, and CO2 from tailpipe emissions. • PM10 and PM2.5 from road dust. • VOC from the absence of venting tanks at well pads.	• Creates fewer emission sources and consolidates control of emissions. • Reduces haul truck trips and decreases associated dust and tailpipe emissions. • Increased economic viability of capturing flash emissions and returning them to market rather than venting.	• In fields that produce significant quantities of natural gas liquids. • Where construction of pipelines is feasible and permissible.	• May not be feasible in some terrain conditions. • May not be feasible if wells are too far apart. • Concentrated emissions occur during construction of centralized facility. • Requires installation and maintenance of pipelines.
5	**Telemetry and Well Automation** - using telemetry, rather than daily visits by operators, to remotely monitor and control production.	• NO from tailpipe emissions. • VOC, CO, and CO2 from tailpipe emissions. • PM10 and PM2.5 from road dust.	• Reduces truck trips and engine emissions. • Decreases associated dust emissions. • Increased safety.	• At least to some extent, can be applied to most projects. • Subject to availability of licensed spectrum and bandwidth.	• May require application-specific development or adaptation. • Training required. • Specialized servicing.
6	**Dust Suppression with Water –** reduce fugitive dust from vehicle traffic by applying	• PM10 and PM2.5 from road dust.	• Emission reduction; can greatly reduce dust near roadway and, to some	• Unpaved and partially paved roadways. • At least to some extent, can be applied	• Most effective with low traffic. • Lasts only hours; requires frequent applications and maintenance.

	water to unpaved roadways.		extent, up to several • miles away from roadway. • May reduce road wear somewhat. • Improved safety for drivers. • Low initial cost.	to most projects.	Availability of water in arid areas. • Tailpipe emissions from vehicles making applications. • Requires administrative authority for implementation and enforcement.
7	**Dust-Suppressant Mixtures** - Reducing fugitive dust from vehicle traffic by applying dust suppressants	• PM10 and PM2.5 from road dust.	• Emission reduction; can greatly reduce dust near roadway and, to some extent, up to several miles away from roadway. Reduced road wear. • Improved safety for drivers. • Moderate initial cost. • Lasts up to a year. Good for low-traffic roads.	• Unpaved and partially paved roadways. • At least to some extent, to most projects.	• Higher cost than water. • Requires periodic re-treatment and maintenance. • Tailpipe emissions from vehicles making applications. • Possible migration of treatment materials. • Requires administrative authority for implementation and enforcement. Check with local authorities regarding the allowable use of specific dust suppressants.
8	**Road Sealing and Surfacing - r**educing fugitive dust from vehicle traffic by sealing or paving	• PM10 and PM2.5 from road dust.	• Emission **reduction**; can greatly improve air quality near roadway and, to some extent, up to	• Unpaved or partially paved roadways. • Where construction of permanent, paved roadways is	• High or very high initial cost; more cost-effective for roads with higher average daily traffic. • Possible increase in

	roadways using chip-seal, asphalt, or other road surfaces.		several miles away from roadway. • Significantly reduced road wear and erosion of roadbed. • Improved safety for drivers. • Effective on high-traffic roads. • Can withstand traffic for several years. • Provide community with better infrastructure	feasible and permissible.	multi-use traffic, with corresponding increases in tailpipe emissions. • Fragmentation of the landscape.
9	**Administrative Controls on Roadways** - Using reduced vehicle speeds to decrease fugitive dust.	• PM10 and PM2.5 from road dust. • Tailpipe emissions including NO, VOC, CO, and CO2 due to improved fuel economy.	• Emission reduction. • Reduced road wear. • Improved safety	• At least to some extent, can be applied to most projects. • Unpaved and partially paved roadways. • On roads with high traffic and high dust potential.	• Requires authority to post speed limits. • Requires effort to implement and enforce.
Air Resource Emission Reduction Techniques Drilling and Development Phase					
1	**Cleaner Diesel Power** - reducing engine emissions by moving toward cleaner diesel (or compression-ignition) engines	• NO, CO, PM10, and PM2.5. • Co2 • Hydrocarbons.	• Uses engines manufactured to meet standards. • Engines are to be available on a regulatory schedule.	• Generator sets where diesel-electric drilling is to be used. • Small and medium wellhead engines, if in use.	• Cost of purchasing newly manufactured engines meeting current emission standards. • Drillers operate under contract to applicants or field operators; any specification

				• May be considered for applications for permits to drill or records of decision; states typically do not regulate mobile-source drill rig engines.	of engine type must flow through a contract.
2	**Natural Gas Power** - reducing engine emissions by using engines and generator sets fueled with natural gas	• NO, CO, SO2, PM10, and PM2.5. • Hydrocarbons.	• Low emission characteristics. • Fuel may be available on-site, following suitable processing.	• In lieu of diesel-electric generator sets, as indicated by comparison of emission benefits and economics. • Compressor stations. • Small and medium wellhead engines, if in use.	• Requires selection of correct engines to meet power requirements. • Cost of capital equipment. • Drillers operate independently of applicants or field operators
3	**Well Completions – Flaring** - Flaring of natural gas in order to avoid venting and prevent safety hazards	• CH4, greenhouse gas emissions. • To some extent, VOC.	• Avoids extensive venting, which should be prohibited or limited by regulation. • May cheaply and directly eliminate safety hazards posed by natural gas under pressure • Limit lost resources.	• Where venting is impracticable (e.g., to prevent forceful venting of natural gas under emergency upset conditions) or prohibited (e.g., by state regulation). • Where permitted, to flare natural gas	• Emits NO, CO, and PM2.5. • CO2 (a less potent greenhouse gas than CH4). • Possibly emits volatile organic compounds that remain after incomplete combustion. • Wastes valuable natural gas resources. • Prohibited in some circumstances

				considered to be economically irrecoverable at condensate wells or oil wells (an increasingly atypical circumstance).	and jurisdictions.
4	**Reduced-Emission Well Completions** - Using "green completions" to recapture a significant portion of product that would have been vented or flared. This type of device separates gas, sand, and water18.	• CH4 and VOC (relative to venting). • NO, CO, and PM2.5 (relative to flaring).	• Reduces CH4 & VOC emissions. • Recovers product for sale. • Improved overall safety at the well site. • Recovers water for reuse.	• Where safety permits recovery of gas (e.g., green completions are not inherently suitable to catastrophic releases of pressure such as blowouts). • Where economics point toward using the technology. • Where a sales line or other gas line with sufficient capacity is available to receive produced gas. • Where natural gas liquids or, in some cases, crude oil accompany produced natural gas.	• Cost. • Requires adequate reservoir pressure. • Pressure of the gas must not exceed the rating of the sand trap or separator vessels. • Gas must meet pipeline specifications.
Air Resource Emission Reduction Techniques Production Phase					

[18] • High-pressure vessel separates sand from field gas. • Gas vessel separates gas from water used for hydrologic fracturing. • Gas is routed to sales line. • Sand dumps to drill pit manually. • Water dumps to media tanks automatically. • Water is filtered and reused for future fracturing jobs, https://www.fs.fed.us/air/documents/EmissionReduction-072011x.pdf

1	**Solar Power** - Using chemical pumps and well monitoring telemetry powered by solar panels.	• NO from tailpipe emissions. • VOC, CO, and CO2 from tailpipe emissions. • PM10 and PM2.5 from road dust.	• Reduces truck trips, engine emissions, and CH4 from gas pneumatic pumps. • Silent operation.	• At least to some extent, can be applied to most projects. • At unshaded well and battery locations.	• Cost of capital equipment. • Requires adequate number of panels to meet power requirements. • Batteries, other electric storage, or alternative power sources needed during darkness.
2	**Electric Power - u**sing electricity from the nation's power grid is typically cleaner than using onsite diesel or natural gas engines to power drill rigs, compressors, and pumping units.[19]	• NO from tailpipe emissions. • VOCs, CO, and CO2 from tailpipe emissions. • PM10 and PM2.5 from road dust.	• Standard rates available from utility. • Eliminates in-field emissions from engines replaced by electric motors. • Eliminates emissions from vehicles hauling product (e.g., condensate trucks). • Reduces CH4 from gas pneumatic pumps. • May reduce overall traffic for maintenance-related trips. • Silent operation.	• Wherever grid power is available.	• Proximity to the grid. • Increased load on grid with increased emissions at electric generating units. • Power loss in transmission (line loss) proportional to the square of the current. • Permitting requirements for new service.
3	**Enclosed tanks** storing to reduce fugitive	• CH4, VOC, hazardous air pollutants	• Containment and control of product.	• Projects involving storage of	• Construction, including access road.

[19] However, overhead power lines may have wildlife or visual impacts

	VOC emissions.		• Improved safety and wildlife protection.	liquid hydrocarbons.	• Cost of tank, fittings, and installation. • Operation and maintenance costs.
4	**Vapor Recovery Units** - reduces vented emissions of VOC and recovers valuable hydrocarbon vapors for sale or use on site[20].	• CH4, VOC, hazardous air pollutants	• Recovery of product otherwise lost. • Potential improvements in fire safety.	• Projects involving storage of liquid hydrocarbons. • On storage tanks, where pressures of hydrocarbons are at or near atmospheric pressure. • Where oxygen can be excluded or explosive mixtures otherwise avoided.	• Cost-effectiveness varies with volume of hydrocarbons that can be recovered. • Must be correctly engineered for safe operation.
5	**Hatches, Seals, and Valves** use and maintenance to minimize VOC emissions.[21]	• CH4, VOC, hazardous air pollutants	• Well-established technology. • Moderate cost.	• Projects involving storage of liquid hydrocarbons. On storage tanks, where pressures of hydrocarbons are at or near atmospheric pressure. • Where oxygen can be excluded or explosive mixtures	• Must be selected appropriately for application. • Will release hydrocarbon vapors at designed pressure and temperature.

[20] Vapor recovery can readily capture 95 percent of the vapors that would be emitted from tanks if left uncontrolled, and capture efficiencies of virtually 100 percent are possible.

[21] In order to minimize emissions and in addition to selecting appropriate hatches, seals, and valves relative to tank design, it is important to establish optimum pressure settings for this equipment.

				otherwise avoided.	
6	**Controls for Compressor Engines** - improve emission controls on new or existing engines using a combination of techniques.[22]	• NO, SO2, CO, and CO2. • Some PM2.5.	• Moderate cost, depending upon application and options selected.	• Projects involving natural gas compression • Include control package as an option on new engines. • Retrofit on existing engines. • May be subject to regulatory approval by county or NEMA	• Availability by engine type and year of manufacture. • May require testing to confirm target emission rate is achieved.
7	**Selective Catalytic Reduction** works by injecting diesel exhaust fluid (DEF, a mixture of water and urea) into the exhaust	• NO • PM2.5 and hydrocarbons (if diesel particulate filter is included).	• Proven capability to reduce emissions. • Feasibility of retrofitting.	• Exhaust streams (on large engines, particularly where loads are steady or predictable). • Where NO emissions are of concern.	• Cost. • Availability by for specific application. • May require testing to confirm target emission rate is achieved. • May be subject to regulatory approval by state.
8	**Dry Seals in Centrifugal Compressors** that emit less methane and have lower power requirements	• CH4 • VOC	• Feasibility of retrofitting.	• Natural gas compression where centrifugal compressors are in use.	• Relatively specialized applications
9	**Packing Seals for**	• CH4 • VOC	• Feasibility of retrofitting.	• Natural gas compression	• Additional operational

[22] Techniques such as: closed loop engine control, selective catalytic reduction (covered as a stand-alone technique in section 3.7), system-installed power supply (solar powered, battery powered), ultra-low sulfur diesel, diesel particulate filter, after burner, and/or other new technologies.

	Compressor Rods23		• Proven capability to reduce emissions.	where reciprocating-rod compressors are in use	burden due to more frequent maintenance. • Cost.
10	**Reduced-Emission Pneumatic Systems**	• CH4. • VOC	• Feasibility and ease of retrofitting with fairly quick cost recovery. • Product recovery. • Proven capability to reduce emissions.	• Fields using natural gas in pneumatic controls. • Where conversion to air-actuated or electric controls is economically infeasible.	• Accessibility of components. • Continues to use natural gas.
11	**Plunger Lift Systems and Automated Systems in Gas Wells**	• CH4 • VOC	• Greater recovery of product. • Operation and maintenance may be simplified. • Potentially improved safety.	• Typically in mature gas wells. • Where down-well accumulation of liquids tends to compel blowdown to restore flow of natural gas.	• Cost-effectiveness. • Relatively specialized application
Monitoring and Maintenance					
1	Directed Inspection and Maintenance and Infrared Leak Detection (DI&M)[24]	• CH4 • VOC	• Detects emissions by remote sensing. • Ease of use following minimal training.	• Most projects involving hydrocarbon production and treatment. • In order to detect leaking process components, including valves,	• No direct quantification of emission rates. • Most effective when used in a structured program requiring oversight and management.

[23] The packing seals of reciprocating-rod compressors leak some gas by design. Emissions from rod packing can be reduced by the economic replacement of rod packing at frequent intervals as: newly installed packing may leak 60 cubic feet per hour. Worn packing has been reported to leak up to 900 cubic feet per hour.

[24] Fugitive gas leaks can be reduced by implementing a DI&M Program which identifies and cost effectively fixes fugitive gas leaks using: Leak Detection, Infrared Camera, Organic Vapor Analyzer, Soap Solution, Ultrasonic Leak Detectors, Measurement, Calibrated Bagging, Rotameters, High Volume Sampler

				flanges, and connections. • Sealing mechanisms, such as on reciprocating rods and pump seals. • Hatches and seals on tanks	• Cost of purchase and repair of instrumentation.
	Air Quality Monitoring[25]	• Indirectly, emissions of any pollutant of concern which can be monitored.	• Gives knowledge of concentrations and trends in the ambient air. • Produces information that can be shared with the public. • Supports air dispersion modeling efforts.	• Large projects or project areas where adequate funding can be arranged. • At a location that is representative under the monitoring objective(s). • Where land access, possibly long-term, can be gained. • Where electric power is available, unless passive sampling or monitoring using low-power equipment can suffice. • In the "ambient air," as defined for regulatory purposes, if required.	• Cost. • Time required in order to collect and report data. • Difficulty of meeting expectations of data users. • Does not directly control or reduce emissions.

[25] Monitoring current and modeling future air quality conditions. Designing emission control strategies. Reviewing monitoringg data and adapting to findings: aadjusting development rates, timing, and places of development; refining mitigation measures

Annex 2 Implementation Matrix

No	Strategic /Activity	Measurement of Achievement	Responsibility	Priority Timeline
Balance environmental protection priorities with priorities of development of upstream petroleum sector				
1	Execute baseline assessments of air quality in regions with oil and gas potential prior to commencement of any petroleum operations	Air quality baseline assessment	NEMA, regional governments	within 3 years
2	Develop energy efficiency programs that will require use of best energy efficiency equipment in petroleum sector	Developed and implemented energy efficiency programs for upstream petroleum sector	MoPM, EPRC	within 3 years
3	Promote pipelines over the use of truck or rail transport to reduce emissions from transport. Encourage reduction of traffic congestion and pollution in the region.	Incentives for pipeline development	MoPM, EPRC	3 - 5 years
4	Require operators to develop and implement community relations programs	Approved community relations programs	NEMA	3 - 5 years
5	Develop a register for monitoring emissions to be reviewed and analyzed by the general public.	Register for monitoring emissions	NEMA	>5 years
Address gaps in Kenya legislation and regulations to be applicable to upstream petroleum operations				
1	Revise EMCA (Air Quality) Regulations to address gaps summarized in S.3.2 of the Strategy.	Revised EMCA (Air Quality) Regulations	NEMA, EPRC	within 3 years
2	Finalize and adopt draft EMCA (Strategic Assessment, Integrated Environmental	Adopted EMCA (Strategic Assessment,	NEMA, EPRC	within 3 years

	Impact Assessment and Audit) Regulations. The EIA forms the basis of the environmental plan and air quality monitoring at facilities.	Integrated Environmental Impact Assessment and Audit) Regulations Established process for air quality monitoring of petroleum operations		
3	Ongoing training aimed at addressing capability gap of NEMA, other Kenyan regulators, inspectors	Trained NEMA officials, inspectors, policymakers and other parties engaged in the process on appropriate measures for EIAs, audits, and potential legislation.	NEMA, EPRC, DOSHS, MoPM	within 3 years
4	Revise other EMCA related regulations to address specific issues related to upstream petroleum operations	Revised EMCA Regulations	NEMA, EPRC	3 - 5 years
5	Develop and/or revise guidelines developed for petroleum sector to support compliance with newly adopted environmental requirements for petroleum sector related to air emissions	Developed/revised guidelines to be used by petroleum sector	NEMA	3 - 5 years
6	Identify opportunities to expand training on the upstream oil and gas exploration activities and related environmental issues for local community	Programs for community training	NEMA	3 - 5 years
Reduction of greenhouse gas and other emissions				

1	Develop technical/environmental regulations to regulate and to limit flaring	Developed and adopted Flaring regulations	NEMA, EPRC, MoPM	within 3 years
2	Establish a plan to encourage development of a natural gas market (for both associated and non-associated gas).	Plan for natural gas development	MoPM, EPRC	within 3 years
3	Develop a market for any associated or non-associated natural gas that is produced.	Natural gas market	MoPM	>5 years
4	Include requirements for the upstream oil and gas industry in any greenhouse gas monitoring or climate change monitoring regulations	Regulations adopted under Climate Change Act with requirements applicable to upstream petroleum sector	MoPM, NEMA	>5 years
Requiring use of best available technologies not entailing excessive costs (BATNEEC) by petroleum sector players				
1	Adopt and require use of recognized industry standards as Kenya Standards for equipment used in the oil and gas exploration activities.	Adopted international and de-facto international standards applicable for petroleum sector	NEMA, EPRC, MoPM	3 - 5 years
2	Develop a Leak Detection and Reduction (LDAR) program and require them at all new well sites and gathering systems. These provisions should be required as a part of the environmental management plan submitted as a part of the EIA licensing process	Enforced LDAR for petroleum sector	NEMA, EPRC, MoPM	3 - 5 years
3	Establish a system to regularly evaluate and revise air emissions programs and requirements at oil and gas well sites.	System for revision of air emission programs	NEMA	>5 years

Development of fiscal and other incentives aimed at emission reduction				
1	Develop incentives to reduce flaring of natural gas.	Incentives reducing flaring	NEMA, EPRC, MoPM, Ministry of Finance	3 - 5 years
2	Provide incentives to encourage the reinjection of natural gas or the use during on-site operations	Incentives for natural gas reinjection	MoPM, EPRC, Ministry of Finance	3 - 5 years
3	Develop incentives for energy efficiency	Incentives for energy efficiency	NEMA, EPRC, MoPM, Ministry of Finance	>5 years

Revision Matrix:

Revision	Date	Purpose	Prepared by	Reviewed/Approved
Draft	19/02/2019	Issued for review	IHS Markit/ESAL	NEMA
Final Draft	05/04/2019	Issued for approval	IHS Markit/ESAL	NEMA
Revised Final Draft	16/01/2020	Aligned with approved review report	IHS Markit/ESAL	NEMA
Final revised draft	06/03/2020	Additional client's comments addressed	IHS Markit/ESAL	NEMA