Amu Power Company Ltd.

Coal Fired Power Plant, Lamu County, Kenya

Climate Change and GHG Specialist Study

29 October 2015

DECLARATION OF THE CONSULTANTS INDEPENDENCE

The author of this report Kevin Tarr-Graham, does hereby declare that he is an independent consultant and has no business, financial, personal or other interest in the activity, application or appeal in respect of which he was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of the specialist performing such work. All opinions expressed in this report are his own.

Kevin Tarr-Graham
July 16

LIST OF ACRONYMS

AfDB	African Development Bank
APCL	Amu Power Company
CDM	Clean Development Mechanism
CER	Certified Emissions Reductions
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CRA	Climate Risk Assessment
CSAG	Climate System Analysis Group
DJF	December January February
ESIA	Environmental and Social Impact Assessment
FEED	Front End Engineering and Design
GCM	Global Circulation Model
GDP	Gross Domestic Product
GHG	Greenhouse Gases, unless indicated otherwise, GHG emissions are made up of CO2, CH4, N2O, HFCs, PFCs and SF6
GWP	Global Warming Potential
H&S	Health and Safety
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
ISO	International Standards Organisation
JJA	June July August
LDO	Light Diesel Oil
MAE	Mean Annual Evaporation
MAM	March April May
N_2O	Nitrous Oxide
PFC	Perflourocarbon
PPP	Public Private Partnership
PS	Performance Standard
SWRO	Seawater Reverse Osmosis
SF_6	Sulphur Hexaflouride
SON	September October November
WFGD	Wet Flue Gas Desulfurization
WBCSD	World Business Council on Sustainable Development
WRI	World Resources Institute

LIST OF UNITS

°C	Degrees Celsius
f/s	Foot per second
Kg	Kilogram
Km^2	Square kilometers
Km/h	Kilometers per hour
kWh	Kilowatt hour
L	Liters
mm	Millimeters
m/s	Meters per second
MW	Mega Watt
MWh	Mega Watt hour
GW	Giga Watt
GWh	Giga Watt hour
t	Tonne (1000 kilograms)
tCO_2e	Tonnes Carbon Dioxide equivalent

Flow rates:	Gas	m^3_n/h
Temperature:	°C	
Power:	MW	
Weight:	kg, tonne	
Volume:	Gas	m^3 (actual)
Area:	km^2	
	m^3/ha	
	M^3	

LIST OF DEFINITIONS

- **El Niño Southern Oscillation (ENSO) -** is an irregularly periodical climate change caused by variations in sea surface temperatures over the tropical eastern Pacific Ocean, affecting much of the tropics and subtropics. The warming phase is known as El Niño and the cooling phase as La Niña.
- **Monsoon** - is a seasonal change in winds resulting from large temperature differences between land and sea. This causes a dry, land-to-sea airflow in winter to reverse to a wet, ocean-to-land wind regime in summer.
- **Hurricanes, typhoons** and **cyclones** are regionally specific names for tropical cyclones. - hurricanes in the Atlantic, eastern and southwest Pacific and Caribbean; typhoons in the northwest Pacific; and cyclones in the Indian Ocean.

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INTRODUCTION

As part of the Environmental and Social Impact Assessment (ESIA) for the proposed 1050MW Coal Fired Power Plant in Lamu County, Kenya, Kevin Tarr-Graham conducted a Climate Change Specialist Study comprising of two distinct parts:

- A climate risk assessment (CRA); and
- A greenhouse gas (GHG) assessment.

A detailed description of the project is available in Project need, alternatives and description section of the ESIA report for the 1050MW Coal Fired Power Plant in Lamu County. The assessments have been performed in-line with the requirments and guidelines of the IFC and GHG Protocols. The IFC standards are a best practise approach to new project investment approach to project responsibilities for managing environmental and social risks.

1.1 CONTEXT

Climate change, and the associated political and social response, is already presenting material risks and opportunities to business and industrial sectors. These risks and opportunities have grown in prominence over the last decade and are expected to increase significantly in scale and coverage in the next decade. Appendix A provides more detail about climate change challenges at a global scale.

Governments are proposing and implementing legislation to mitigate greenhouse gas emissions such as carbon taxes, emission limits, air quality etc., and the cost of business interruption following extreme weather events is increasing the need for implementation of adaptation measures.

In this context, forward thinking business and governments are beginning to identify their exposure to climate change issues, understand the financial implications and develop mitigation strategies and adaptation response plans in order to 'climate ready ' their operations going forward. The physical impacts of climate change are accelerating and pose a threat to business operations and financial earnings through extreme weather events such as storms and droughts. The effect of these changes could result in business interruption through damage to physical assets and disruption to supply chain and distribution networks.

In recognition of this, the IFC Performance Standards (2012) applies to all investment and advisory clients whose projects go through IFC's initial credit review process after January 1, 2012, explicitly require assessment of climate change risk and an understanding of greenhouse gas (GHG) emissions and energy use:

- **IFC Performance Standard 1**(Assessment and Management of Environmental and Social Risks and Impacts): The risks and impacts identification process will consider the emissions of greenhouse gases, the relevant risks associated with a changing climate and the adaptation opportunities, and potential transboundary effects, such as pollution of air, or use or pollution of international waterways.

- **IFC Performance Standard 3** (resource Efficiency and Pollution Prevention) requires:
  - measures for improving efficiency in consumption of energy, water, as well as other resources and material inputs;
  - options to reduce project-related GHG emissions during the design and operation of the project; and
  - for projects > 25,000 tonnes of carbon dioxide equivalent (tCO_2e)/year quantification of direct greenhouse gas emissions within the physical project boundary and indirect emissions associated with off-site production of energy (i.e. purchased electricity)

- **IFC Performance Standard 4** (Community Health, Safety and Security): calls for projects to take into account the fact the communities are already subjected to climate change and may also experience an acceleration and/or intensification of impacts from project activities since climate change impacts may exacerbate their vulnerability. As such, projects are encouraged to identify and mitigate risks and potential impacts on priority ecosystems services that may be exacerbated by climate change.

Understanding the nature of these risks will allow new facilities to be designed in a manner which increases resilience and takes advantage of opportunities from the outset thereby reducing costs going forward. In addition, designing a facility with a view to having the lowest possible carbon footprint will reduce exposure to potential national and international regulatory risks in the future.

1.1.1 Assessment Aims and Benefits in the ESIA context

The Climate Risk Assessment (CRA) and Greenhouse Gas (GHG) assessment for the 1050MW Coal Fired Power Plant, Lamu County are separate but complementary to the Environmental and Social Impact Assessment (ESIA) conducted by Kurrent Technologies Ltd. Whilst the ESIA aims to identify and mitigate the impacts of a proposed project on the environment, the CRA looks at the impacts of the environment (and environmental changes) on the project. There are a number of key drivers for conducting a CRA and GHG assessment alongside an ESIA for a new development, and they are summarised below,

- Climate change impacts (as identified through the CRA) may have implications on the environmental performance of the project; for example, if changes in extreme weather events result in damage to facilities that lead to environmental impacts (e.g. from leaks or damage to equipment and storage facilities).
- Integrating CRA into ESIA's can help to improve the climate resilience of projects and can help to avoid the maladaptation of projects to climate change. Projects failing to consider climate change risks at the planning stages could face severe financial, safety and operational impacts in the future if climate change impacts bring about the damage or disruption to operations, assets, infrastructure and energy supply.

- Projects conducting a CRA and GHG assessment as part of the ESIA process are likely to be identified by stakeholders as being forward looking and responsible, bringing about reputational benefits.

1.1.2 Objectives

This Climate Change Specialist Study has the following objectives:

- Undertake a high level assessment of the physical risks facing the development, such as high temperatures, floods, strong winds, monsoons etc, and identify adaptation measures that could reduce the risk or take advantage of opportunities; and
- Estimate the operational carbon footprint of the proposed 1050MW Coal Fired Power Plant, Lamu County, identify high level opportunities for minimising the carbon footprint, and understand exposure to applicable regulation.

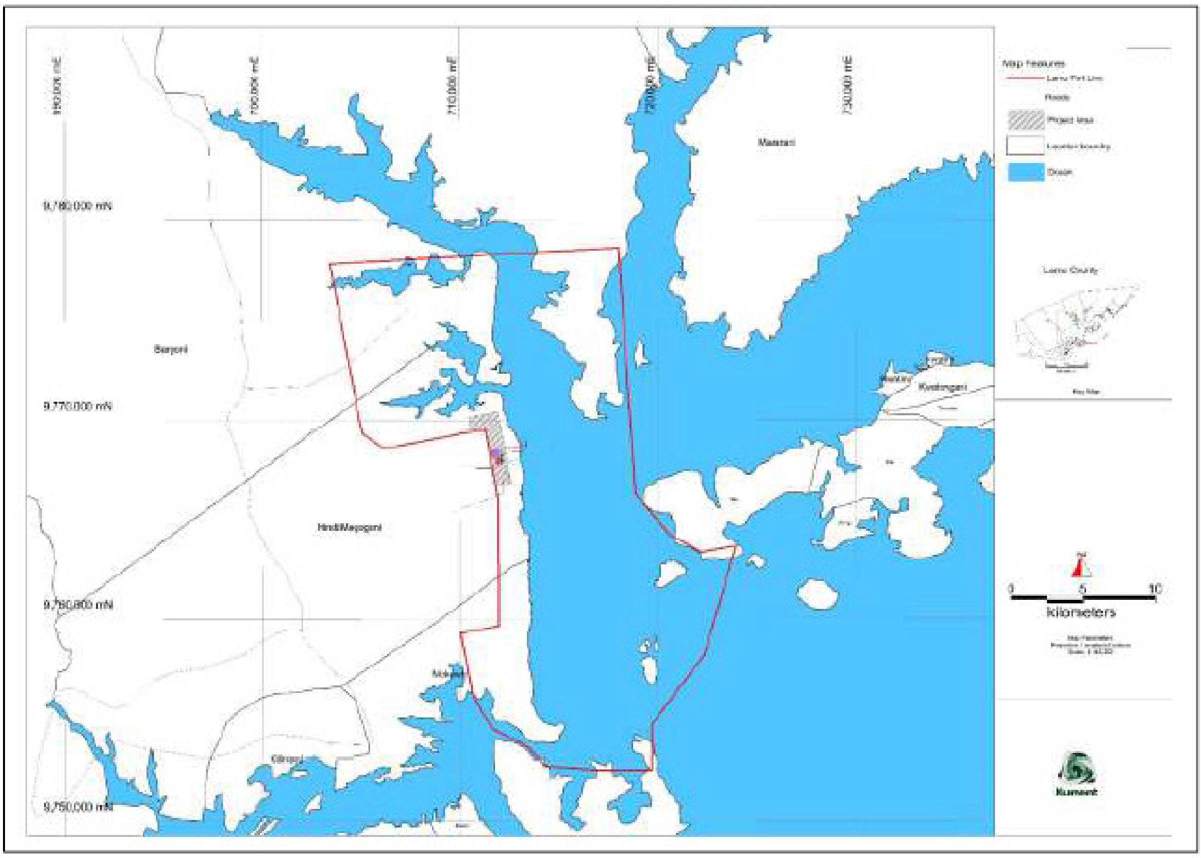
1.1.3 Project Description

Project Location

The Lamu Coal Power Station is a proposed 1050 megawatt coal-fired thermal power station in Kenya, the largest economy in the East African Community, which would be developed on about 880 acres of land and feature a 210 meter tall smoke stack, which would become East Africa's tallest structure.

The power station would be located on about 880 acres of land at Manda Bay, Lamu County, on Kenya's coast, approximately 250 kilometres (160 mi), by air, northeast of Mombasa. The driving distance would be approximately 300 kilometres (190 mi).

Figure 1.1 Project Location



Project Components

- Safety;
- Air Quality Controls;
- Water Discharge controls;
- Power Station Infrastructure and Faculties;
- Transport Network;
- Community Support;
- Energy/Power Supply;
- Water Capture, Recycling, Treatment and Disposal;
- Health; and
- Coal and Ash Storage Facilitates.

1.1.4 Report Structure

The remainder of the report is structured as follows:

Section 2 Climate Change Risk Assessment (CRA)

- Provide a short overview of the aims of the CRA;
- Introduces the rationale behind conducting a CRA;
- Describe the methodology adopted for the CRA;

- Sets out step 1 of the CRA process, namely the scope for the assessment;
- Introduces step 2 of the CRA process starting with the climate baseline based on the analysis of historic weather data. Thereafter, the climate change projections for the project area and the climate scenarios are discussed;
- Defines the climate change-related risks to the project as identification on the baseline on the baseline and climate change scenarios;
- Assess the impact that the identified climate change related risk will likely have on the project; and
- Describes possible mitigation measures to reduce the likelihood of the impacts or avoid the impact altogether.

Section 3 Greenhouse Gas Assessment

- Outlines the approach to undertaking this study and provide details of the methodology used to estimate the carbon footprint and assess the impacts;
- Describes the aspects of the project considered to be within the scope of this study with particular reference to the definition of the boundary within which the carbon footprint is to be estimated;
- Describes the affected environment in relation to current greenhouse gas emissions in Kenya and the project emissions;
- Describes the estimated carbon footprint for the 1050MW Coal Fired Power Plant facilities in Lamu County and estimated regulator costs if applicable;
- Identify applicable policies, legislations, standards and guidelines which may affect the Lamu Coal Fired Power Plant's operation in Lamu County in Kenya with regards to climate change and greenhouse gases;
- Assess the impact of the increase in GHG emissions from the Lamu Coal Fired Power Plant facilities on the National GHG emissions, and provides a comparison with emissions from similar facilities globally if available;
- Provide recommendations on management of GHG emissions and alternative design and/or operational activities which could lead to a reduced footprint; and
- Provides recommendations on monitoring of GHG emissions in the future.

2 CLIMATE RISK ASSESSMENT

2.1 OVERVIEW

This section presents the findings of the climate risk assessment (CRA) and review of adaptation (impact mitigation) options for the Lamu County 1050MW Coal Fired Power Plant.

The objectives of the CRA are to:

- Identify the principle climate-related risks to the Lamu Coal Fired Power Plant across the timescale of the project;
- Prioritise the principal climate related risks; and
- Identify potential mitigation measures that could reduce risk or take advantage of opportunities (i.e. climate change adaptation[1])

It should be noted that the development of this report was conducted post completion of the project ESIA and is independent of all other specialist studies, as such, the results of those studies should be read with the understanding of how the climate is likely to change in the future.

2.2 RATIONALE FOR THIS ASSESSMENT

Human-induced climate change is one of the most complex and serious challenges confronting the world today. Amongst other things, the burning of fossil fuels to generate energy, the release of carbon from soil into the atmosphere when land is ploughed, the mining of calcium carbonate for cement production, the release of methane from farm animals and landfills, the emissions of industrial gases, and the deforestation of forested areas that sequestrate atmospheric carbon dioxide (CO_2) all increase the retention of solar radiation within the atmosphere, raise the temperature and destabilises the global climate system (Figure 2.1)

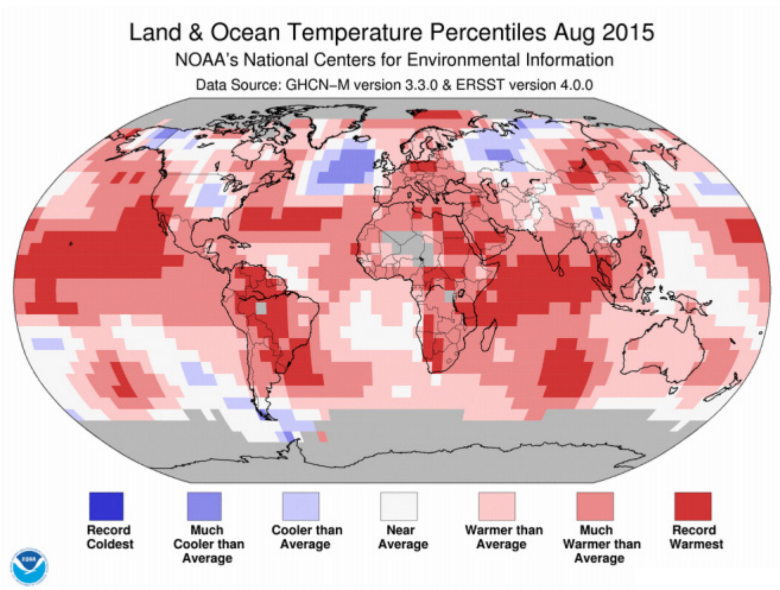
Climate change has already begun to affect physical and biological systems, including people. On average, the world is currently 1°C[(2)] warmer on land [Figure 2.2], 0.55°C warmer in oceans [Figure 2.3] and 0.67°C Land and Ocean as at the end of August 2015 [Figure 2.3]. A record warm June, July, and August (2015) resulted in the highest global land and ocean average temperature for June–August at 0.85°C above the 20th century average, surpassing the previous record set in 2014 by 0.11°C.

[1] Climate change adaptation in the context of capital project development can be thought of as activities to avoid, minimise or mitigate the business risks arising from extreme weather events and/or gradual changes in climate. Adaptation measures include altering physical design of the mine site or infrastructure, implementation business procedures, and altering operating patterns.

[2] http://www.ncdc.noaa.gov/cag/time-series/global National Centre for Environmental Information

'Without further commitments and action to reduce greenhouse gas emissions, the world is likely to warm by more than 3°C above the preindustrial climate. Even with the current mitigation commitments and pledges fully implemented, there is roughly a 20 percent likelihood of exceeding the 4°C by 2100. If they are not met, a warming of 4°C could occur as early as the 2060's. A 4°C world would be one of unprecedented heat waves, severe drought, and major floods in many regions, with serious impacts on ecosystems and associated services'. "Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850." IPCC

Figure 2.1 Land and ocean Temperature Percentiles



The global temperature record dates to 1880 (136 years)

Figure 2.2 Global Land Temperature Anomalies

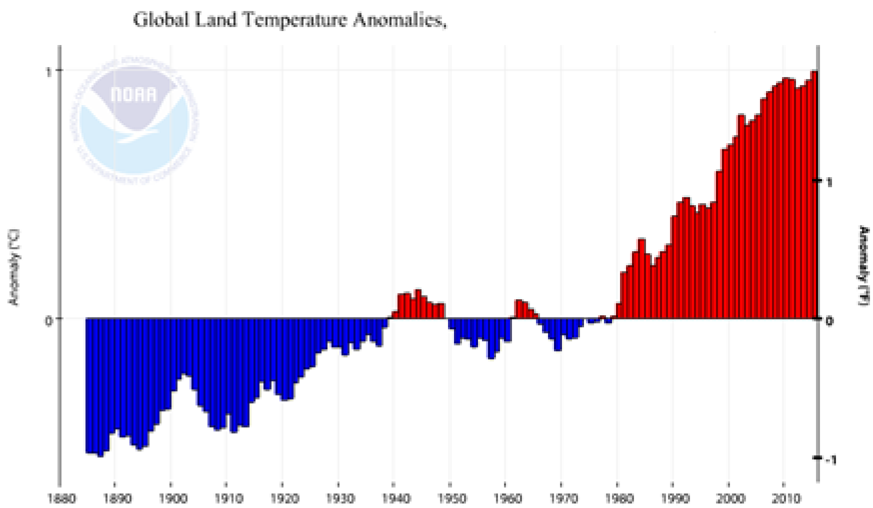


Figure 2.3 Global Ocean Temperature Anomalies

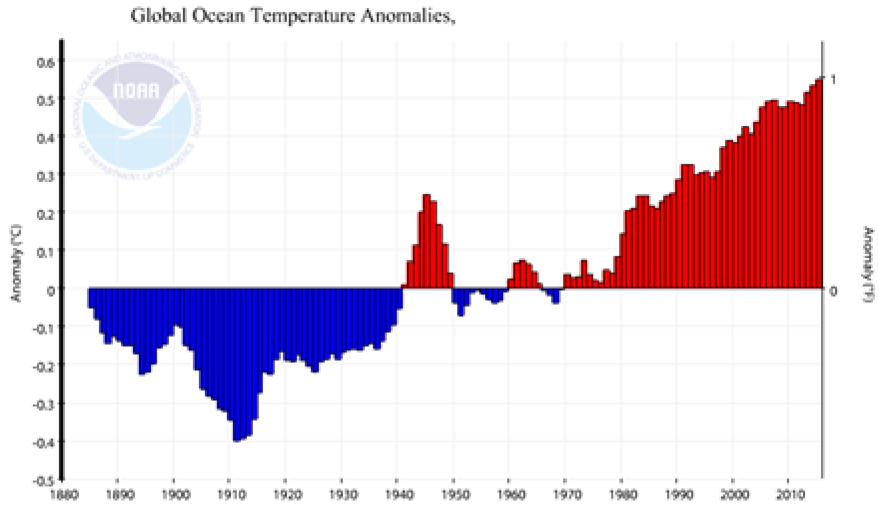
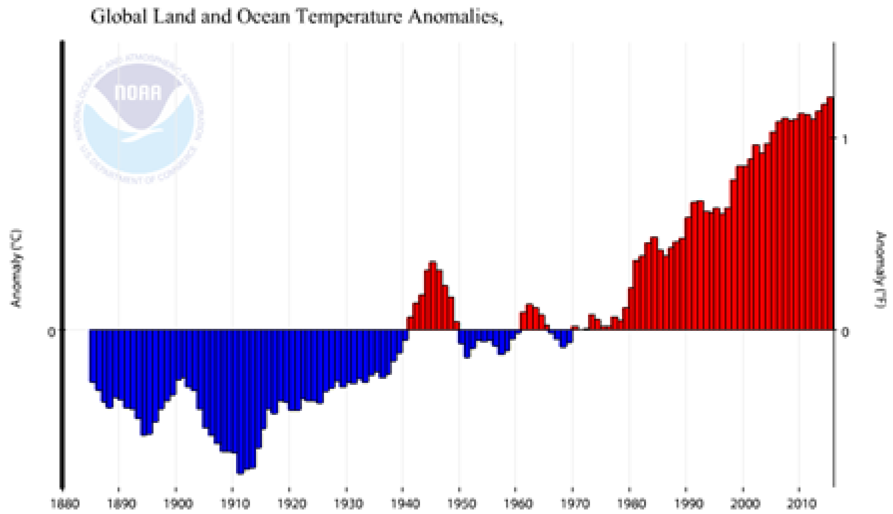
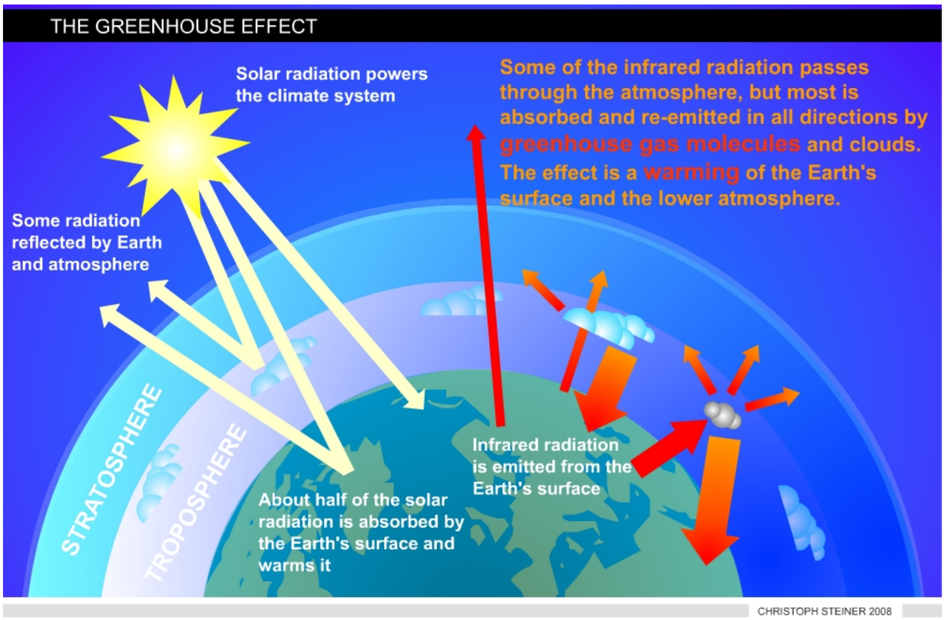


Figure 2.4 *Global Land and Ocaen Temperature Anaomalies*



The term '*climate*' is used to describe the weather conditions that characteristically prevails in a particular region i.e. the average weather conditions in a region over a long period of time (~30 years). On a short term or day-to-day basis, we experience *'weather'*, which is characteristic of the climate at a given point in time (usually hours or days) in terms of variables such as temperature, humidity, precipitation, cloudiness, wind and atmospheric pressure. At times, weather can impact human activities, often through a *'weather event'* such as a storm, heatwave, heavy precipitation, wind gusts etc., in which we experience the climate variable within a relatively concentrated or intense period of time. *'Extreme'* weather events are unusual, severe or unseasonal weather events occurring at the extremes of what has been seen historically. In this document, we discuss identifying, assessing, evaluating and managing the risks associated with both weather events and more gradual long term changes in climate. (*Climate change*), collectively known as *climate risk*.

Figure 2.5 The Greenhouse Effect (redrawn from www.ipcc.ch)



Business Risk from Extreme Weather and Climate Change

It is critical that Amu Power Company Ltd manages business risks arising from extreme weather events and climate variability (i.e. climate risk) to minimise disruption to operations including (but not limited to) supply chains, water suppliers, transport networks, and energy supplies.

No matter what we did, further warming and impacts are inevitable. Preparing realistically for what is ahead, reducing risks and building resilience in a way that meets the needs of the most vulnerable will be crucial.

2.3 METHODOLOGY

The CRA was conducted by reviewing historic data on climate and weather events in the project region and surrounding towns, and overlaying the findings with peer-reviewed scientific projections of climate change in order to assess and identify future climate risk and opportunities for the project. Key interactions between project components and climate risk sources were subsequently analysed and prioritised.

The CRA followed the five-step process as discussed below and as outlined in *Figure 2.6.*

Figure 2.6 The Five-step CRA Process

Step 1	*-*	*Project Scoping*
		• *scope geographical location, temporal timescales and project assets* • *prioritise scope*
Step 2	*-*	*Climate Baseline and Scenarios*

		• *assess historic weather data* • *investigate future climate projections for project location*
Step 3	***-***	***Define Climate-related Risks***
		• *overlay risks onto project* • *identify key interactions*
Step 4	***-***	***Risk Scoring***
		• *assess current and future risk using risk framework* • *utilising ESIA impact assessment matrix*
Step 5	***-***	***Risk Mitigation***
		• *identify appropriate risk mitigation measures*

Step 1: Project Scoping

This step involved an assessment of the location of the 1050MW Coal Fired Power Plant, Lamu County, the project's assets and temporal scale (i.e. timelines and project components). The relevant climate variables to be assessed during the CRA should have been determined during the Project Scoping exercise, but this did not happen, so a theoretical determination of the variables was performed. As this report is post the completion of the ESIA report only a desktop exercise was possible. During this step, the likely interactions between the project and the climate were identified in order to focus the risk assessment.

Step 2: Climate Baseline and Scenarios

The weather conditions of the project's location (i.e. the climate baseline) were determined following the analysis of historic weather data. Thereafter, peer-reviewed climate change projections were sourced for the region in order to determine the likely future climate scenarios over the project lifetime.

Step 3: Define Climate-related Risks

Based on the findings of Step 2, the key climate-related risks to specific project components or activities were identified during Step 3.

Step 4: Risk Scoring

The significance of each climate-related impact on the project was assessed using a customised version of an ESIA impact assessment methodology. The methodology is discussed further below.

Step 5: Risk Mitigation

Based on the risks identified and prioritised, appropriate adaptation measures to mitigate the impacts and risk were identified during Step 5

2.4 STEP 1 CRA SCOPE

The Amu Power Company Ltd scoping report and ESIA report was used to inform the CRA scoping exercise. Project location and component details are discussed below.

The CRA focused on the following project components and identified the specific risks to these:

- Safety;
- Air Quality Controls;
- Water Discharge controls;
- Power Station Infrastructure and Faculties;
- Transport Network;
- Community Support;
- Energy/Power Supply;
- Water Capture, Recycling, Treatment and Disposal;
- Health; and
- Coal and Ash Storage Facilitates

These components were selected for the CRA based on experience with climate impacts in the power station sector as well the duration of time these components would be present/'active' on site during the project lifetime.

Project Termporal Scale

The project lifetime comprises the following phases:

- Planning and design;
- Construction (~3 ½ years) ;
- Operational (to span approximately ~25 years (PPA) to 2040); and
- Decommissioning phase. (Out of scope)

It is envisaged that the first unit will be commissioned in 36 months from the construction commencement date (estimated early 2016), followed by the second unit in 39 months and the third unit in 42 months from the construction start date respectively.

Climate Variables to be considered

The following climate-related variable and weather events were investigated as part of the CRA:

- Air temperature;
- Precipitation levels;

- Wind speed;
- Relative Humidity;
- Evaporation;
- Storms;
- Heavy rainfall;
- Flooding; and
- Drought.

Given the location of the project site, preliminary research results and data availability, this study focuses on those variables with potential to adversely impact project activities (e.g. the coast means there is a real risk from sea level rise, cyclones and storm surges and the topography means the landside risk is low (~6 -12m).

A key consideration when conducting the scoping exercise was the timescales of the project activities. This is because climate change risks and opportunities are likely to increase in magnitude and frequency with time, meaning that activities with long timescales should be focused on. Project activities with shorter timescales, including planning and design, were deemed to be lower priority than project activities with longer timescales, namely Operations (spanning over ~25 years (PPA) to 2040).

2.5 STEP 2: CRA DEVELOP CLIMATE BASELINE AND SCENARIOS

2.5.1 *Introduction*

In order to understand future climate change were measured. The climate risk in the area of the Lamu Coal Fired Power Plant and the existing climate was assessed to create a baseline against which future climate change were measured. This then fed into the risk assessment in Step 3.

2.5.2 *Methodology*

The climate baseline reflects recent climate in a region. In order to construct a climate baseline for a region, the following examples of historic data on climate variable and extreme weather events weather events were consulted from a number of sources.

- Precipitation information was sourced from the ESIA report data source for Lamu.
- Precipitation and evaporation data for the catchment area around the project site were sourced from ESIA and Internet.
- Baseline weather data (including precipitation, wind speed and temperature were source the ESIA report data from the Lamu County.
- Information on reporting weather events/incidences for Kenya and surrounding coast areas near the Lamu Coal Fired Power Plant

The climate scenarios were generated using peer-reviewed scientific research on the impacts of climate change, including Kenya's Risk and Vulnerability Atlas, Intergovernmental Panel on Climate Change (IPCC) Assessment Report, as well as the IPCC's data portal and other studies. As far as possible, projections were sourced from the period during which the plant will be active.

2.5.3 *Climate Baseline*

Temperature

Since 1960, Kenya's mean annual temperature has increased by 1.0°C, at an average rate of 0.21°C per decade. The rate of increase has been most rapid in March-May (0.29°C per decade) and slowest in June-September (0.19°C per decade).

The 1050MW Coal Fired Power Plant is located in Lamu County of Kenya, a characteristically tropical region comprising a portion of mangroves.

Summers are hot and dry within the region in which the project site is situated with mean maximum temperature in the 30's°C between Nov and April. The hottest month (Nov), has a mean maximum temperature of 39°C. During the summer months, daily maximum temperatures regularly exceed 30°C (*Figure 2.7*) between 2000 and 2015, it was recorded that in March, on average, maximum daily temperatures are greater than or equal to 30°C on 24 days of the month (*Figure 2.7*).

Figure 2.7 – Average Maximum and Highest Recorded Temperatures, Average Number of Days Exceeding 30°C during the Summer Months (www.weatherbase.com)

Average High Temperature — Years on Record: 15

	ANNUAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
C	28	30	30	31	30	28	27	26	26	27	28	30	30

Highest Recorded Temperature — Years on Record: 15

	ANNUAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
C	39	33	35	37	38	36	30	29	30	32	37	39	35

Average Number of Days Above 30C — Years on Record: 15

	ANNUAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Days	156	21	19	24	20	11	2	---	1	3	14	21	22

During winter, mean maximum temperature range from 26 to 28°C; days are cool and nights are cold. April is the coldest month with a mean temperature of 15°C and a mean maximum temperature of 30°C. Temperatures in Lamu county range from an absolute minimum of 15°C to a maximum of 39°C based on historic records from 20000 – 2015. Lamu Coal Fired Plant is located in one of the cooler and wettest regions of Kenya.

Figure 2.8 Mean Average Minimum, Lowest Recorded Temperature and average number of days below 23°C, in Lamu County for between 2000 and 2015 (*www.weatherbase.com*)

Average Low Temperature — Years on Record: 15

	ANNUAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
C	26	26	26	27	27	26	25	24	24	25	25	26	26

Lowest Recorded Temperature Years on Record: 15

	ANNUAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
C	15	17	17	16	15	18	20	17	20	20	18	16	16

Average Number of Days Below 75F/23C Years on Record: 15

	ANNUAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Days	74	3	2	1	2	5	7	10	16	9	6	6	6

Figure 2.9 Average Annual Temperatures over Lamu County (www.weatherbase.com)

Average Temperature Years on Record: 15

	ANNUAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
C	27	28	28	29	28	27	26	25	25	26	27	28	28

Evaporation

Mean annual evaporation (MAE) in the area is 4.493mm and average monthly evaporation is set out in *Table 2.1* below.

Table 2.1 - Average Monthly Evaporation (mm)

Month	Mean Evaporation (mm)
January	5.155
February	5.464
March	5.582
April	4.864
May	4.040
June	3.750
July	3.770
August	4.010
September	4.500
October	4.440
November	4.070
December	4.267

Precipitation

The site of the Lamu Coal Fired Power Plant falls within Autumn/Winter precipitation area.

There is typically little to heavy precipitation in the project region, with Lamu (the town closest to the project area) receives an average of 895mm of precipitation per annum. The

Lamu region receives greater than 65% of its annual precipitation between April and June (+/- 579mm) with May and June receiving the most precipitation.

Lamu region experiences its highest mean monthly precipitation in May (approximately 299mm) [*Figure 2.10*]. Lamu received its maximum monthly precipitation (655mm) in May, 2001. That equated to an estimated 54.6mm in a 24 hour period

Figure 2.10 - Average Annual and Month Precipitation and Average Days of Rain over Lamu Region (www.weatherbase.com)

Average Precipitation — Years on Record: 30

	ANNUAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
mm.	895	7	3	32	135	299	145	82	41	47	37	42	25

Average Number of Days With Precipitation — Years on Record: 15

	ANNUAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Days	55	1	1	2	6	12	8	7	5	4	3	4	2

Figure 2.11 Average number of Rainy Days and Ave number of Days with thunderstorms (www.weatherbase.com)

Average Number of Rainy Days — Years on Record: 15

	ANNUAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Days	55	1	1	2	6	12	8	7	5	4	3	4	2

Average Number of Days With Thunderstorms — Years on Record: 15

	ANNUAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Days	12	1	1	2	3	1	---	---	---	---	---	2	2

Flooding

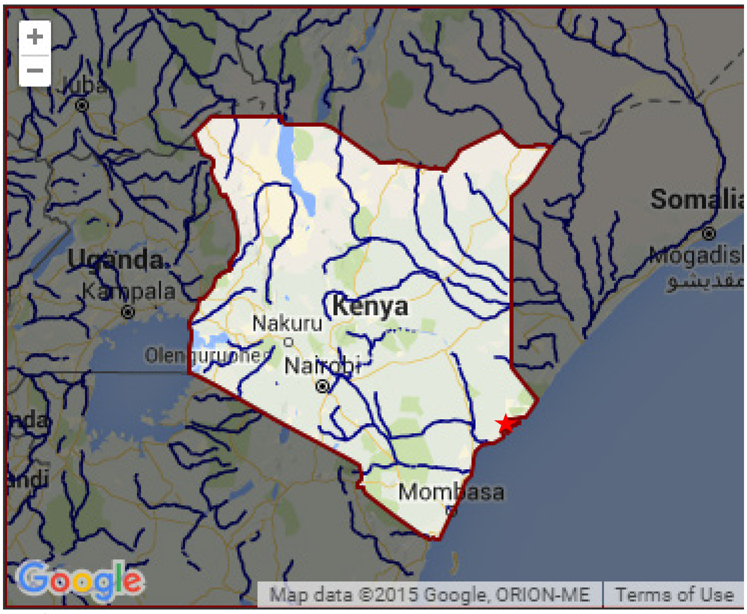
There are no rivers near the proposed project site and surface water mainly accumulates on the site during the rainy season. The topography of the site is such that the land generally slopes eastwards towards the Manda Bay; subsequently, surface water will mainly drain to the sea from west to east in a scattered mode. The project site is at a higher elevation than the seasonal gully located towards the north of the project site; therefore the site potentially accumulates water in rainy season on the west, while sea tides on the east will have minimal flood influence on the site.

Low risk of site flooding from rain, however rising sea-level with storm surges are a potential risk in the future considering climate change.

A recent study provides new knowledge relative to the IPCC AR4, for coastal impacts in Kenya. A 10% intensification of the current 1-in-100-year storm surge combined with a 1m

Sea Level Rise (SLR) could affect around 42% of coastal total land, 22% of coastal agricultural land, 32% of coastal GDP, and 39% of coastal urban areas.

Figure 2.12 Major Rivers in Kenya



★ Indicative location of project

Research presented in the first national communication of Kenya to the Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCC) also suggests that Kenya is highly vulnerable to SLR, and that impacts could be severe, especially in the Mombasa district, but less so in the area of the project. The project topography elevations range from 6 to 12m.

There is no evidence of incidences of flooding and other extreme weather events in the region surrounding the project area. This could be that they have not been recorded or that they have not happened in the area, there is insufficient granular information to verify.

Relative Humidity

Relative humidity in the area is highest over the summer months, during which time humidity has been known to reach a maximum of 91% (with Nov & Dec being the most humid month(s) on average over the years. Average humidity is also greatest in the [morning/afternoon/evening] with average annual humidity being 87%.

Figure 2 .13 Average Morning and Evening Humidity and Average Due Point (www.weatherbase.com)

Average Morning Relative Humidity Years on Record: 5

	ANNUAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
%	87	88	88	87	88	87	82	81	82	84	88	91	91

Average Evening Relative Humidity Years on Record: 8

	ANNUAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

%	67	62	61	61	70	76	72	70	69	68	66	66	65

Average Dew Point — Years on Record: 6

	ANNUAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
C	22	22	22	23	24	23	21	21	21	21	22	23	23

Wind Speed

Wind speeds in Lamu and by extension the project area are typically low, with monthly average wind speeds ranging from 1km/h to 19km/h. Average gust between the year is 16km/h.

Figure 2 .13 Wind conditions (www.weatherbase.com)

Average Wind Speed — Years on Record: 6

	ANNUAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
km/h	16	16	16	12	14	17	19	19	17	16	16	12	14

Average No. of Days With Blowing Dust/Sand — Years on Record: 15

	ANNUAL	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Days	8	1	---	1	---	1	---	1	1	---	1	1	1

Summary

The climate in the location of the project area is typically hot & dry with low precipitation throughout the year.

Extreme weather events are not characteristic of the region and the project site in particular and those that have taken place do not appear to have had a significant impact apart from droughts impacting fresh water supply.

Temperatures across all of Africa are projected to increase over the 21st Century (across all seasons) and the warning is anticipated to exceed the global mean annual temperature increase, which is projected to be approximately 3.4°C by 2100[1]. In Kenya, warming is expected to be greater over the Northern and Central parts and lower along the coast (within which the project area falls).

Overall, it is projected that the area in which the project is situated is likely to get hotter and drier with increasingly variable precipitation as a result of climate change. Additionally, storm surges along the coast may become more common given projected increases in severe weather events specially the El Niño Southern Oscillation (ENSO), La Niña and Inter-Tropical Convergence Zone (ITCZ).

1 The IPCC warns that if global society continues to emit greenhouse gases at current rates, the average global temperature could rise by 2.6–4.8°C by 2100. The IPCC's Fifth Assessment Report - What's in it for Africa

2.6 *STEP 3 - DEFINE CLIMATE RELATED RISKS*

Based on experience with climate change risks in the power utility industry, an assessment was made of the main risks which the project might face in the future given a change in the climate. They key risks are summarised in *Table 2.1.* Details of individual risks and the associated significance of the impact to the project can be found in the following section (2.7.2).

Table 2.1 - Key Climate related Risks to the Project

Weather variable	Risk to project	Potential consequence
High Temperature (air/oceans)	• Health risk to workforce and community • Equipment efficiency • Sea temperature increase	• Reduce workforce efficiency • Potential community unrest • Downtime and delays due to reduced productivity and problems with equipment • Downtime in ability to cool due to marine life damage
Flooding	• Very low with only some localised pooling	• No major consequences
Drought	• Reduced water availability (e.g. water restrictions as water prioritised for community) • Increased need of water for dust suppression (during construction) • Evaporation of ponds/dams/water supply • Evaporation causing vegetation loss and erosion • Drying up of natural local fresh water supply in sand dunes	• Reduced production • Delays • Community stress and unrest • Livestock loses • Shut downs due to cooling discharge water heating marine area and impacting marine life beyond best practice levels.
Sea Level Rise	• Limited due to site elevation of between 6 & 12 m above sea level. • Storm surges could have some impact on the lower areas of the project site	• Disruption to the generation plant will be limited but flood defence barriers to be considered.

2.7 *CRA STEP 4 RISK SCORING*

2.7.1 Methodology

The traditional environmental impact assessment involves analysis of impacts on the environment as a result of project activities. This assessment, on the other hand, is looking at the impact of changing climate conditions on the project and the associated risks to the business.

Standard methodology for impact assessments has been used as the basis for risk scoring and the definitions of some of the key characteristics have been amended to reflect the specific conditions associated with the assessment of physical climate risks on project activities. The significance of an impact against the sensitivity/vulnerability of receiving environment as described below:

Magnitude

Magnitude is determined according to type, extent, duration and scale of the impact. *Table 2.2* defines the characteristics used to assess the significance of impacts in relation to climate risk.

A rating of positive/negative/small/medium/large magnitude is assigned based on the characteristic of the impact.

Table 2.2 Impact Characteristics for the CRA Impact Assessment

Characteristic	Definition	Designation
Type	A description indicating the relationship of the impact to the project (in terms of cause and effect)	**Direct** – Impacts that result from a direct interaction between a climate event and the project (e.g. heavy rainfall flooding the operation) **Indirect** – Impacts on the project which is not the result of a climate event affecting the project (e.g. community health affecting workforce) **Induced** – does not apply
Duration	The time period over which the project is affected by the impact	**Temporary** – less than one day **Short-term** – one day to one week **Medium-term** – longer than one week, shorter than a month **Long-term** – longer than a month **Permanent** – impact to sustain a number of years and up to the entire life of operation.
Extent	The reach of the impact	**On-site –** impacts that are limited to the project site **Local –** impact that are limited to the project site and adjacent properties **Regional –** impacts that affect communities/properties as a regional scale (with implications for the project)
Scale	The severity of the impact on the project	1. project functions and/or processes remain **unaltered,** e.g. heat stress affects part of workforce 2. Project functions and/or processes are **somewhat altered** e.g. wind delays construction/maintenance activities 3. Project functions and/or processes are **notably altered** e.g. flooding results in a one day shut down. 4. Project functions and/or processes are **significantly altered** e.g. flooding results in a two week shutdown.

Sensitivity/Vulnerability

CRA impact assessments typically assess significance in relation to the magnitude and the likelihood of events given that impacts are not continuous.

Sensitivity/vulnerability has therefore been defined in relation to the frequency and likelihood for the CRA impact assessment, as described in table 2.3 below. Frequency refers to the frequency of the extreme weather event occurring over the project lifetime and likelihood describes the probability of the project experiencing a negative consequence as a result of the extreme weather event.

Table 2.3 Frequency and Likelihood Definitions for Extreme Event Impacts

Characteristic	**Definition**	**Designation**
Frequency	Measure of the periodicity of the extreme weather event	1 – Occurs once in 10 years or more 2 – Occurs once in 5 to 10 years 3 – Occurs once in 1 to 5 years 4 – Occurs once a year or more
Likelihood	The probability of the project experiencing a negative consequence as a result of the extreme weather event	**Unlikely** – the event is unlikely to result in the project experiencing a negative consequence **Possible** – the event may well result in a negative consequences for the project **Likely/Certain –** the event will result in one or more negative consequences for the project

The sensitivity/vulnerability of the project to the impact is then determined based on the frequency and likelihood of the impact and described as being high, medium or low, as set out in *Table 2.4* below. (Risk = Likelihood * Impact/frequency)

Table 2.4 - Impact Sensitivity/vulnerability Rating Matrix

		Frequency of extreme event			
		>Every 10 years (>10)	***Every 5 – 10 years (5-10)***	***Every 1 – 5 years (1-5)***	***Once a year or more (>1)***
Likelihood of experiencing a negative consequence	**Unlikely**	**Low**	**Low**	**Low**	**Medium**
	Possible	**Low**	**Low**	**Medium**	**High**
	Likely/Certain	**Medium**	**Medium**	**High**	**High**

Significance

Impacts are described in terms of 'significance'. Significance is a function of the magnitude of the impact and the likelihood of the impact occurring. Impact magnitude (sometimes termed severity) is a function of the extent, duration and intensity of the impact. Significance of an impact is qualified through a statement of the degree of confidence. Confidence in the prediction is a function of uncertainties, for example, where information is insufficient to assess the impact. Degree of confidence is expressed as low, medium or high.

Significance is determined using the magnitude and sensitivity/vulnerability rating as per *Table 2.5 below*

Table 2.5 - Impact Significance Rating Matrix

		Sensitivity/Vulnerability		
		Low	**Medium**	**High**
Management of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Small	**Negligible**	**Minor**	**Moderate**
	Medium	**Minor**	**Moderate**	**Major**
	Large	**Moderate**	**Major**	**Major**

Impacts are described in terms of 'significance'. Significance is a function of the magnitude of the impact and the likelihood of the impact occurring. Impact magnitude is a function of the extent, duration and intensity of the impact. Significance of an impact is qualified through a statement of the degree of confidence. Confidence in the prediction is a function of uncertainties where information is insufficient to assess the impact. Degree of confidence is expressed as low, medium or high.

Positive consequences will be assessed but will not be assigned a significance rating. Thereafter, the degree of confidence is determined. The degree of confidence pertains to whether there are any uncertainties in the prediction, for example, where information is insufficient to fully assess the impact. Degree of confidence is expressed as low, medium or high.

The likelihood of the project experiencing a negative consequence is reduced when adaptation measures are in place.

2.7.2 *Impact Assessment results*

As detailed in this report, impacts relating to temperature, rainfall and associated floods, sea level rising, and drought were identified. These impacts were assessed using the methodology set out above and under three conditions, namely:

1. The impact under **current baseline weather conditions** (and with currently proposed baseline mitigation measures – if any) (*Table 2.6*).

2. The impact under **future projected climate change conditions** (*Table 2.7*).

3. The impact with **mitigation measures in place** (*Table 2.8*).

As a result of the coastal climate in which the project site is situated, the likelihood of the identified impacts occurring and having negative consequences on the project is generally low to medium and as such, none of the impacts were assessed to be of major significance to the project. Only one impact was assessed to be of moderate significance to the project under the baseline conditions, namely the impact to the project stemming from storm surges and sea level rising in the project and surrounding area caused by climate change severe events and melting of the ice caps which would result in potential disruption to the operation. By introducing suitable mitigation measures (e.g. implementing flood control measures) the significance of the risk changes from moderate to being minor.

Those impacts that emerged as being of moderate significance to the project under future predicted climate change conditions were:

High Temperature

- Affecting staff health and potentially productivity;
- Physically affecting nearby communities, which may lead to community unrest;
- Reducing access to water and affecting subsistence agriculture in nearby community, which may lead to community unrest;
- Reducing the efficiency of equipment, which may compromise productivity;
- Low rainfall comporting water availability within region, which may result in reduced productivity;
- Increased sea water temperature which could lead to productivity issues, as cooling system may need to be stopped due to discharge water into sea increasing beyond best practise levels, which could damage marine life; and
- Increase risk of more severe stores over the warmer seas.

Rainfall and Flooding

- Flooding will be minor and limited to surface water build up with severe weather events, but run off to the ocean will limit this impact;
- Maintenance could be impacted if parts are shipped in or trucked in from areas within the flood prone zones within Kenya. Delays could have a minor impact on operation efficiencies;
- Construction could be impacted by high temperatures causing worker fatigue and equipment in-efficiencies and failure due to excessive heat;
- Wetting the coal supplier in storage rendering it un usable till dried; and
- Access of supplier from areas within the high flood risk zone in Kenya.

Sea Level Increase

- Damage from storm surges to plant, infrastructure and erosion,

- Sea water egress into plant and damaging equipment, and
- Port access for supplies of coal could be delayed due to severe storm events.

Based on the more significant types of impacts, it is advisable that Amu Power Company invests in a mitigation measures that will act to reduce the influences of hotter temperatures on the plant, it's staff and the nearby communities as well as appropriate flood and sea level control measures.

In terms of the degree of confidence, all temperature related impacts were considered to be medium confidence whereas all other impacts were determined to be low confidence given the comparatively little amount of climate data available.

It should be noted that this assessment is high level not based on a detailed technical analysis of hydrology in the area or plant layout/design due to the availability of information and the timing of this study and other specialist studies.

It is recommended that these studies be examined and the potential for change in the climate as outlined in this report considered when reviewing the impact on the project – this is particularly in relation to sea water temperature, sea levels and flooding.

Table 2.6 - Assessment of Impacts Under Baseline Weather Conditions

Impact and consequence description	Consequence Type	Determination of Magnitude				Magnitude	Determination sensitivity/vulnerability		Sensitivity / Vulnerability	Significance (magnitude x sensitivity/ vulnerability)
		Type	Duration	Extent	Scale		Frequency	Likelihood		
High temperature may affect staff health (i.e. lead to heatstroke/dehydration) and may hamper productivity during summer months	Health	Direct	Medium Term	Local	Remain unaltered	Negligible	>1	Unlikely	Medium	*Negligible*
High temperatures during summer may adversely affect access to water and any subsistence agriculture underway in the communities leading to community unrest	Social/ Communities/ Environmental	Indirect	Long Term	Local	Remain Unaltered	Negligible	>1	Unlikely	Medium	Negligible
High Temperatures may reduce the efficiency of certain types of equipment utilised by the Coal Fire Power Plant	Financial	Direct	Temporary	On-Site	Somewhat Altered	Small	>1	Unlikely	Medium	Minor
High Temperatures with low rainfall could compromise water availability with in the region. Such conditions could have impact on staff and community. Lower productivity and possible unrest	Social/Health	Direct	Medium Term	On-Site and Local	Remain Unaltered	Medium	>1	Unlikely	Medium	Minor
High Temperatures and Sea Temperature increasing the environmental concerns with the cooling system discharge into the bay. The dissipation	Environmental Financial	Indirect Direct	Temporary	On-Site	Somewhat altered	Medium	5-10	Possible	Low	Minor

Impact and consequence description	Consequence Type	Determination of Magnitude				Magnitude	Determination sensitivity/vulnerability		Sensitivity / Vulnerability	Significance (magnitude x sensitivity/ vulnerability)
		Type	Duration	Extent	Scale		Frequency	Likelihood		
of the warmer water if increasing the area to high it could damage local marine life. The likely impact would be the suspension of discharge into the bay and ultimately shutting down the plant										
Severe Weather Events caused by storms originating over the warmer oceans and rising sea levels breaching the flood lines and entering the plant and preventing coal ships from docking and delivery stock	Environmental Financial	Direct	Short-term	On-site	Notably Altered	Medium	>10	Likely / Certain	Medium	Moderate
Flash Floods may prevent access to and from the Power Plant thereby preventing the transport of product/equipment/staff	Financial	Direct	Short-tem	Local	Somewhat Altered	Small	5-10	Possible	Low	Negligible

Table 2.7 - Assessment of Impacts Under Future Projected Climate Change Conditions

Impact and consequence description	Project Stage	Description of scenario and future impact	Determination Magnitude				Magnitude	Determination sensitivity/vulnerability		Sensitivity / Vulnerability	Significance (magnitude x sensitivity/ vulnerability)
			Type	Duration	Extent	Scale		Frequency	Likelihood		
High temperature may effect staff health (i.e. lead to heatstroke/dehydration) and may hamper productivity during summer months	Construction & Operational	Mean temperatures are projected to increase across all seasons. This may impact the likelihood and frequency of the impact	Direct	Long Term	Local	Remain un Altered	Small	>1	Possible	High	Moderate
High temperatures during summer may adversely affect access to water and any subsistence agriculture underway in the communities leading to community unrest	Construction & Operational	Mean temperatures are projected to increase across all seasons. This may impact the likelihood and frequency of the impact	Indirect	Long Term	Local	Remain Un Altered	Small	>1	Possible	High	Moderate
High Temperatures may reduce the efficiency of certain types of equipment utilised by the Coal Fire Power Plant	Construction & Operational	Details concerning the operational envelope of power plant were not available and hence the information insufficient to determine the significant change to baseline risk	Direct	Temporary	On-site	Somewhat Altered	Small	>1	Possible	High	Moderate

Impact and consequence description	Project Stage	Description of scenario and future impact	Determination Magnitude				Magnitude	Determination sensitivity/vulnerability		Sensitivity / Vulnerability	Significance (magnitude x sensitivity/ vulnerability)
			Type	Duration	Extent	Scale		Frequency	Likelihood		
High Temperatures with low rainfall could compromise water availability with in the region. Such conditions could have impact on staff and community. Lower productivity and possible unrest	Construction & Operational	Mean temperatures are projected to increase across all seasons. This may impact the likelihood and frequency of the impact	Indirect	Short Term	Local	Somewhat Altered	Medium	5-10	Possible	Medium	Moderate
High Temperatures and Sea Temperature increasing the environmental concerns with the cooling system discharge into the bay. The dissipation of the warmer water if increasing the area to high it could damage local marine life. The likely impact would be the suspension of discharge into the bay and ultimately shutting down the plant	Operational	Mean sea temperatures are projected to increase across all seasons. This may impact the likelihood and frequency of the impact	Indirect	Short Term	On-site	Notably Altered	Medium	1-5	Possible	Medium	Moderate
Severe Weather Events caused by storms originating over the warmer oceans and rising sea levels breaching the flood lines	Operational	Mean sea temperatures and Wind are projected to increase across all seasons. This may	Direct	Short Term	On-Site	Notably Altered	Medium	>10	Likely/Certain	Medium	Moderate

Impact and consequence description	Project Stage	Description of scenario and future impact	Determination Magnitude				Magnitude	Determination sensitivity/vulnerability		Sensitivity / Vulnerability	Significance (magnitude x sensitivity/ vulnerability)
			Type	Duration	Extent	Scale		Frequency	Likelihood		
and entering the plant and preventing coal ships from docking and delivery stock		impact the likelihood and frequency of the impact and severe weather events									
Flash Floods may prevent access to and from the Power Plant thereby preventing the transport of product/equipment/staffs	Operational / Construction	Precipitation projected to increase across all seasons, but in particular summer. This may impact the likelihood and frequency of the impact and severe weather events	Direct	Short Term	Local	Remain Unaltered	Medium	1-5	Likely/Certain	Medium	Moderate

Table 2.8 - Assessment of Impacts Were Mitigation Measures are in Place

Impact and consequence description	Consequence Type	Description of Scenario and future impacts	Determination Magnitude					Magnitude	Determination sensitivity/ vulnerability		Sensitivity / Vulnerability	Significance (magnitude x sensitivity/vulnerability)
			Type	Duration	Extent	Scale		Frequency	Likelihood			
High temperature may effect staff health (i.e. lead to heatstroke/dehydration) and may hamper productivity during summer months	Adaptation measures are not available for such conditions	Construction & Operational	Direct	Long Term	Local	Remain Unaltered	Small	>1	Unlikely	Medium	Minor	
High temperatures during summer may adversely affect access to water and any subsistence agriculture underway in the communities leading to community unrest	Reduce, Reuse and recycle water on site. Install Water Treatment Plant Install Rain Water Harvesting	Construction & Operational	Indirect	Long Term	Local	Remain Unaltered		Small	>1	Possible	High	Moderate
High Temperatures may reduce the efficiency of certain types of equipment utilised by the Coal Fire Power Plant	Ensure regular maintenance schedule	Construction & Operational	Direct	Long Term	Onsite	Somewhat Altered		Small	>1	Possible	High	Moderate
High Temperatures with low rainfall could compromise water availability with in the region. Such conditions could have impact on	Adaptation measures are not available for such conditions	Construction & Operational	Direct	Long Term	Onsite	Somewhat Altered		Medium	1-5	Unlikely	Low	Minor

Impact and consequence description	Consequence Type	Description of Scenario and future impacts	Determination Magnitude					Magnitude	Determination sensitivity/ vulnerability		Sensitivity / Vulnerability	Significance (magnitude x sensitivity/vulnerability)
			Type	Duration	Extent	Scale		Frequency	Likelihood			
staff and community. Lower productivity and possible unrest												
High Temperatures and Sea Temperature increasing the environmental concerns with the cooling system discharge into the bay. The dissipation of the warmer water if increasing the area to high it could damage local marine life. The likely impact would be the suspension of discharge into the bay and ultimately shutting down the plant	Install early warning systems Design pumps to withstand more frequent flooding Implement appropriate flood control measures	Operational	Direct	Short Term	Onsite	Remain unaltered		Medium	1-5	Possible	Low	Minor
High Temperatures and Sea Temperature increasing the environmental concerns with the cooling system discharge into the bay. The dissipation of the warmer water if increasing the area to high it could damage local marine life. The	Install early warning and measuring systems Implement appropriate control measure to maintain ocean temp at best practise	Operational	Direct	Short Term	Onsite	Remain Unaltered		Medium	1-5	Possible	Low	Moderate

Impact and consequence description	Consequence Type	Description of Scenario and future impacts	Determination Magnitude					Magnitude	Determination sensitivity/ vulnerability		Sensitivity / Vulnerability	Significance (magnitude x sensitivity/vulnerability)
			Type	Duration	Extent	Scale		Frequency	Likelihood			
likely impact would be the suspension of discharge into the bay and ultimately shutting down the plant	levels											
Severe Weather Events caused by storms originating over the warmer oceans and rising sea levels breaching the flood lines and entering the plant and preventing coal ships from docking and delivery stock	Early Warning forecasts Ensure stockpile is adequate to cater for short term stock supply issues.	Operational & Construction	Direct	Short Term	On-site	Remain unaltered		Medium	1-5	Unlikely	Medium	Minor
Flash Floods may prevent access to and from the Power Plant thereby preventing the transport of product/equipment/staffs	Adaptation measures are not available for such conditions Ensure adequate stoke levels	Operational & Construction	Direct	Short Term	On-site	Remain Unaltered		Small	>1	Unlikely	Medium	Minor

2.8 *STEP 5: CRA RISK MITIGATION*

In the climate change context, mitigation of risk is associated with the physical impacts of climate change and is referred to as 'adaptation'. Climate Adaptation in the context of capital projects development can be thought of as activities to avoid, minimise or mitigate the business risk arising from extreme weather events and/or gradual changes in climate. Adaptation measures include altering physical design of power plant or infrastructure, implementing business procedures, and altering operating patterns.

Successful adaptation will encompass a variety of physical, operational, management or strategic measures and will include a strong on-going review element to re-visit and confirm the climate science projections and assumptions that underlies the original risk assessment.

Figure 2.15 provides an overview of different approaches to adaptation. At a plant level, climate adaptation measures could include:

- **'Hard' adaptation measures** that are incorporated into the design. For example, where flooding is a key risk for an area, on operation may adapt by building flood defences to protect flood prone areas. Alternatively, where increasingly intense storms pose a risk to power transmission lines, burrying exposed portions of the line may significantly reduce the risk of interruptions.
- **'Soft' adaptation measures** are incorporated into operational procedures or processes. For example, where increased risk of extreme high temperatures and heat wave events is identified at a site, procedural health and safety measures could be implemented that address this particular risk, e.g. changing shift patterns to avoid employees or contractors working during the hottest part of the day.

Figure 2.15 Climate Adaptation Approaches (based on IPCC, 2012)

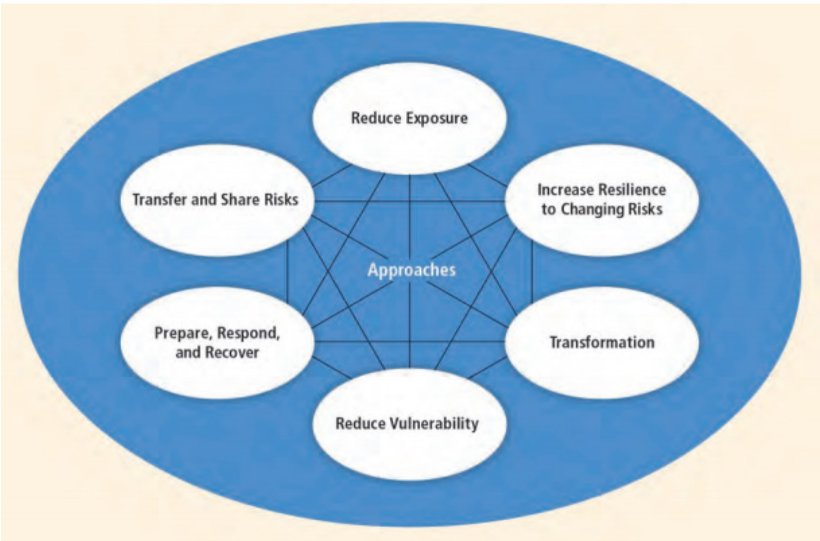


Table 2.9 outlines a selection of potential adaptation measures which could be implemented on site. Amu Power Company engineers should consider the potential impact of weather events on the project during the design process.

Table 2.9 Possible Adaptation Options to Mitigate Climate – induced Risks on Power Plant

Climate Variable/Event	Potential Impact on Power Generation and Associated Activities	Phase of Power Plant Affected	Project Component Impacted	Possible Adaptation Measure
Change in disease distribution	Increase incidence of dengue, diarrhoea, bartonellosia, malaria and other vector-borne diseases (given increase high temperatures) will impact the health of workforce and surrounding community putting strain on health facilities	Construction & Operational	Health	Rollout community health programmes as part of community based adaptation Establish a health support programme for staff including training on the avoidance of diseases and infections as well as distribution of prevention materials (i.e. mosquito nets etc.) Clear unwanted water bodies to prevent breeding grounds for Mosquitos
Cyclone/High Winds	Increase dust, blow the Fly ash being blown around	Construction & Operational	Community Support and Health/Safety	Improve dust suppression mechanisms under high wind conditions
Human adaptation/mitigation and increased competition for land	Changes in climate impacting agricultural (subsistence) and food security could lead to conflict with local communities	Construction & Operational	Community Support	Roll out community-based adaptation programme considering improving food security under climate change conditions.
Pluvial/Fluvial flooding	Disrupted access to facility due to flooding leading to interruption to supply of inputs such as diesel, materials. Diesel inparticular during construction phase, material supply throughout life of project.	Operational	Supply Chain	Implement appropriate flood control measures Implement appropriate stock control system

Climate Variable/Event	Potential Impact on Power Generation and Associated Activities	Phase of Power Plant Affected	Project Component Impacted	Possible Adaptation Measure
Storm Events	Increased delay to construction, docking of coal ships, as well as increased maintenance costs and possible business delays during operations Storm surges.	Construction & Operational	Power Plant and Harbour Infrastructure and facilities	Undertake more regular maintenance of infrastructure Implement flood control measures and controls
Temperature	Power Plant staff may experience health impacts as a result of temperature e.g. heat stress, which may result in delays	Construction & Operational	Health	Prevent working under very hot temperatures Ensure availability of cool drinking water for all on-site staff Change working hours to avoided hot working parts of the day
Temperature	Reducing efficiency of equipment due to hotter operating temperatures resulting in increased operational costs (trips/premature failures etc.)	Operational	Power Plant infrastructure and facilities	Review and adjust if possible the operational temperatures for equipment Increase maintenance schedule to prevent slow/shut downs

3 GREENHOUSE GAS ASSESSMENT GREENHOUSE GAS ASSESSMENT

3.1 APPROACH AND METHODOLOGY

3.1.1 Introduction

This GHG Specialist Study has been undertaken in accordance with international best practise emissions estimation techniques as outlined in the GHG Protocol and applied to the 1050MW Coal Fired Power Plant, Lamu County, Kenya. This section provides an overview of the methodology for calculating the carbon footprint and provides comment on how the impact assessment has been approached.

The study has involved a desktop assessment of international and national climate change literature; reviewing of relevant Amu Power Company Ltd documentation and Kurrent Technologies specialist study reports. It must be noted that due to timelines it was not possible to have interviews with Amu Power Company representatives and cosnultants of specialist studies. No field work was undertaken for the scope of work undertaken in this report.

3.2 CARBON FOOTPRINT CALCULATION

3.2.1 Methodology

A carbon footprint is a measure of the estimated greenhouse gas emissions caused directly and indirectly by an individual, organisation, event or product. The calculation of a carbon footprint generally involves the following equation:

Carbon footprint emissions = activity data x emissions factor x global warming potential

- *Activity data* relates to the emission causing activity e.g. the combustion of a quantity of diesel or the use of a quantity of refrigerant gases;
- *Emission factors* convert the activity data collected and consolidated into tonnes of the relevant greenhouse gas.
- *Global warming potentials* are applied to non-CO_2 GHG to convert the result to carbon dioxide equivalent (tCO_2e).

The Amu Power Company carbon footprint has been estimated in accordance with the *GHG Protocol: Corporate Accounting & Reporting Standard* developed by the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI). The *GHG Protocol* provides comprehensive guidance on accounting and reporting corporate GHG emissions. It is the most widely used standard for mandatory and voluntary GHG programmes and makes use of the Intergovernmental Panel on Climate Change (IPCC) GHG Inventory guidelines for specific heating values, carbon content, densities and emission factors. Where applicable referrence to Amu Power Company specific data relating to the Lamu Power Plant were used, but if date was not available the following sources for country and process specific factors were used:

- Intergovernmental Panel on Climate Change (IPCC) 2006 GHG Inventory guidelines and 2013 supplement where and when applicable;
- Department for Environmental, Food and Rural Affairs (Defra) 2014 GHG Conversion Factors for Company Reporting Guidelines;
- Kenya's intended National Determination Contribution (INDC) (23 July 2015);
- National Climate Response Strategy (NCCRS 2010);
- National Cliamte Change Action Plan (NCCAP 2013); and
- National Adaptation Plan.

The calculation using these standards ensures that the Lamu Power Plant Carbon Footprint is aligned with international standards.

3.2.2 Emissions Boundary Definition

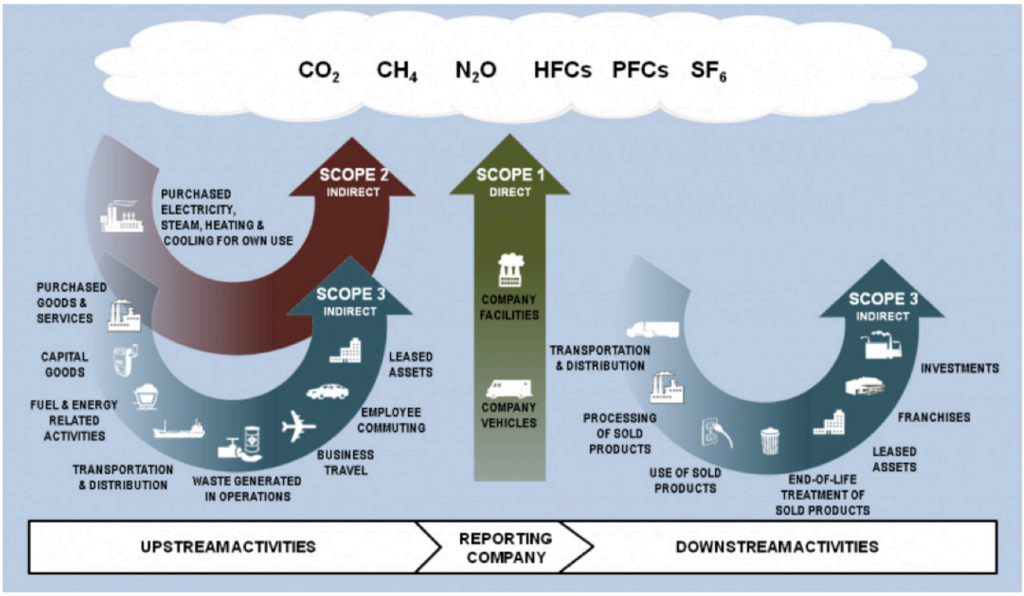
The scope of the carbon footprint depends on definition of two boundaries relating to the organisational and operational aspects of the project as outlined below. The boundaries drawn for the purposes of this project are discussed further in report.

Organisational boundaries determine whether reporting is done according to the "equity share approach" (different economic interest is reflected by companies being wholly owned, incorporated or non-incorporated join ventures or subsidiaries) or the "control approach" (emissions accounted for from operations under the direct operational control of the parent company).

Operating boundaries determine which emission causing activities will be included in the carbon footprint. The GHG Protocol divides emissions into three categories as described below and illustrated in *Figure 3.1*

- *Scope 1 – direct emissions* from sources owned or under the operational control of the company;
- *Scope 2 – indirect emissions* from the consumption of purchased electricity; and
- *Scope 3 – indirect emissions* an optional reporting category allowing for other indirect emissions associated but not controlled by the company to be included such as contractor activities.

Figure 3.1 GHG Protocol Emissions Scopes



3.3 *IMPACT ASSESSMENT METHODOLOGY*

A traditional impact assessment is conducted by determining how the proposed activities will affect the state of the environment prior to development of a project as per the E*SIA Report* associated with this specialist report. In the case of GHG emissions, this process is complicated by the fact that the impact of GHG emissions on the environment cannot be quantified within a defined space and time.

The greenhouse effect occurs on a global basis and the point source of emissions is irrelevant when considering the future impact on the climate. It is not possible to link emissions from a single source – such as the Lamu Power Plant facility - to particular impacts in the broader study area.

Subsequently, this specialist study does not consider the physical impacts of climate change resulting from increasing GHG emissions, but rather the impact of the project on Kenya's National GHG Inventory and the implications of this.

The impact of the estimated operational emissions for the Lamu Coal Power Plant has been compared with a national emissions trajectory of Kenya from 2016 to 2040 which has been determined based on historic and projected economic growth and development pathways. The last official GHG emissions inventory for Kenya was completed for the year 1994 and used in the First National Communication, in 2002. Since then Kenya's GHG emissions from 2000 to 2010 have historically been calculated using the Intergovernmental Panel on Climate Change (IPCC) 2006 guidelines for GHG emissions inventories.

When assessing the impact of GHG Emissions of the power plant it will be done on the estimated Lamu Power Plant operational emissions and the impacts of these emissions on Kenya's national GHG inventory;

1. Comparison with the most recent and published GHG inventory for Kenya, published by United Nations Climate Change Secretariate – (UNFCCC Country brief 2014;
2. Comparison with the most recent published (2013) National Climate Change Action Plan 2013 – 2017 (Vision 2030),
3. Comparison with an an emissions trajectory from 2016 to 2040 which has been determined based on historic and projected economic growth and development pathways.

4 SCOPE OF THE CARBON FOOTPRINT

4.1 INTRODUCTION

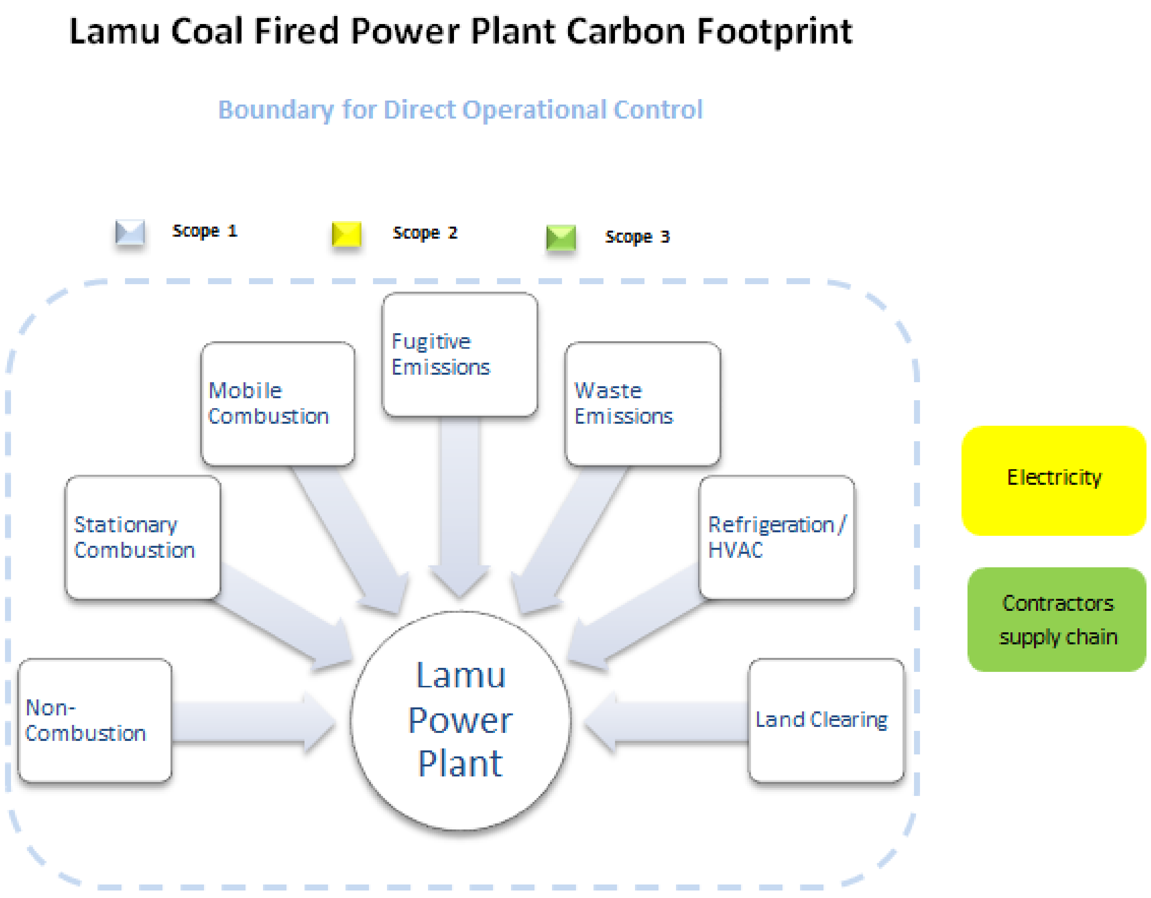
This section defines the scope of the Lamu Power Plant carbon footprint in terms of emission boundaries, timing of emission causing activities coming online, and an overview of emission causing activities. The results of the carbon footprint calculation are presented further in the report.

4.2 ORGANISATIONAL AND OPERATIONAL BOUNDARY

The organisational boundary has been defined according to the control approach where emissions from sources under the direct operational control of Amu Power Company will be included in the carbon footprint as illustrated in *Figure 4.1*.

Scope 3 (indirect) emissions would typically be from outsourced activities, such as contractor activity and employee business travel. These emissions have been excluded for the purposes of this study due to the fact that there is considerable uncertainty with respect to estimating contractor activity and employee business travel.

Figure 4.1 Amu Power Company – Lamu Power Plant Carbon Footprint Boundary



It is assumed that Amu Power Company will not pay for the fuel used by contractors (during construction phase) on site and therefore the emissions associated with their activities have been excluded. All electricity is generated on site (Scope 1) and therefore there are no Scope 2 emissions from purchased electricity. Scope 3 emissions associated with distribution of electricity have been estimated but not included in the overall carbon footprint.

4.3 *TIMEFRAME*

Construction is due to begin in 2016 with operations beginning as first 350MW comes online during Quarter 1of 2019. The production capacity of each boiler is 350 MW or 3.06GWh per year. Construction will continue until 2020 when the 3rd boiler will be in operation bringing the total 1050MW of the facility to 9.198 GWh per year. The life of the facility is anticipated to be 25 years indicating closure in 2045, unless another PPA is agreed upon. *Table 4.1* shows the timing of the 3 x boilers coming online and how the 3 phases of activity are expected to impact the number of people working on site.

Table 4.1 Timeframe from construction to full operations of Lamu Power Plant

Phase	Timing of Generation capacity coming on line	Approx number of people on site
Construction 2016 – 2019	N/A	3 000
Combined Construction and Operations 2019 – 2020		3 300
Operations only Phase 2020 – 2045	N/A	300

4.4 *OVERVIEW OF LAMU POWER PLANT EMISSION CAUSING ACTIVITIES*

The proposed Lamu Power Plant and support facilities are expected to cover an area of some 0.8 km^2 with a coal storage yard of approximately 0.16 km^2 within the border area. The Project Description in the *ESIA Report* provides a detailed account of the activities associated with the proposed project.

There are 3 major components to the project which include:

- Jetty/harbour for receiving imported and local coal;
- Onshore
  - Power Plant complex;
  - a residential colony accommodating up to 500 people; and
  - services including storage yards, roads, power, water and sewage etc.

Table 4.2 summarises the key emission sources occurring on site and indicates those which are included in the carbon footprint.

Table 4.2 Summary of key emission sources (all Scope 1)

Emission Scope	Emission Source
Mobile combustion	Fuel used in freight carriers

Emission Scope	Emission Source
	Fuel used in terrestrial vehicles including cars, utility vehicles, buses etc Fuel used in airplanes for business travel
Stationary combustion	Diesel used for power generation (black start and during construction phase) Coal fired boiler
Waste emissions	Methane emissions from waste water (sewage) treatment
Refrigerants	Leakage/use of refrigerant gases in air conditioning units in vehicles and offices/accommodation
Fugitives	Methane escaping from coal storeage yards
Lubricants	Use of lubricant oils and greases in machinery
Land clearance	Clearance of vegetated land (at the start of the project)

4.5 ASSUMPTIONS MADE IN ESTIMATING OPERATIONAL ACTIVITY DATA

Good practice for calculating a carbon footprint dictates that actual activity data (e.g. litres of diesel consumed) for a financial year is used. Given that this project involves an estimation of a future carbon footprint for activities yet to begin, a series of assumptions have been made in order to obtain the activity data required to undertake this calculation.

Data was obtained from the ESIA report, the specialist studies, on-line research and through discussion with lead consultanting firm, Kurrent Technologies Ltd to clarify and confirm some assumptions. The carbon footprint has been estimated in accordance with current design options and these may well change following completion of the ESIA and Front End Engineering and Design (FEED) studies. *Appendix B* provides an account of assumptions that have been made in relation to each aspect of the carbon footprint calculation.

The carbon footprint includes estimated direct emissions from activities associated with the construction and operation of the facilities. Embedded emissions associated with the materials used are regarded as Scope 3 and not included as they are outside the scope of this project. The emissions from the transmission losses and consumption of electricity sold by Amu Power Company are not included as this is outside the control of the company.

5 GHG EMISSIONS IN KENYA AND FROM LAMU POWER PLANT

5.1 GHG EMISSIONS IN KENYA

The only publicly available detailed inventory of Kenya's national GHG emissions is for the year 1994 contained in First National Communication. This inventory was published in 2002 by the Government as part of Kenya's first National Communication to the UN Framework Convention on Climate Change (UNFCCC). The accuracy of the emissions estimate in the National Communication cannot be verified, however, GHG emissions have historically from 2000 to 2010 been calculated using the Intergovernmental Panel on Climate Change (IPCC) 2006 guidelines for GHG emissions inventories upon which this report base this assessment on.

Kenya's national emissions were estimated to be 73 million tCO_2e in 2010[1] and the vast majority of emissions arose from land use, land use change and forestry and agriculture (75%). The energy sector accounted for 11.37% of emissions in 2010.

In the absence of actual emissions data, GDP growth has been used as a proxy for emissions growth from 2003 to present. Table 3.3 illustrates the variation in Kenya's growth rate from 2003 – 2015. The extent of the increase in national emissions is somewhat dependent on the policy, legislative framework, the type of development (e.g. manufacturing, mining, oil and gas) and GDP growth in Kenya, and the timing thereof. It is, however, the best estimate of potential future emissions in the country. *Figure 4.3* illustrates Kenya's projected national emissions from a 2000 baseline.

Table 4.3 Kenya GDP growth rates 2003 – 2015

Real GDP growth (Source - World Bank)

2003	2004	2005	2006	2007	2008	2009	2010
2.8%	4.6%	5.5%	6.3%	7.0%	0.2%	3.3%	8.4%
2011	**2012**	**2013**	**2014***	2015*			
6.1%	**4.6%**	**5.7%**	**5.3%**	6.2%			

*Estimate

5.2 ESTIMATED GHG EMISSIONS FROM LAMU FACILITY

5.2.1 Overview

The operational carbon footprint for the Lamu Facility is estimated to be approximately ~8.8 million tonnes CO_2e per year from 2016 onwards. Onshore Power Plant is responsible for the majority of the carbon footprint with transport and other source contributing insignificant amounts when compared to the generation of electiricty

[1] Kenya's Intended National Determination Contribution – 23 July 2015

It should be noted that this does not include additional activities which may come into play in future..

During the construction phase (2016-2019), emissions are relatively low. The first boiler unit comes online in Q1 of 2019 with an additional boiler units coming online every 3 months resulting in a sharp increase in emissions during the period 2019 – 2020 as the energy needed to generate the electricity is substantial. The first full year of full operation is expected to be in 2020 when all boilers should be running to full capacity.

5.2.2 Emissions from Lamu Power Plant Operation

Lamu Power Station coal storage emissions

Fugitive emissions from leaching of gases from coal stored in the 2 coal yards is real but due to insufficient information and lack of quantifieable data, have been excluded from this assessment.

Lamu Power Plant onshore emissions

GHG Emissions from the onshore plant operational activities including electricity generation are estimated to be ~8.8MtCO_2e per year when all 3 units are fully operational.

Amu Power Company did not provide all GHG emission estimates for the various stationary combustion units at the onshore facility. It is understood that since the design has not yet been finalised, the emissions estimates are based on the most emissions intensive design option.

Background data used in the calculation was unavailable and was therefore not able to verify the calculation. However, it is understood that the calculation is based on the design parameters of the equipment to be employed and the estimated annual coal quality and feed rate. The accuracy of the overall carbon footprint depends on the accuracy of the calculation carried out by Amu Power Company engineers.

5.2.3 Emissions from transport related activities

Emissions from transport related activities account for approximately 284.22tCO_2e (0.00003%) of the total operational emissions from Lamu Power Plant's activities in the area. Maritime transport associated with port activities have been excluded as no data available . This is estimated to be negligiable in the context of the entire operations emissions. Shipping emissions have been excluded as out of scope as assets are not owned/controlled by Amu Power Company and are Scope 3 emisisons..

There are, due to the lack of data provided and available, there are significant uncertainties associated with the projected number and type of vehicles as well as how much each vehicle will be utilised (i.e. distance travelled). As a result, broad assumptions have been made in calculating emissions.

A key assumption is that all shipments will be carried out by contractors and therefore the emissions fall under Scope 3 and have not been included in the direct carbon footprint assessment.

5.2.4 Emissions from the Colony, Offices and other services

Emissions from the Colony, offices and other services will predominantly be indirect as they run off electricity produced by the Lamu Power Plant facility and therefore captured under Scope 1 at this point. Emissions associated with these locations and activities relate to the disposal and treatment of waste and the use of refrigerants in housing and offices.

Emissions from waste water (sewage) treatment estimated to account for (3 290tCO_2e per annum) less than 0.04% of the operational carbon footprint. However, due to the significantly higher number of people on site during construction (up to 3 000) waste water treatment contributes a higher proportion of emissions during the initial stages (construction) of the project.

A key assumption is that there will be on-site waste water treatment plant to cater for consutruction workers and when in operation this plant will continue to be used for the colonly. We have excluded as no data available for landfill waste, but this will be negligiable contributing factor to emissions in the context of the level of the operations emissions.

5.2.5 Construction related electricity generation[1]

During the construction phase of the project, the electricity required to run operations will be provided by diesel generators until the Lamu Coal Power Plant is up and running. It is understood that approximately 20MW of electricity would be needed to power the camps and construction of the facility requiring the consumption of 15.8 million litres of diesel per year. The emissions associated with the diesel combusted are 0.42XMtCO_2e. It is assumed that once the first coal carrier and boiler comes online in 2019, no further diesel power generation will take place except for black starts.
A key assumption is that there will be a requirement for energy to perform the construction phase and therefore a estimate requirement of 20MW. The assumption is that this power will be provided by means of diesel generators.

5.2.6 Uncertainty and gaps

The significant direct emission sources have been included in the estimated carbon footprint of the construction and operations of the Lamu Power Plant facility. There is a significant level of uncertainty in the estimates given at this the early stage of project design. This report is based on the designs and assumptions available at the time of writing and the results may or may not correlate to the final design of the facility.

[1] See appendix for caluclations

6 IDENTIFICATION OF APPLICABLE POLICIES, LEGISLATION, STANDARDS AND GUIDELINES

6.1 INTRODUCTION

Kenya does not currently regulate emissions of greenhouse gases and there are no indications to suggest that any form of legislation or tax could come into force in the near future. However, the International Finance Corporation (IFC) requires their clients that facilities will emit over 25,000tCO_2e per year, monitor and report emissions on an annual basis and that steps should be taken to reduce emissions and enhance resource efficiency of all activities.

This section looks at international climate change frameworks and Kenya's commitments under these, as well as the requirements of the IFC in relation to greenhouse gas emissions.

6.1.1 International Climate Change Frameworks and Mechanisms

6.1.2 The UNFCCC and Kyoto Protocol

The United Nations Framework Convention on Climate Change (UNFCCC) was established in 1992 with the aim of stabilising greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

In 1997, the Kyoto Protocol (an 'update' to the UNFCCC) was signed, setting binding limits on the amount of greenhouse gas emissions allowed in 'developed countries' over the period 2008 – 2012. It divides the world into Annex I 'developed' countries which have a greenhouse gas target and all other countries 'non-Annex I' which do not have targets. The Kyoto Protocol came into force on 16 February 2005 following ratification by Russia, bringing the global emissions covered by the 177 signatories to over 50%. The USA, China and Canada (who withdrew in 2011) are the only major emitters not to have ratified the protocol.

The Doha Climate Change Conference, the 18th Conference of Parties (COP18) of the UN Framework Convention on Climate Change, held at the end of 2012 resulting in the "Doha Climate Gateway" decisions. The main outcomes were:

- A second commitment period for the Kyoto Protocol. However, fewer coutries are particpipating, and they have only agreed to reduce their overall emissions by at least 18% below 1990 levels in the 8 year period (2013 – 2020). Participating countries represent 15% of the global greenhouse gas emissions, and the emissions reduction comittments are insufficient to keep global warming below the 2°C limit;
- Agreement to consider the creation of an international mechanism for loss and damage from extreme weather and slow the onset od climate impacts in developing countries;
- The need for a plan for long-term finance was reiterated. However, no firm commitment on scaling up finance towards the agreed US$ 100billion a year were forthcoming.

Climate finance pledges amounting to approximately US$ 10 billion were made by some European countries; and
- Developed countries were urged to increase the ambition of their emission reduction targets and a work programme will be established to clarify pledges.

International negotiations are in progress (Paris) to either extend the Kyoto Protocol or develop a new system to allow other developed countries (such as the USA and Canada) and fast developing countries (such as China, India, Brazil and South Africa). The aim is to agree to binding emission reduction targets in light of the need to significantly reduce emissions to limit climate change and to enhance technology transfer, capacity building and finance.

While there are currently no legally-binding emissions reductions targets in several developed countries (including the USA), those countries are increasingly applying political pressure through other institutions such as the World Bank and African Development Bank, in order to encourage climate change mitigation in the developing economies.

The 2015 United Nations Climate Change Conference, COP21 or CMP11 will be held in Paris,[1] from November 30 to December 11. According to the organizing committee, the objective of the 2015 conference is to achieve, for the first time in over 20 years of UN negotiations, a binding and universal agreement on climate, from all the nations of the world.

6.1.3 Market Mechanisms to promote emission reductions

The Kyoto Protocol created market mechanisms to help finance emissions reduction projects - creating a carbon market. Participation in Emissions Trading, the Clean Development Mechanism (CDM), and Joint Implementation (JI) allow Annex 1 countries to meet the GHG emission limitations by purchasing GHG emission reduction credits from projects that reduce emissions in non-Annex 1 countries (CDM), or from other Annex 1 countries through JI or emissions trading.

Japan have withdrawn from the continuation of the Kyoto Protocol, and have proposed their own scheme, the Bilateral Offset Crediting Mechanism (BOCM). Japan's BOCM is similar to the CDM in that a funding country (Japan) invests in emissions reduction projects or programs in developing countries and gains offset credits. The key difference lies in a simplified procedure which stays mostly at the bilateral level whereas the CDM is administered by the international body UNFCCC. International oversight under the BOCM is minimised to the function of providing guidance for emissions monitoring, reporting and verification (MRV) and accounting rules only. Despite potential benefits, issues relating to the accounting rules, environmental integrity and implications to carbon markets warrant further consideration prior to international recognition.

6.2 KENYA'S INTERNATIONAL CLIMATE CHANGE COMMITMENTS

Following the 2009 UNFCCC Climate Change Conference in Copenhagen (COP15), countries (both developed and developing) were requested to show their support for the

'Copenhagen Accord' and outline emission reduction commitments and nationally appropriate mitigation actions which they would undertake in order to play their part efforts to reduce GHG emissions.

Kenya has indicated its support for the Copenhagen Accord but noted that it has no obligations under the Kyoto Protocol and did not set a voluntary emission reduction target. The country remains committed to make a contribution to the global mitigation efforts in the context of National Sustainable Development Strategy and Plans, with international support and finance, technology, and capacity building.

Under the current status of Kenya as a non-annex 1 country, there are no imminent plans to implement emissions targets. The Kenyan Government has recently in 2014 introduced the Environmental Management and Co-Operation (Air Quality) Regulations, but does not set out emission standards, targets or guidelines. This regulations does provide the bases to mitigate GHG emissions. As international carbon markets grows, new opportunities may be identified to involve Kenyan companies. Local businesses can currently participate in the carbon market through the Clean Development Mechanism (CDM) and the Voluntary Carbon Markets to generate revenue for Lamu Power Plant and these local businesses.

6.3 INTERNATIONAL WORLD BANK GUIDELINES

The following World Bank Guidelines and Performance Standards are applicable to their client in with respect to greenhouse gas emissions, and are described in more detail below. Amu Power Company is not a client of World Bank but this report is based where posisible on the IFC performance standards as a best practise approach.

- IFC Performance Standard 3: Resource Efficiency and Pollution Prevention (January 2012).
- Guidance Note 3 relating to Performance Standard 3: Resource Efficiency and Pollution Prevention (January 2012).
- General Environmental Health and Safety (EHS) Guidelines: Environmental air emissions and ambient air quality (April 30, 2007).

6.3.1 IFC Performance Standard 3: Resource Efficiency and Pollution Prevention

The requirements of Performance Standard 3 with respect to GHG emissions are detailed in *Box 7.1*.

Box 7.1 IFC Performance Standard 3

In addition to the resource efficiency measures…, the client will consider alternatives and implement technically and financially feasible and cost-effective options to reduce project-related GHG emissions during the design and operation of the project. These options may include, but are not limited to, alternative project locations, adoption of renewable or low carbon energy sources, sustainable agricultural, forestry and livestock management practices, the reduction of fugitive emissions and the reduction of gas flaring.

For projects that are expected to or currently produce more than 25,000 tonnes of CO_2-equivalent annually[1], the client will quantify direct emissions from the facilities owned or controlled within the physical project boundary[2], as well as indirect emissions associated with the off-site production of energy[3] used by the project. Quantification of GHG emissions will be conducted by the client annually in accordance with internationally recognized methodologies and good practice[4].

1 The quantification of emissions should consider all significant sources of greenhouse gas emissions, including non-energy related sources such as methane and nitrous oxide, among others.

2 Project-induced changes in soil carbon content or above ground biomass, and project-induced decay of organic matter may contribute to direct emissions sources and shall be included in this emissions quantification where such emissions are expected to be significant.

3 Refers to the off-site generation by others of electricity, and heating and cooling energy used in the project.

4 Estimation methodologies are provided by the Intergovernmental Panel on Climate Change, various international organizations, and relevant host country agencies.

Guidance on compliance with this standard is provided in *Guidance Note 3 relating to Performance Standard 3: Resource Efficiency and Pollution Prevention* and focuses specifically on:

- The methodology to be used for quantifying emissions, namely the use of the 2006 IPCC Guidelines;
- Examples of project activities that may result in greater than 25,000 tons CO_2 equivalent per year; and
- Guidance on evaluating greenhouse gas performance of projects.

Although not a formal requirement under Performance Standard 3, clients are encouraged to disclose their GHG emissions annually through corporate reports, or through other voluntary disclosure mechanisms currently being used by private sector companies internationally such as the Carbon Disclosure Project (1).

6.3.2 *General EHS Guidelines: Environmental air emissions and ambient air quality*

The only section applicable to the greenhouse gas study within the *General EHS Guidelines: Environmental air emissions and ambient air quality* section describes sectors that may have potentially significant emissions of greenhouse gases and provides general recommendations for mitigation, which are in line with those described in *Performance Standard 3*.

(1) www.cdproject.net

Recommendations for reduction and control of greenhouse gases include:

- Carbon financing;
- Enhancement of energy efficiency;
- Protection and enhancement of sinks and reservoirs of greenhouse gases;
- Promotion of sustainable forms of agriculture and forestry;
- Promotion, development and increased use of renewable forms of energy;
- Carbon capture and storage technologies;
- Limitation and / or reduction of methane emissions through recovery and use in waste management, as well as in the production, transport and distribution of energy (coal, oil, and gas).

7 IMPACT ASSESSMENT

7.1 INTRODUCTION

A traditional impact assessment is conducted by determining how the proposed activities will affect the state of the environment described in the baseline. In the case of greenhouse gas emissions, this process is complicated by the fact that the impact of greenhouse gas emissions on the environment cannot be quantified within a defined space and time.

The greenhouse effect occurs on a global basis and the point source of emissions is irrelevant when considering the future impact on the climate. Carbon dioxide has a residence time in the atmosphere of approximately 100 years by which time emissions from a single point source have merged with other anthropogenic and natural (e.g. volcanic) greenhouse gas emissions. The global nature of the impacts of climate change such as temperature changes increases, changes in crop productivity, disease distribution etc, as discussed in Appendix A. It is not possible to link emissions from single source – such as Lamu Power Plant – to particular impacts in the broader study area. This specialist study, therefore, looks at the impact of the project on Kenya's National GHG Inventory and the implications of this rather than the physical impacts of climate change.

The remainder of this section looks at the downstream impact of the project on global emissions, assesses the impact of the Lamu Coal Power Plant Facility on Kenya's national GHG inventory and compares the estimated operational emissions intensity of the project with other [power plant] projects around the world.

7.2 IMPACT ON GLOBAL GREENHOUSE GAS EMISSIONS

An indirect impact of Lamu Power Plant's activities in Kenya is the effect on global greenhouse gas emissions. In 2013, global emissions of greenhouse gases from anthropogenic activities excluding land use change and deforestation came to 36 giga tonnes (Gt) CO_2e(1),this is 61% higher than 1990 (the Kyoto Protocol reference year) and 2.3% higher than 2012.

Current generation from the LamuPower Plant Facility is anticipated to be approximately 1050 MW of electricity per year (~8.8 GWh) from 3 600 000 tonnes of coal per annum. It must be noted that all but the parasitic load[2] will be distributed via national grid to local electricity demand. Excluding the emissions from transport of coal, transmission losses and downstream combustion of this electricity will result in the emission of approximately ~ $MtCO_2e$ per year – a 0.024% increase in global emissions (World Total: 36 131 $MtCO_2$).

(1) From http://co2now.org/Current-CO2/CO2-Now/global-carbon-emissions.html

[2] represents the power consumed when the power plant is not generating electiricty for the grid and/or self generated load required to provide generation to grid i.e. it operational power.

Globally, there is a move towards lower carbon fuels and an increase in the availability of natural gas support the shift away from more carbon intensive fuels such as coal and diesel. Given the growth in Asia, the availability of gas will support lower carbon development in countries such as India and China which otherwise would rely more heavily on coal. Without an in depth analysis of future market dynamics with increased availability of natural gas, it is not possible to comment on whether or not the consumption of coal will be offset in whole or in part by the use of natural gas. However, given that the emissions factor associated with the consumption of gas is approximately half that of coal, any fuel switch/offset which does occur can be expected to reduce the associated emissions by around fifty percent.

7.3 CUMULATIVE IMPACTS

Traditionally, the cumulative effect of different sources of a common potential impact (e.g. effluent discharge or air pollution) is assessed to understand how the activities in question contribute to the overall impact on the environment described in the baseline.

Given the global nature of climate change already discussed, the cumulative impact of the Lamu Power Plant in terms of emissions is discussed in relation to Kenya''s national future emission scenarios rather than in comparison with a selection of new facilities. Given the absence of long term emission scenarios in Kenya, the emissions projections based on GDP growth have been used as the frame of reference for assessing the cumulative impacts. This is discussed further below.

7.4 ASSESSMENT OF IMPACTS – KENYA'S NATIONAL GHG INVENTORY

The impact of the estimated Lamu Power Plant operational emissions against Kenya's national GHG inventory has been assessed by comparison with an emissions trajectory from 2010 to 2040 which has been determined based on historic and projected economic growth and development pathways.

Given growth in national emissions over time, by 2030 (143MtCO_2e)[1], Lamu Power Plant could account for around 6 – 10% of national emissions.

7.5 THE LAMU POWER PLANT FACILITY IN RELATION TO KENYA'S SPECIFIC ISSUES

It is evident then that the Lamu Power Plant Facility's emissions will increase the level of Kenya's emissions by ~6 - 10%[2] when operations begin to 2030. To determine whether this is significant or not, the increase in emissions is discussed against Kenya's specific issues:

[1] Kenya's Intended Nationally Determined Contribution (INDC) 23 July 2015

[2] Calculated on the estimated growth of 3.4% on 2010 GHG emissions of 73GtCO_2e projected 2030 figrue of 143GtCO_2e and the estimated Lamu Power Plants emisisons of ~8.8GtCO_2e

7.5.1 *Annual emissions increase*

The emission projection based on GDP growth and projected emissions by 2030 assumes an ~3.4% increase in emissions annually[1]. This is based on the emissions growing from the 2010 level of 73MtCO_2e to 143MtCO_2e. Since there is no actual data upon which to base this assumption it is not possible to assess whether this figure is an over or under estimate of future emissions. Assuming that emissions will increase by 6% per year, the addition of the Lamu Power Plant facility will increase Kenya's emissions by an equivalent amount during the first few years of operation, reducing each year as national emissions rise.
Should the country's emissions growth be less than 6% then this project could add more emissions to the atmosphere per year than the annual increase from the entire country.

7.5.2 *Future greenhouse gas regulation*

Kenya, as a developing country, does not currently have an obligation to reduce greenhouse gas emissions and it unlikely to take on either voluntary or mandatory targets in the future. The country's main focus in relation to climate change is to ensure the safety of vulnerable communities, environments and infrastructure in the face of changing disease distribution, crop productivity and extreme weather events such as droughts, floods and cyclones.

However, the government acknowledges the need for Kenya to play its part in the international response to climate change but needs finance, technology and capacity building in order to do so. Whilst there is unlikely to be legislated emissions targets in the short term, the international community will be looking to Kenya to develop a green, low emissions economy and given the high emissions associated with the Lamu Power Plant, Amu Power Company may face pressure to reduce emissions voluntarily and can look at mitigating this in assuring a clean coal technological implementation and/or some carbon off-set program.

7.6 *ASSESSING SIGNIFICANCE*

Without mitigation, the proposed project will increase greenhouse gas emissions in Kenya by approximately 6% to 10% on 2010 figure of 73MtCO_2e and 2030 143MtCO_2e.[2]

In order to conclude whether this impact is deemed significant or not, a risk classification approach is used. The approach is derived from classic risk assessment nomenclature which involves the expression of risk as the consequence of the event multiplied by the probability of that event. The environmental assessment equivalent is the magnitude of the impact multiplied by the likelihood of the impact. Impact magnitude is a function of the potential intensity of the impact moderated by the extent and duration of that impact. Expressed mathematically impact significance is:

[1] Based on the Intended National Determined Contibution (INDC) 23 July 2015

[2] Kenya's Intended Nationally Determined Contribution (INDC) 23 July 2015

*(Intensity + extent + duration) * likelihood = impact significance*

The remainder of this section, and in particular *Table 3.2*, assesses the significance of the impact of the project on Kenya's national emissions, based on a methodology for impact assessments.

Table 3.2 Assessment of significance

Item	Criteria
Extent	The extent of the impact is national as it is Kenya's greenhouse gas emissions that are directly increased due to the impact of the project. Although the greenhouse effect is transboundary and global emissions are directly affected, this project assesses the impact on Kenya's emissions.
Duration	The duration of the impact is regarded as permanent as science has indicated that the persistence of carbon dioxide in the atmosphere is said to range between 100 and 500 years and therefore continues beyond the life of the project.
Intensity	The substantial increase in Kenya's national greenhouse gas emissions and the long residence time in the atmosphere would indicate that the impact would have a medium intensity during the construction phase when emissions are low and a high intensity during the operational phase when emissions are orders of magnitude higher.
Magnitude	Magnitude is a function of extent, duration and intensity. Given the far reaching and permanent nature of the impacts as well as the high intensity of the impact on Kenya's national emissions, the magnitude of the negative impacts is considered to be medium during the construction phase and high during the operational phase.
Likelihood	The probability of the impact of increased levels of greenhouse gas emissions with the proposed project is regarded as definite.

Significance

In light of the above, the significance of the impact of the emissions from the Lamu Power Plant Facility in Kenya's national emissions can be considered major as illustrated in *Table 3.3*.

Context of Impact Significances

- An impact of negligible significance is one where a resource/receptor (including people) will essentially not be affected in any way by a particular activity or the predicted effect is deemed to indistinguishable from natural background variations.
- An impact of minor significance is one where a resource/receptor will experience a noticeable effect, but the impact magnitude is sufficiently small (with or without

mitigation) and/or the resource/receptor is of low sensitivity/ vulnerability/ importance. In either case, the magnitude should be well within applicable standards.

- An impact of moderate significance has an impact magnitude that is within applicable standards, but falls somewhere in the range from a threshold below which the impact is minor, up to a level that might be just short of breaching a legal limit. This does not necessarily mean that impacts of moderate significance have to be reduced to minor, but that moderate impacts are being managed effectively and efficiently.
- An impact of major significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors.

It must be noted that the impacts is based on the impact the operation will have on the national GHG emissions level which are low in a global context and therefore the impact on that bases is Major.

Table 3.3 Impact Assessment Significance Rating

	Likelihood	Unlikely	Likely	Definite
MAGNITUDE	Negligible	Negligible	Negligible	Negligible
	Low	Negligible	Minor	Minor
	Medium	Minor	Moderate	Major
	High	Moderate	Major	Major

The potential magnitude of the impact is highly uncertain and involves unique/unknown risks. However, according to current designs, there is high confidence that the significant greenhouse gas emissions from the Lamu Power Plant Facility would have a major impact on Kenya's national emissions.

7.7 OVERALL IMPACT ON KENYA'S NATIONAL EMISSIONS

In conclusion, the following assumptions can be defined:

- The impacts of climate change are global in nature;
- Kenya's emissions were low in 1994 but based on GDP growth rate and Planned build plan for new national generation capacity are projected to grow significantly in the coming decades;
- The Lamu Power Plant Facility is estimated to emit approximately ~ 8.8 Mega tonnes of CO_2 per year during full operation.
- Without mitigation, the proposed project will increase greenhouse gas emissions in

Kenya by approximately 06 to 10% on 2010 figure of 73MtCO_2e it must be noted that it is from a low base.

- The Lamu Power Plant Facility has relatively high emissions intensity (kgCO_2e per kWh produced) than other energy generation facilities like nuclear, gas or renewables.
- The Kenyan government acknowledges the need for the country to play its part in the international response to climate change and has put in place the Environmental Management and Co-Ordination (Air Quality) Regulation 2014;
- The Kenyan government has also state that they intent on a 30% abatement on BAU projections of GHG emissions (143MtCO_2e) by 2030and
- Amu Power Company may face pressure from shareholders and the international community to reduce emissions voluntarily.

Based on above assessment that the magnitude of the impact of the Lamu Power Plant Facility on Kenya's national emissions could be medium to high and the definite likelihood of the impact occurring, the significance of the impact is rated as **Major** as summarised in *Table 3.4*.

Table 3.4 Impact of Lamu Power Plants GHG Emissions on Kenya's National Emissions

	Without mitigation	**Residual Impact (With mitigation)**
Construction Phase		
Extent	National/Global	National/Global
Duration	Permanent	Permanent
Intensity	Medium	Medium
Magnitude	Medium	Medium
Likelihood	Definite	Definite
Significance	***Major***	***Major***
Operational Phase		
Extent	National/Global	National/Global
Duration	Permanent	Permanent
Intensity	High	High
Magnitude	High	High
Likelihood	Definite	Definite
Significance	***Major***	***Major***
Decommissioning and Closure Phase		
Duration	n/a	n/a
Scale	n/a	n/a
Severity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	During decommissioning, emissions from the project will decrease significantly and will cease after closure. However, the long residence time of carbon dioxide in the atmosphere means that the long term impact on the greenhouse effect and climate change will continue well beyond the closure of the plant.	

8 RECOMMENDATIONS FOR POTENTIAL EMISSION REDUCTION ACTIONS

8.1 INTRODUCTION

Given its global nature, mitigation of the impact of climate change takes the form of reducing the concentration of greenhouse gases in the atmosphere. Amu Power Company has an opportunity to influence the overall impact of the Lamu Power Plant Facility and associated activities on GHG emissions by ensuring that the final design includes the most energy efficient and low emissions options available.

The greenhouse gas efficiency of Lamu Power Plant facilities is influenced by a range of factors, including (not an exhaustive list):

- Boiler efficiencies;
- Grade of coal;
- Coal moisture content;
- How power is generated – choice of energy source, technology and configuration; and
- Waste heat recovery.

This section identifies a number of best practice options Amu Power Company could consider to increase the energy efficiency and/or emissions intensity of its activities in Kenya and thereby reduce Scope 1 emissions.

These options include:

- Waste Management
- Transportation
- Green buildings
- Reduced deforestation

Given the early stage in the design of the project, it was not possible to accurately estimate the abatement potential of each option. These activities will, however, contribute towards the sustainability of the project, reducing the greenhouse emissions, and reducing costs (e.g. fuel use for electricity generation). It is recommended that the design engineers consider these issues in the development of the FEED Study.

8.2 MITIGATION OPTIONS

8.2.1 *Waste Management*

There are currently two options for the treatment of waste water (sewage) from the site. The first is standard treatment with waste water and solids being disposed of at sea (this is the option included in the carbon footprint calculation) or used as compost. The second, which is for the organic rich waste to be filtered through man-made mangroves to clean the water naturally and to sequester carbon deep within the mangrove root systems and soil and thus acting as a carbon sink. A 300-hectare field study of natural mangrove intertidal wetlands in

Shenzhen[1]. The findings suggest that mangrove intertidal wetlands are of great potential for natural wastewater treatment,and are unlikely to produce any harmful effect on the higher plant communities. The ESIA reports have noted that the sewage treatement plant proposed will reuse the water as dust suppressant and all solids will be composted.

8.2.2 Transportation

Optimisation of transport logistics (e.g. equipment, products and people) and the use of energy efficient vehicles and machinery will reduce fuel consumption and therefore GHG emissions. (Hybrid Buses and cars, restrict air travel and use video conferencing)

8.2.3 Green Buildings

The majority of emissions linked to offices and accommodation are associated with electricity use and heating/cooling. By building well insulated buildings which utilise renewable energy and efficient cooling systems, the carbon footprint associated with these activities will be reduced as will the cost of fuel and energy

There are a number of initiatives which can be implemented when constructing the camps and offices which will help reduce electricity consumption and GHG emissions. Whilst the majority of these initiatives may not significantly reduce the overall carbon footprint, they would improve the efficiency of the buildings. Initiatives include:

- **Solar power -** significant reductions in electricity use from buildings can be expected if all hot water is provided from water heaters and photovoltaic panels can supplement fossil fuel generated electricity;
- **Insulation** – well insulated walls and ceilings will reduce temperature extremes within the buildings leading to more comfortable living/ working conditions and reduced air conditioning requirements;
- **Lighting** – use of natural light where possible and compact fluorescent or LED lighting throughout the site will reduce electricity consumption;
- **Cooling** – energy efficient air conditioners which use refrigerant gases with a low global warming potential (such as R134); and
- Buildings (particularly offices) should be fitted with sensors, timers and **control systems** which allow lights and equipment to switch off or go onto stand by when not in use (e.g. overnight).

All of the above will contribute towards electricity savings and thereby reduce the overall operational carbon footprint of the site.

[1] Asia-Pacific Conference on Science and Management of Coastal Environment (1997-01-01) 123: 49-59 , January 01, 1997 By Wong, Y. S.; Tam, N. F. Y.; Lan, C. Y.

8.2.4 *Reduced Deforestation/Offsets*

Land clearance in advance of construction of the facility is estimated to account for approximately a third of estimated total emissions for the first year of construction and the other two thirds being the construction and living activities on site. This 'once off' release of emissions can be offset by progressive rehabilitation of unused land on site as well as a 'biodiversity offset' elsewhere in the region which will could act as a carbon sink and offset some, if not more than the emissions from land clearance.

The communities surrounding the proposed site primarily obtain energy for cooking and heating from biomass created from surrounding vegetation leading to potentially high levels of deforestation. The Lamu Power Plant has already reduce this deforestation and therefore improved the local air quality and living conditions for local communities by providing solar lighting to the local community, planted over 300,000 seedling of tress with a goal of planting 1,000,000 seedlings in their own nursery by the end of 2015. By the end of 2016, the plan is to plant about 3,000,000 seedlings. All the seedlings will be transplanted within the project site and surrounding areas of Lamu County

Whilst not contributing to a reduction in Lamu Power Plant's direct carbon footprint, it supports national efforts to reduce deforestation and to improve living standards in rural communities.

8.3 RECOMMENDATIONS FOR MITIGATION

It is recommended that Amu Power Company consider the following whilst undertaking the FEED Study and finalising the design of the Lamu Power Plant Facility in order to minimise greenhouse gas emissions:

- Consider options for implementation of waste heat recovery in order to improve the thermal efficiency of the plant;
- Consider the development of a man-made mangrove for the treatment of sewerage in order to sequester carbon[1]
- Optimise transport logistics
- Incorporate 'green building' features in the design of offices and accommodation;
- Explore options for providing local communities with electricity to offset deforestation.

[1] Asia-Pacific Conference on Science and Management of Coastal Environment (1997-01-01) 123: 49-59 , January 01, 1997 By Wong, Y. S.; Tam, N. F. Y.; Lan, C. Y.

9 RECOMMENDATIONS FOR MONITORING

In order to align the Lamu coal power plant with the IFC requirements for annual reporting of GHG emissions, it is important for an effective and efficient data management system to be implemented from the start. The system can be used to monitor a range of sustainability indicators in addition to energy use and emissions such as water, biodiversity, health and safety etc. A robust carbon management strategy and carbon/sustainability reporting framework could be developed which should:

- Enable a **management and reporting policy** to provide direction and commitments to sustainable development and carbon reporting.

- Outline **reporting procedures** in light of this policy.

- Assign **roles and responsibilities** to ensure effective implementation of both internal and external carbon and sustainability reporting requirements.

- Define **timing for data reporting** - quarterly reporting of data will enable Amu Power Company to monitor progress against targets, facilitate effective progress on annual sustainability reporting and carbon management and ensure the integration of sustainability into the business.

- Develop a robust **monitoring and reporting methodology** detailing calculations and measurements, estimations, assumptions, definitions, conversion factors etc. In the case of measurements this should include: the type and frequency of sampling; checks on the reliability of tests; corrective measures; instructions regarding missing data etc. If Amu Power Company has formal ISO14001 &/or ISO 50001 Environemtnal and Energy management systems respectively in place there is an opportunity to integrate 'monitoring and reporting' of environmental data into the Environmental Management Systems (EMS) in terms of formalised procedures and controls. The monitoring and reporting of the full range of environmental parameters could be included and driven under the 'other requirements' clause of ISO 14001. It is recommended that duplication of systems is minimised and existing management systems be used as a 'vehicle' providing the framework of procedures (controls) and audit trails (documented evidence) required for reporting and auditing purposes.

- Compile a **'Carbon Reporting Operating Manual'** to provide guidance on data requirements, achieve consistency in definition interpretation and establish the foundation for an audit trail for future data verification.

- Report on GHG emissions and sustainability performance annually to investors, shareholders and the public (e.g. through Amu Power Plant's Sustainability Report).

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Appendix A

The Climate Challenge

APPENDIX A: THE CLIMATE CHALLENGE

This Appendix presents background information on climate change to provide context.

The Greenhouse Effect

The earth is a complex system with geological, hydrological, biological and atmospheric cycles intimately linked by a series of positive and negative feedback interactions causing fluxes in the concentration of greenhouse gases in the atmosphere and the global mean surface temperature over millennia. The earth system is also affected by external influences such as the intensity of solar radiation and its orbit around the sun.

Solar radiation entering the atmosphere is absorbed by the earth's surface and then re-radiated as infrared radiation. Some of this infrared radiation is absorbed by certain "greenhouse" gases in the atmosphere, preventing its return to space. Without the regulating influence of the atmosphere, the earth's mean surface temperature would be 30˚C colder than today's ambient 15˚C. The "greenhouse effect" is the key mechanism for trapping warmth from the sun in the atmosphere.

There is consensus that human activity, through the emission of greenhouse gases, has significantly contributed to the observed warming since the pre-industrial revolution era[1].According to an ongoing temperature analysis conducted by scientists at NASA's Goddard Institute for Space Studies (GISS), the average global temperature on Earth has increased by about 0.8° Celsius (1.4° Fahrenheit) since 1880. Two-thirds of the warming has occurred since 1975, at a rate of roughly 0.15-0.20°C per decade.[2] The year 2014 was the warmest year across global land and ocean surfaces since records began in 1880. The annually-averaged temperature was 0.69°C above the 20th century average of 13.9°C, easily breaking the previous records of 2005 and 2010 by 0.04°C. This also marks the 38th consecutive year (since 1977) that the yearly global temperature was above average. Including 2014, 9 of the 10 warmest years in the 135-year period of record have occurred in the 21st century[3].

The Impact of Climate Change

The increase in temperature associated with rising CO_2 concentrations could have significant consequences on the earth system. Changes in temperature will affect weather patterns which may result in more extreme precipitation events, storms, droughts etc. Melting ice caps and glaciers and thermal expansion of the oceans are projected to increase sea levels. These may have knock-on implications for many aspects of the environment and human

[1] IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp.

[2] http://earthobservatory.nasa.gov/

[3] www.ncdc.noaa.gov

society. According to the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment report published in 2014, notes that over large parts of Africa, warming could exceed 2°C by 2050 and rise by as much as 2.6 – 4.8°C by the end of the century. Key impacts projected for Africa for the period 2020 to 2050 include the following[1]:

- 75 to 250 million people will experience greater water stress by 2020;
- Rain-fed agricultural yields could be reduced by 50% by 2020 in some countries;
- 10-30% reduction in average river run-off and water availability by ~2050;
- Drought-affected areas will increase in extent;
- Flood risk in high rainfall areas will increase;
- Surface temperatures have already increased by 0.5–2°C over the past hundred years;
- Ecosystem structures will change and there will be a loss of biodiversity if temperatures increase more than 1.5 to 2.5°C;
- Human health challenges will arise, e.g. possible changes in malaria transmission potential.

It is widely accepted that climate change has already begun to affect physical and biological systems, including people, and that current concentrations of GHGs (which are still increasing at an accelerating rate) commit the world to at least 2°C warming and probably 2.4 °C [2], and hence continued environmental change. Both the Millennium Ecosystem Assessment and the IPCC Fourth Assessment Report, outline the effects of global climate change, including more frequent extreme weather events, rising sea levels, water shortages, threats to food security, disease and other health effects. *Figure A.1* outlines these effects in relation to global temperatures and their severity.

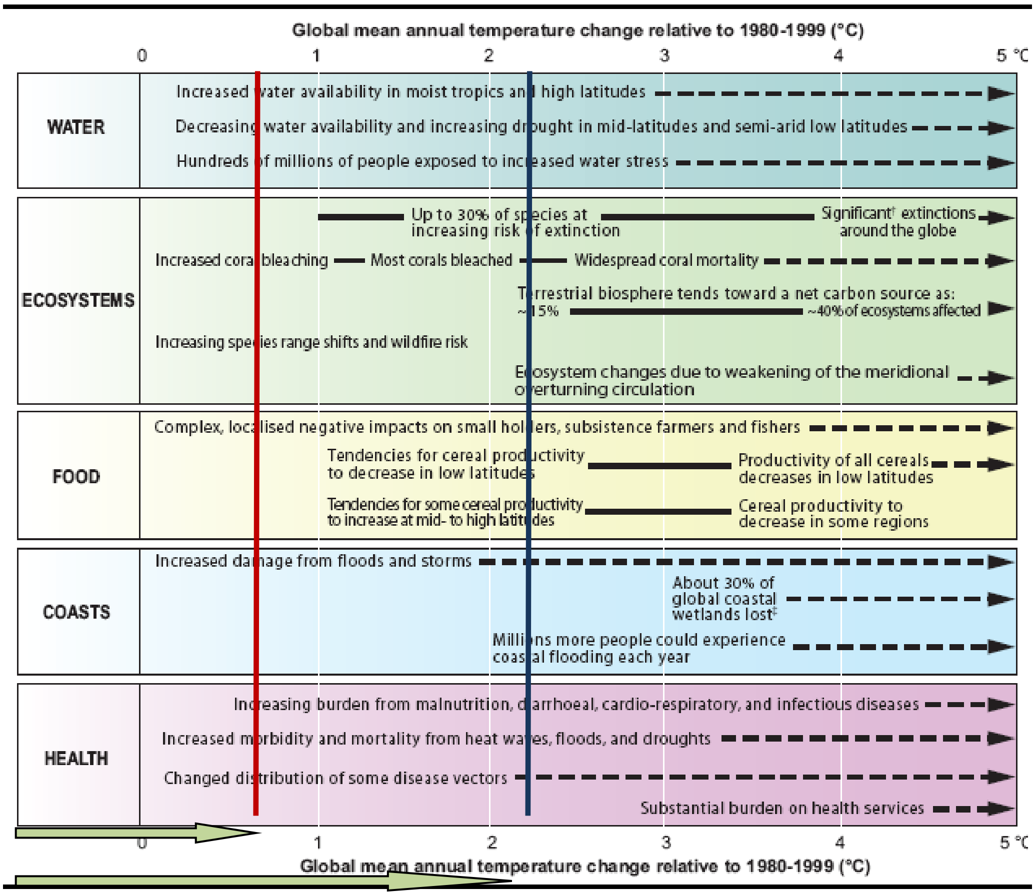
On average the world is currently 0.74°C warmer than it was 100 years ago which implies that the physical and biological changes identified by the IPCC that appear to the left of the red line (at 0.74°C) in *Figure A.1* are already taking place. Current concentrations of GHGs in the atmosphere almost certainly commit the world to a 2.2°C temperature rise by 2050, implying that the changes to the left of the purple line are inevitable.

Figure A.1 The impact of rising temperatures on natural systems [3]

[1] Report. Summary for Policy Makers, IPCC, 2007

[2] IPCC (2007) Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment. Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 976pp.

[3] www.ipcc.ch/publications_and_data/ar4/syr/en/spms3.html



Future climate trends for Africa[1]

Projected temperature trends: During this century,temperatures in the African continent are likely to rise more quickly than in other land areas, particularly in more arid regions. Increases in average temperatures are very likely in the mid- and late-21st century under both low- and high emissions scenarios.

Under a high-emissions scenario, average temperatures will rise more than 2°C, the threshold set in current international agreements, over most of the continent by the mid-21st century. Average temperatures will rise more than 4°C across most areas by the late 21st century. Changes in average temperature are projected to be greater over northern and southern Africa and relatively smaller over central Africa. Under a low-emissions scenario, average temperature rises across Africa are projected to be less than 2°C by both the mid- and late-21st century.

Projected rainfall trends: Projections for rainfall are less certain than projections for temperature. Most areas of the African continent do not show changes in annual average rainfall under low-emissions scenarios. However, projections do show a very likely decrease in annual average rainfall over areas of southern Africa beginning in the mid-21st century, and expanding substantially by the late-21st century, under a high-emissions scenario. In

[1] www.cdkn.org - (AR5 IPCC Whats in it for Africa)

contrast, likely increases in annual average rainfall are projected over areas of central and eastern Africa beginning in the mid-21st century for the same high-emissions scenario.

Projected extreme events: In the next two or three decades, the expected increase in climate extremes will probably be relatively small compared to the normal year to year variations in such extremes. However, as climate change impacts become more dramatic, their effect on a range of climate extremes in Africa, including heavy rainfall, heat waves and drought, will become increasingly important and will play a more significant role in disaster impacts.

Projected sea level rise: Under all emissions scenarios – low and high – the rate of sea level rise will very likely exceed that observed during the past three decades due to increased ocean warming and increased loss of mass from glaciers and ice sheets. Global mean sea level rise during the last two decades of the 21st century (as compared to sea level in 1986–2005) will likely be in the range 26–55 cm under a low-emissions scenario, but 45–82 cm for a highemissions scenario – with total sea level rise of up to 98 cm (~ 1m) by 2100 under this latter scenario. This magnitude of sea level rise by the century's end implies significantly increased risks for Africa's coastal settlements, as well as for coastal economies, cultures and ecosystems.

East Africa Summary

Observed Climatic Changes (Hulme et al., 2001; IPCC, 2001) in East Africa:

- Warming of 0.7°C over the 20th century for Africa;
- 0.05°C warming per decade through the 20th century; and
- Increased precipitation for East Africa

Projected Climate Change (Hulme et al., 2001; IPCC, 2001) in East Africa;

- Projected warming for Africa ranges from 0.2°C per decade (low scenario) to more than 0.5°C per decade (high scenario);
- 5-20% increase in precipitation from December-February (wet months);
- 5-10% decreased in precipitation from June-August (dry months);
- Annual flow reductions of 6-9% in the River Pangani and 10% in the River Ruvu (Tanzania) (VPO-URT, 2003);
- El Nino events produce abnormally high amounts of precipitation in parts of equatorial East Africa and can result in flooding and decreased agricultural yields (IPCC, 2001);
- Intensity of future disease outbreaks and may increase the spread of diseases in some areas (IPCC, 2001);
- Mangroves are at threat from deforestation, coastal erosion and extreme weather and have been identified as one of the most vulnerable species to sea-level rise and inundation (IPCC, 2001);
- A temperature increase of 1.2°C and the resulting changes in precipitation, soil moisture and water irrigation would cause large areas of land that now support tea cultivation in Kenya to be largely unusable (Simms, 2005).

Extreme Weather Events

- Warming temperatures are projected to cause more frequent and more intense extreme weather events, such as heavy rain storms, flooding, fires, hurricanes, tropical storms and El Nino events (IPCC, 2001);
- Climate change is projected to cause more frequent and intense ENSO events, leading to widespread drought in some areas and widespread flooding in others (Wara et al., 2005);
- Warming temperatures are projected to cause more frequent and intense hurricanes and tropical storms that inundate coastal areas (IPCC, 2001).

Appendix B

Carbon Footprint Assumptions and Calculations

ASSUMPTIONS AND CALCULATIONS FOR CARBON FOOTPRINT

B.1 MOBILE COMBUSTION

Road Transport

- 60 Seater Hybrid diesel bus
  - Total distance was calculated according to assumptions and internet research on potential routes and likely number of trips per week;
  - According to http://en.wikipedia.org/wiki/Fuel_efficiency_in_transportation a diesel bus uses 39 litres per 100km;
  - A Volvo hybrid diesel bus is 37% more efficient than a standard diesel bus. This equates to 24.5litres per 100km www.volvobuses.com/bus/india/en-in/_layouts/CWP.Internet.VolvoCom/NewsItem.aspx?News.ItemId=116277&News.Language=en-gb ;
  - From the IPCC 2006 GHG Guidelines 1 litre of diesel emits 2.71 kilograms of CO_2;
  - To determine kilograms CO_2 per kilometer the following equation was used.
  - CO_2 Emissions = Fuel Used x Heating Value x Emission factor - (39 * (1-0.37)) * 2.71 / 100 = 0.665 kg CO_2 /km
  - Total kilometers travelled were then multiplied by this conversion factor to obtain yearly and quarterly tCO_2e.

- Double and Single Cab 3L D-4D Toyota Hilux
  - Total distance was calculated according to asumptions and internet research on possible routes and likely number of trips per week;
  - 226 grams CO_2 per kilometer was sourced from http://www.toyota.co.za/VehicleHighlights.aspx?vehicleModelId=34. This figure was converted to 0.26 kg CO_2 / km; and
  - Total kilometers travelled were then multiplied by this conversion factor to obtain yearly and quarterly tCO_2e.

- Toyota Prius Sedan
  - Total Distance was calculated according to assumptions and internet research on possible routes and likely number of trips per week;
  - 94 grams CO_2 per kilometer was sourced from http://www.toyota.co.za/VehicleHighlights.aspx?vehicleModelId=85 . This figure was converted to 0.94 kg CO_2 / km; and
  - Total kilometers travelled were then multiplied by this conversion factor to obtain yearly and quarterly tCO_2e.

- Articulate Truck (3.5 - 33t)
  - Total distance was calculated according to assumptions and internet research on possible routes and likely number of trips per week;
  - 0.87706 kilograms CO_2 per kilometer was sourced from DEFRA 2013 Conversion Factors for Company Reporting for Articulate Truck (3.5 – 33t) at 50% capacity; and

    - Total kilometers travelled were then multiplied by this conversion factor to obtain yearly and quarterly tCO2e.

- Rigid Truck (3.5 -7.5t)
    - Total Distance was calculated according to assumptions and internet research on possible routes and likely number of trips per week;
    - 0.59739kilograms CO2 per kilometer was sourced from DEFRA 2011 Conversion Factors for Company Reporting for Rigid Truck (3.5 – 7.5t) at 50% capacity; and
    - Total kilometers travelled were then multiplied by this conversion factor to obtain yearly and quarterly tCO2e.

B.2 STATIONARY COMBUSTION

Diesel Use

- Diesel Generators
    - According to the assumption that a 20MW of power would be generated per year until the first boiler is on online. This would require 15,783,784 litres of diesel per year;
    - Standard IPCC 2006 GHG guidelines were used to determine the tCO2e emissions per year; and
    - The diesel generators were assumed to be off line from Q1 of 2020.

- Construction Work
    - It was assumed that ~12,500 litres of diesel would be used per day for construction;
    - Standard IPCC 2006 GHG guidelines were used to determine the tCO2e emissions per year; and
    - Construction was assumed to be complete by the end of Q1 2020.

B.3 WASTE EMISSIONS

Waste Water Treatment

- Assumption of the waste water flow rate was estimated at 1130 litres per day for a camp of 4000 people. This rate was then adapted for the number of people on site during the construction(3000), construction and operation(3500), and only operation phase (500); and
- The biological oxygen demand treatment process was used for the waste water treatment and standard IPCC 2006 GHG guidelines were used to determine the tCO2e emissions per year.

B.4 LAND CLEARING

Land cleared for the construction of the site

- The area deforested will be approximately 80ha;
- A carbon fraction of 0.47 above ground forest biomass for tropical and dry coastal forest (tonnes C / tonnes dry matter) was taken from Table 4.3, Volume 4 of IPCC Guidelines for National Greenhouse Gas Inventories;

- The average biomass on Lamu Power Plant site of 46 m3/Ha[1] was estimated using google map of estimated site location;
- Compensation factor for soil carbon stock used a factor of 1.20, this figure was sourced from forestry expert Thi-Tam Vu;
- Tree densities were calculated using data from http://www.protea-timbers.co.zadensity.htm . The calculated tree density was 0.946 tonnes per m3; and
- Standard IPCC 2006 GHG guidelines for land clearing were used to determine the tCO2e emissions for the first year of construction. It was assumed no further land clearing would occur for the duration of the Lamu Power Plant project.

B.5 NON COMBUSTION EMISSIONS

Refrigerants

- Refrigerant emissions are calculated by the amount of refrigerant that is replaced on a yearly basis. Standard refrigerants have very high global warming potentials (GWP) making them a potentially high emission source. However, international regulation are phasing out harmful refrigerants and new refrigerants will very low GWP are available;
- It was assumed that all refrigerants would be filled using HFO-1234yf which has a GWP of 4. This is very low considering the standard R134A refrigerant has a GWP of 1430; and
- The amount of refrigerant replaced is multiplied by the GWP and converted to tCO2e.

Lubricants and Oils

- Lubricants used for heavy duty machinery and equipment were considered to be fossil fuel based; and
- Emissions from the use of lubricants and oils were calculated using standard IPCC 2006 GHG Guidelines for lubricants and oils.

B6 Petrol, Coal to Electiricty Calcualtions

	Quantity Litre	Density kg/L or kg/m³ for LPG	Quantity of fuel combusted (kg)	Heat/Calarific Value of fuel MJ/kg	C content factor (kg/GJ0)	CH4 emission factor (kgCH4/GJ)	N2O emissions factor (kg N2O/GJ)	Oxidation Factor	Unit conversion factor	Total CO2	Total CH4	Total N2O	Total CH4 emissions (t/CO2e)	Total N2O emissions (tCO2e)	Annual Total (tCO2e)
Petrol	235 486	0.74	174 260	44.3	18.9	0.003	0.0006	100%	0.001	534.9753522	0.023159106	0.004632	0.486341	1.435865	537
Diesel	792 000	0.85	673 200	43	20.2	0.003	0.0006	100%	0.001	2144.05224	0.0868428	0.017369	1.823699	5.384254	2151
Stationary Diesel	15 783 784	0.85	13 416 216	43	20.2	0.003	0.0006	100%	0.001	42728.85982	1.730691892	0.346138	36.34453	107.3029	42 873
Coal to Electricty			3 600 000 000	25.8	25.8	0.001	0.0015	100%	0.001	8786448	92.88	139.32	1950.48	43189.2	8 831 588
															8 877 148
				2006 IPCC Guidelines for national Greenhouse Gas Inventories, Volume 2: Energy, Chapter 1 Introduction	2006 IPCC Guidelines for national Greenhouse Gas Inventories, Volume 2: Energy, Chapter 1 Introduction	2006 IPCC Guidelines for national Greenhouse Gas Inventories, Volume 2: Energy, Chapter 2 Stationary Combustion	2006 IPCC Guidelines for national Greenhouse Gas Inventories, Volume 2: Energy, Chapter 2 Stationary Combustion								
				Table 1.2	Table 1.3	Table 2.2	Table 2.2								
				Page 18	Page 21	Page 16	Page 16								

[1] Forestry Department Food and Agriculture Organization of the United Nations – Wood Volume and Woody Biomass – Review FAO & IPCC 2006 - Volume 4 Chapter 4_Forest_Land