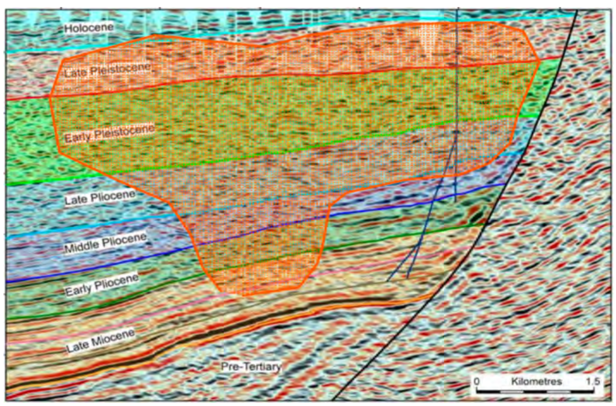
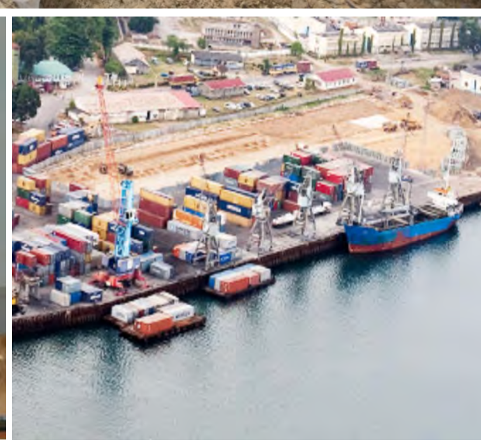
East Africa Crude Oil Pipeline:

EACOP lifetime emissions from pipeline construction and operations, and crude oil shipping, refining, and end use





By Richard Heede

Climate Accountability Institute

21 November 2022

Climate Accountability Institute

Principal Investigator: Richard Heede
heede@climateaccountability.org
Snowmass, CO 81654 USA
970-343-0707 mobile

Hormann, Christoph (2012) Views of the Earth, Lake Albert and the Albertine Lift from the north, http://earth.imageco.de

Report commissioned by:
Climate Litigation Accelerator at the Center for Human Rights and Global Justice at New York University Law School, on behalf of:
Natural Justice, Nairobi and Capetown

Project coordinator: César Rodríguez-Garavito (NYU)

Any errors, omissions, and shortcomings are the author's.

Note on units: International SI units are used throughout, except where reporting is in bbl of oil, cubic feet of natural gas, or (short) tons of coal. Emissions of methane are expressed in CH_4 or in CO_2-equivalent terms (CO_2e; AR4: 100-y, $28xCO_2$).

Cover: NS Energy Business, Robert Stewart (seismic line, from Logan et al. 2009, University of Houston), GeoExpro (2018) & Tullow Oil, Tanzania Port Authority (Tanga Port)

TABLE OF CONTENTS

FIGURES

TABLES

< 0 >

ABSTRACT

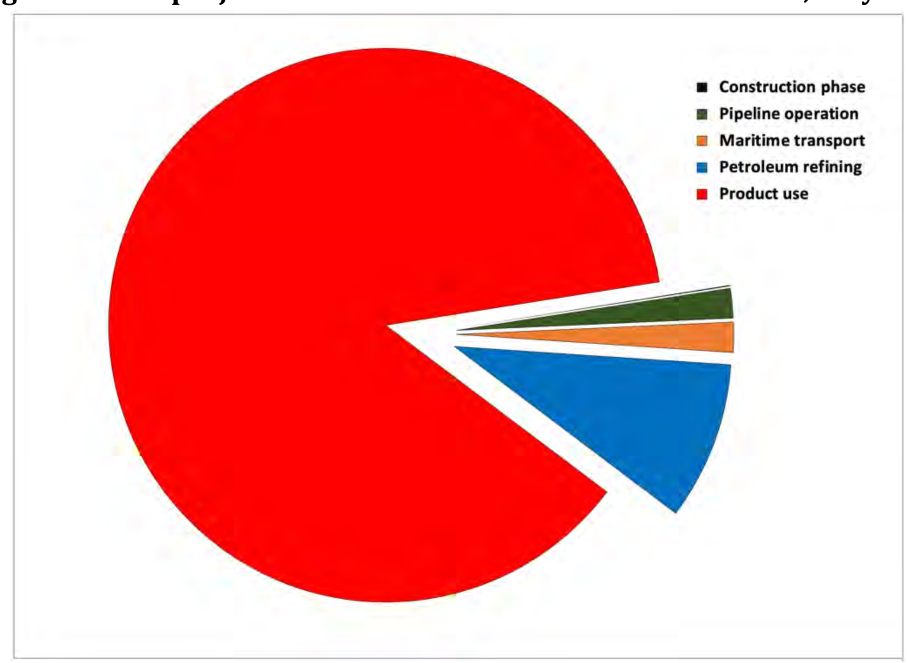
"He who can but does not prevent, sins." — Antoine Loysel, 1607.

"*The government and oil companies have not informed us about the negative impact that the EACOP will have on our wellbeing. All they tell us are good things that the EACOP will bring like roads and jobs. We also want to know the negative impact of the pipeline so that we can make informed decisions."*

– A community member from Rujunju village, Kikuube District in Uganda.[1]

Climate Accountability Institute (CAI) has reviewed the environmental assessments by the East Africa Crude Oil Pipeline (EACOP), a consortium of the oil companies TotalEnergies (France) and China National Offshore Oil Corporation (CNOOC) for the purpose of transporting crude oil from their fields at Tilenga and Kingfisher at Lake Albert through the proposed 1,443 km pipeline to the Marine Storage Terminal at Port Tanga, Tanzania. CAI's evaluation of the EACOP assessments of greenhouse gas emissions attributable to the pipeline's construction phase and its 25-year operational life is that the source identification, emissions quantification, detailed calculations, and documentation are neither reliable nor complete. Neither report presents energy use data in the needed detail for our verification or additional emission calculations.

Figure 25: full project emissions from construction to end use, 25-yr life



The EACOP reports do not acknowledge the full climate impacts of the crude oil with respect to emissions from maritime transport of the crude oil to global markets, its refining into petroleum products, or, more significantly, emissions from the end use of the carbon fuels, once refined and sold to and used as intended by consumers in Europe or China or wherever their crude is refined

[1] Quoted in Oxfam (2020) *Empty Promises*: Box p. 68.

and sold. Considering EACOP's omissions, CAI calculates these three significant emission sources, - which are far larger than the pipeline emissions covered by EACOP.

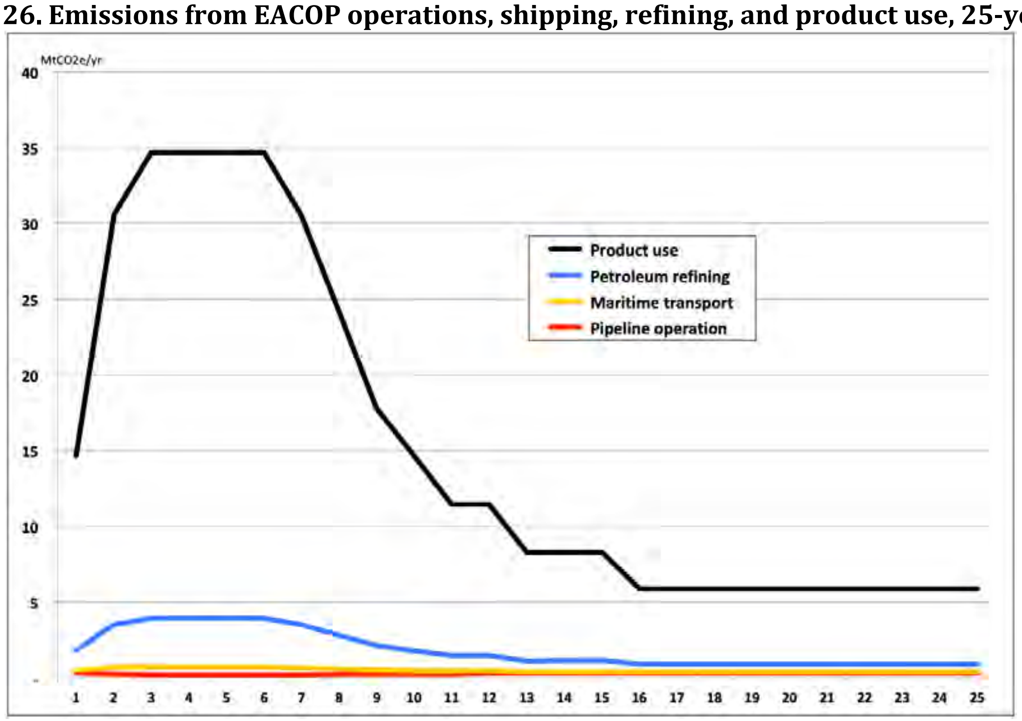
CAI documents EACOP emissions totaling 379 million tonnes CO_2e ($MtCO_2$e) for the full value chain of emissions from pipeline transport of crude oil to the oil's end use by global consumers. This far exceeds the partial estimate of 0.24 $MtCO_2$e for EACOP pipeline construction and the incomplete and poorly documented estimate of pipeline operational emissions of 6.55 $MtCO_2$ over the pipeline's anticipated 25-year planning horizon. See the following chapters for discussion.

Of the full lifecycle emissions (excluding production and field emissions) detailed in this report, EACOP's estimated construction and operational emissions over the project's 25-year lifetime accounts for only 1.8% of the project total, as quantified here. In our assessment, emissions from maritime shipping to Europe and/or China accounts for 1.8% (including the empty return trip), emissions from refining the crude oil into marketable petroleum fuels accounts for 9.2%, and emissions from the products being used as intended the lion's share of 87.2%.

Table 15: value chain emissions: construction, operations, shipping, refining, & product use

	Project phase $MtCO_2$e	Percent	Comments
Upstream production			not included
Construction phase	0.24	0.06%	partial EACOP estimate, Uganda only
Pipeline operation	6.55	1.73%	relies on EACOP data, flawed?
Maritime transport	6.67	1.76%	preliminary estimate, CAI
Refining	35.00	9.23%	preliminary estimate, CAI
Product use	330.71	87.22%	end use estimate, net non-energy
Total:	**379.17**	**100%**	**379 million tonnes CO_2e**

Figure 26. Emissions from EACOP operations, shipping, refining, and product use, 25-year life



-#-

< 1 >

INTRODUCTION: BOUNDARY & SCOPE

Introduction

Climate Accountability Institute (CAI) is commissioned to calculate the emissions of carbon dioxide (CO_2) from the end use of crude oil transported through the proposed East Africa Crude Oil Pipeline (EACOP) that would transport oil from the French oil major Total SA's and China National Offshore Oil Company's (CNOOC) oil fields on the northern and eastern shores of Lake Albert in west Uganda through a 1,443 km pipeline (24-inch diameter carbon steel, buried, insulated, and heated) from Hoima in Uganda to the Port of Tanga in northeastern Tanzania. See Figure 1.

CAI is also asked to assess reliability and completeness of EACOP's emission estimates attributable to pipeline construction and its 25-year operational life.

CAI relies on data published by EACOP (2019) *Environmental and Social Impacts Assessment: Tanzania* and EACOP (2020) *Environmental and Social Impacts Assessment: Uganda* reports. CAI consulted several other reports on various aspects of the proposed EACOP pipeline, its environmental impacts and greenhouse gas emissions (CNOOC[2]), project costs,[3] declining value of Uganda oil production in the context of a shrinking global carbon budget (Climate Policy Initiative[4]), project financing (Bank Track[5]), human rights (Oxfam et al.[6]) and various technical and scientific resources for quantifying the climate impacts of the proposed oil field development and pipeline project.

Figure 1. Map of EACOP pipeline route from Hoima, Uganda to Tanga, Tanzania.

[2] CNOOC (2018) *Kingfisher Oil Development Environmental and Social Impact Assessment.*

[3] TotalEnergies FID is for $3.5 billion, but costs are escalating: Esau, Iain (2022) Plenty to ponder: 'Sky rocketing prices' drive cost of TotalEnergies' EACOP pipeline to $5 billion as schedule slips, *Upstream*, 21 April.

[4] Climate Policy Initiative (2020) *Understanding the impact of a low carbon transition on Uganda's planned oil industry*.

[5] BankTrack et al. (2019) *Your Bank's Role in Arranging Finance for the East Africa Crude Oil Pipeline*.

[6] Oxfam (2020) *Empty Promises Down the Line? A Human Rights Impact Assessment of the East African Crude Oil Pipeline*,

Figure 2. Diagram of EACOP pipeline system components.[7]

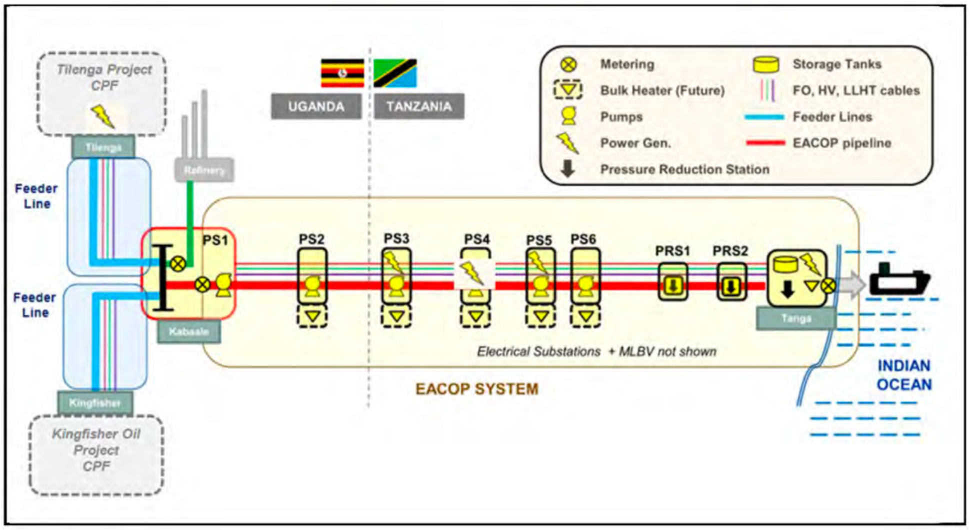


Figure 3. Tanzania ESIA report, Table 2.2-1: Project design basis.

Parameter	Value
Design flow rate	216,000 barrels per day
Pipeline diameter	24 in. nominal
Pipeline minimum operating temperature	50°C
Marine storage terminal (MST) minimum storage tank oil temperature	63°C

Boundary discussion

A project of this scope can have a broad range of boundary definitions, by which we mean the various sources of emissions that are related to the construction, development, and operation of a project and extending all the way to the end use of a resource (in this case crude oil produced by CNOOC and Total and exported via the EACOP pipeline over the project's 25-year time horizon). A boundary can also include energy and emissions arising from the manufacturing and transportation of material resources brought to a project, such as steel for the ~367,000-tonne pipeline.[8] By way of example, steel production emits, on average, 1.85 tCO_2/tonne, thus 679,000 tonnes CO_2 for the proposed pipeline, *excluding* shipping and transportation from steel mills to pipe yards along the pipeline route.[9] However, steel emissions are outside our defined boundary and are thus excluded.

The focus of this report is two-fold. First, the construction and operation of the pipeline, the use of fuels and electricity in construction (such as fuel used by construction vehicles, road construction equipment, trenching, pipelaying, worker camps) and operation (such as bulk heaters and pump stations along the length of the EACOP pipeline). We rely on EACOP's two *Environmental and Social Impact Assessment* (ESIA) reports – one each for Uganda and Tanzania – for basic data and emissions attributable to construction and operational energy use. We evaluate the quality of these CO_2 emission estimates, and comment on shortcomings and uncertainties of their CO_2 estimates.

---

[7] East Africa Crude Oil Pipeline (2019) *Environmental and Social Impact Assessment, EACOP Project, Tanzania ESIA*, Project Description, page 2.

[8] ASTM 24-inch pipe for crude oil transport weighs ~254 kg/meter. (ASTM A53 pipe, nominal thickness 0.69 inches), https://www.engineeringtoolbox.com/ansi-steel-pipes-d_305.html). This indicates a quantity of steel weighing 367,000 tonnes, excluding gathering lines, drilling rigs, processing stations, pump stations, refinery, machinery, and equipment.

[9] McKinsey & Company (2020) *Decarbonization challenge for steel*, McKinsey, 3 June. "Every ton of steel produced in 2018 emitted on average 1.85 tons of CO_2" (Source: World Steel Association). https://www.mckinsey.com/industries/metals-and-mining/our-insights/decarbonization-challenge-for-steel

Second, but more significant, is the quantification of emissions from the end use of the carbon fuels refined from Ugandan crude oil by consumers in various European and Chinese markets (or any markets the EACOP consortium markets its crude to). Climate Accountability Institute quantifies end use (or product use) emissions, based on crude oil pipeline flows over the project's anticipated 25-year life in chapter 8, as well as shipping emissions from the Suezmax tankers required to bring crude oil to refineries in Europe or China, and the substantial energy and emissions from refining the waxy crude into petroleum products for distribution to regional or global consumers.

Boundary definition

The boundary of our study is focused on the EACOP pipeline and downstream climate impacts:

- emissions from the pipeline's construction: 1,443 km length, bulk and trace heaters, work camps, road construction, trenching, power generation equipment, matériel yards, pumping stations, crude oil storage tank farm at Port Tanga, etc.;
- emissions from its planned 25-year operational life of transporting crude oil through the 1,443-km pipeline from Hoima to Tanga;
- emissions from maritime shipping of crude oil from Port Tanga to CNOOC's and/or Total's refineries in Europe and China;
- energy and emissions of refining the crude oil transported by the EACOP pipeline;
- emissions from the end use of EACOP's transported oil.

We provide a preliminary estimate of emissions from maritime transport of the crude oil delivered to the 2 million bbl tank farms at Port Tanga and subsequent shipping of crude oil by Suezmax tankers to Total's and CNOOC's facilities and refineries in France (or Rotterdam or elsewhere in Europe) and in China, respectively.

We quantify emissions from refining of Ugandan crude oil into finished carbon fuels. Refinery emissions of both CO_2 from refinery operations (typically natural gas and purchased electricity, as well as flaring and vented and fugitive methane) can be substantial, especially for the waxy medium-gravity crude oil produced in the Lake Albert oil fields.[10]

We also quantify emissions from the consumption of those finished fuels by Total's and CNOOC's ultimate consumers. These emissions comprise the lion's share of overall supply chain emissions from extraction to end use of carbon fuels, and both Total and CNOOC and the environmental assessment reports ignore these "indirect" but inevitable emissions.

In accounting for end use emissions, we deduct for refinery diversion of petroleum products into non-energy uses, such as petrochemicals, lubricants, road oil, and so forth. We deduct a global average net non-energy factor of 8.02%, based on the peer-reviewed Carbon Majors methodology.[11]

We exclude emissions of CO_2 and methane (CH_4) from tank farm storage, flaring and venting, emissions from refinery operations, delivery to ultimate consumers, etc. Crude oil processing, storage, refining into carbon fuels (e.g., petrol, diesel, jet fuel, heating oil, distillates), and transport add significant emissions that are not quantified here.

The purpose of extracting crude oil and refining the oil into finished carbon fuels is to burn the fuels for heat and power, hence these emissions are an inescapable consequence of providing crude oil to regional or global markets, and as such must be quantified and evaluated in any comprehensive assessment of a project's climate impacts. The EACOP ESIA reports fail to do this.

---

[10] Jing et al. (2020) Carbon intensity of global crude oil refining and mitigation potential, *Nature Climate Change.*

[11] Heede (2019) *Carbon Majors: Accounting for carbon and methane emissions 1854-2010 Methods & Results Report.*

Figure 4. EACOP boundary definition.

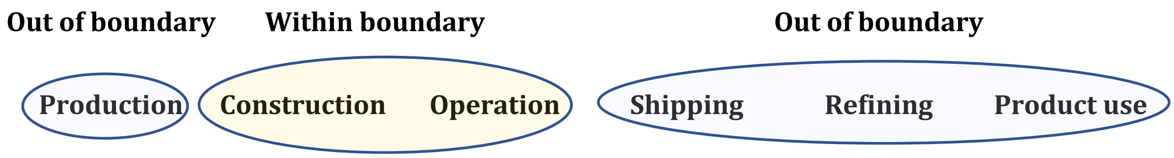
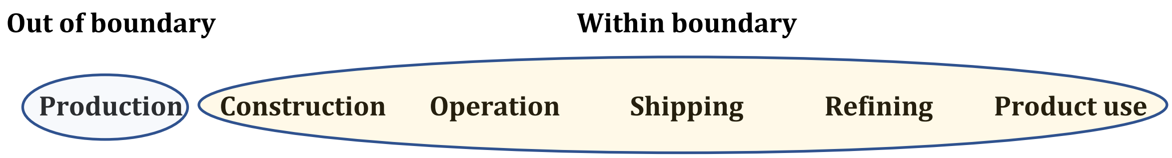


Figure 5. This report's boundary definition.



< 2 >

EMISSIONS: OIL FIELD OPERATION

Note: this report adopts a boundary definition focused on emissions attributable to the East Africa Crude Oil Pipeline (EACOP) and emissions and impacts from maritime transport of the crude oil delivered to Port Tanga in Tanzania as well as emissions from the refining and end use of the transported oil.

Therefore, emissions from oil field development and operation upstream from EACOP are *outside* the boundary, and are not added to the full lifecycle emissions of this analysis. However, for informational purposes we include the following discussion, based on CNOOC greenhouse gas assessment. We do not evaluate the accuracy or completeness of CNOOC's assessment and quantification. To our knowledge, Total has not issued a parallel assessment of emissions from producing oil (and gas) at its Tilenga fields.

CNOOC air quality and greenhouse gas assessment (CNOOC 2018) [12]

The objective of which was to "develop an inventory of potential sources of air emissions associated with the proposed project, and assess these emissions." This includes a baseline assessment and an impact assessment.

CNOOC report does *not* quantify CO_2 emissions from natural gas production or gas used in power generation, or flaring. The ESIA does report CO, NOx, PM_{10}, etc. Section 4.2 Air Emission Inventory lists sources for power and heat generation, boilers, turbines, reciprocating engines, including "emissions resulting from flaring and venting of hydrocarbons," and "fugitive emissions," but the report does not calculate CO_2 emissions from any of these sources.

CAI calculates CO_2 emissions from CNOOC's ESIA *Air Quality and Greenhouse Gas Assessment* report, Section 4.2 Air Emission Inventory (page 67), where production is stated as (quoted):

- Oil at 40 000 BPD (1,991,878 tpa); and,
- Gas at 229 scf/bbl (72,887 tpa).

Oil production thus equals 14.6 million bbl per year (Mb). Gas production (associated gas) of 229 scf/bbl equals 3.34 billion cubic feet per year (Bcf).

CNOOC affirms that:

- Natural gas produced will be consumed in combustion processes;
- 56% will be used for power generation (16 MW output), the remainder (44%) flared.

CAI calculates, using an emission factor of 0.0544 $MtCO_2$/Bcf, annual emissions rate of 0.182 $MtCO_2$ from CNOOC's Kingfisher oil field production.[13]

This is the only field production emission estimate we have, and we cannot assume that Total's field production on the northern section of Lake Albert will have the same rate of natural gas production per bbl of oil produced.

---

[12] CNOOC (2018*) Kingfisher Oil Development Environmental and Social Impact Assessment: Kingfisher Oil Development Physical Environment Report,* Report 4A, February, 746 pp. Air Emissions, page 4.

[13] U.S. Environmental Protection Agency (2020) *Emission Factors for Greenhouse Gas Inventories*: 0.0544 $kgCO_2$/scf (= 0.0544 $MtCO_2$/Bcf).

However, as a scoping estimate, and assuming EACOP plateau pipeline volume of 216,000 bbl per day, which equals 78.8 Mb of crude oil per year, indicates natural gas production of 18.1 Bcf, and 0.983 MtCO_2 of gas-related combustion.

This calculation ignores several emission sources associated with oil field development and production, such as fugitive and vented methane, fuel used in road grading, airfield improvement, pipeline construction (from both Total's field in the north and CNOOC's field at Kingfisher to the gathering point at Hoima), drilling, oil processing (such as water separation and re-injection), oil storage, crude oil tank heating, and related emission sources.

< 3 >

Reserves

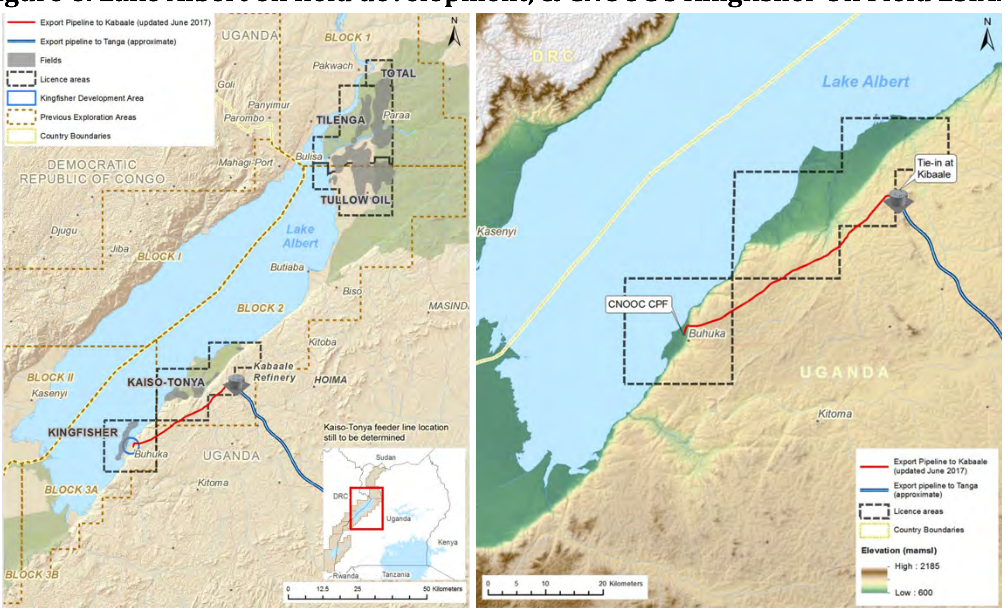
China National Offshore Oil Corporation (CNOOC) Uganda recoverable oil reserves:

CNOOC Form 20-F 2019, page 43:

> "Africa is one of the regions where the Company has a relatively large oil and gas reserve and production. The Company's assets in Africa are primarily located in Nigeria and Uganda. As of the end of 2019, reserves and production in Africa reached 83.6 million BOE and 120,925 BOE/day, respectively, representing approximately 1.6% of the Company's total reserves and approximately 8.7% of its production.
>
> P.44: The Company owns one-third interest in each of EA 1, EA 2 and EA 3A blocks in Uganda. EA 1, EA 2 and EA 3A blocks are located at the Lake Albert Basin in Uganda, which is one of the most promising basins in terms of oil and gas resources in onshore Africa.

Insofar as we do not have CNOOC data on Nigerian reserves (which are combined with Uganda reserves above), we can only surmise that its Lake Albert proven reserves amount to less than 83.6 Mb, and possibly considerably less.

Figure 6. Lake Albert oil field development, & CNOOC's Kingfisher Oil Field ESIA.[14]



Total SA Uganda recoverable oil reserves:

Total SA Form 20-F 2019, page 43:

> "In Uganda, Total holds a 33.33% interest in Blocks EA1, EA2, and EA3 for the development of the Lake Albert project. Total is the operator of Block EA1, where most of the reserves are located. The project has reached an advanced technical stage, in terms of the engineering of the surface facilities and the oil pipeline, as well as for the drilling. The State-owned company has an option to acquire a 15% interest in the project, which would reduce Total's share to 28.33%, if exercised.

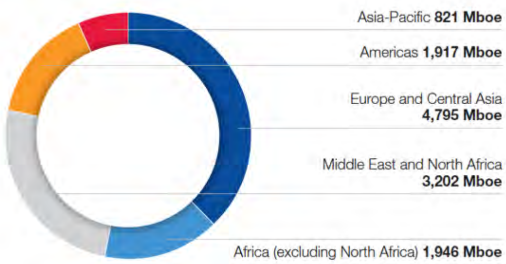
[14] CNOOC (2018) *Kingfisher Oil Development Environmental and Social Impact Assessment: Kingfisher Oil Development Physical Environment Report*, Report 4A, February, 746 pp. Air Emissions pp. 1-70; Figures 2 and 31.

Form 20-F 2019, Page 48 / Reserves:

Proved reserves

As of December 31	2019	2018	2017
Hydrocarbon reserves *(Mboe)*	12,681	12,050	11,475
Oil (including bitumen) *(Mb)*	5,167	5,203	4,615
Gas (including Condensates and associated NGL) *(Mboe)*	7,514	6,847	6,860

As of December 31	2019	2018	2017
Hydrocarbon reserves *(Mboe)*	12,681	12,050	11,475
Liquids *(Mb)*	6,006	6,049	5,450
Gas *(Bcf)*	36,015	32,325	32,506



Proved reserves of hydrocarbons based on SEC rules (Brent at $62.74/b in 2019) were 12,681 Mboe at December 31, 2019. The proved reserve replacement rate[2], based on SEC rules (Brent at $62.74/b in 2019), was 157% in 2019 and 138% over three years.

Subsequent to Total's 2019 statement above, the company acquired Tullow Oil's assets, thus Total has a 66.67 percent share of the Lake Albert reserves, subject to Uganda National Oil Company exercising its option to acquire 15% of the assets.[15] Note: we have read elsewhere that UNOC has an option for 28% of the reserves; final disposition remains to be clarified.

Total's Ugandan resources are a fraction of Total's Sub-Saharan reserves of 1,934 Mb (Total is currently operating in Angola, Republic of Congo, Gabon, and Nigeria).

Independent reserve estimates:

BankTrack cites (but does not reference):[16]

> "Approximately **1.7 billion barrels** of recoverable oil have been discovered in the Albertine Graben, the basin of Lake Albert, on the border between Uganda and the Democratic Republic of the Congo. Extraction will take place at two oil fields: the Kingfisher field, operated by China National Offshore Oil Corporation Ltd (CNOOC Ltd), and the Tilenga field, operated by Total S.A."

U.S. Energy Information Administration (2016) *Country Studies: Uganda*:

> "The first commercial oil discovery in Uganda was made in the Albertine Graben area in 2006. Since then, successful well appraisals have boosted Uganda's proved crude oil reserves from zero in 2010 to **2.5 billion barrels** as 2015, according to the *Oil & Gas Journal* (OGJ). The Ugandan govt estimates that the Albertine Graben area contains 6.5 billion barrels of oil in place. Proved natural gas reserves were estimated at 500 billion cubic feet as of the end of 2015, according to OGJ."

Tullow Oil (2020) *Annual Report and Accounts 2019*, page 1: global reserves 243 Mb (proved and probable commercial reserves); no information on Ugandan reserves.

In summary, lacking detailed reserve estimates from Total, CNOOC, and Tullow, at best we can only put a lower and upper bound on Ugandan reserves in the Lake Albert region.

Lower bound: CNOOC, a fraction of CNOOC Uganda plus Nigeria reserves of 83.6 million bbl (Mb).

Upper bound: EIA's estimate of Uganda proven reserves totaling 2.5 billion bbl (Gb).

-#-

15 Energy Facts (2020) Total acquires Tullow entire interest in the Uganda Lake Albert Project, *Energy Facts*, 24 April. Worldwide Oil & Gas (2020) Total acquires Tullow Oil Uganda assets for $575 million, *Worldwide Oil & Gas*, 23 April.

16 BankTrack (2020) *East African Crude Oil Pipeline (EACOP) Uganda*, online update, 9 October.

< 4 >

PRODUCTION & PIPELINE CRUDE OIL TRANSPORT

Planned pipeline crude oil throughput varies by year, according to EACOP's Uganda *Environmental and Social Impact Assessment report*. The maximum upstream production capacity (for both Total's Tilenga field and CNOOC's Kingfisher field) is 230,000 bbl per day (bpd),[17] at plateau production, of which the maximum pipeline flow rate will be 216,000 bpd in years 3 through 6 (see table 1).[18]

The crude oil discovered in the Albertine Graben at Tilenga and Kingfisher "is generally medium – light with API gravity mostly ranging between 30–34° and a pour point of 40°C. The crude oil is sweet with very low sulphur content on the order of 0.11%."[19]

The pour point is relatively high, and requires that the crude oil be heated to >45°C for pipeline transport, and reportedly to 63°C-68°C for tank storage at the Marine Storage Terminal. For this reason, the EACOP pipeline is engineered to be heated along its entire 1,443 km route, insulated with foam insulation, with seven pump stations and bulk heaters (at each pump station) and trace heaters atop the entire length of the pipeline to ensure that the crude does not become a giant Chapstick™. We cite estimated emissions for crude oil heating in chapter 5 on Operations.

The EACOP pipeline will transport crude oil in various phases. Based on the flow rates presented in the Uganda ESIA (see Table 1), CAI calculates flow rates by year and over the 25-year operational life of the EACOP pipeline cumulative crude pipeline transport of 848 million bbl (Mb).

While we do not yet know how much of the oil produced by CNOOC and Total will be refined at the planned refinery at Kabaale – reportedly 30,000-60,000 bpd – the current estimate of recoverable reserves of ~1.2 to 1.6 billion bbl (Gb) (perhaps as high as 2.5 Gb, EIA 2016) appear adequate to export a cumulative 848 Mb through EACOP, even without additional discoveries or extensions.

Figure 7. Characteristics of key assets under review in this project, Climate Policy Institute[20]

	Upstream (Tilenga and Kingfisher)	Midstream (EACOP)	Downstream (Kabaale refinery)
FID timing	Late 2021	Late 2021	Late 2021
Commissioning date	Late 2024	Late 2024	Late 2024
Size of resource	Up to 1.6 billion barrels of commercially recoverable production	-	-
Maximum production / capacity	230,000 barrels per day	216,000 barrels per day	60,000 barrels per day
Capital investment (US$ real 2020)	6 billion [11] (development) 3.5 billion (maintenance and life extension) 3.9 billion (future phases)	3.6 billion [12]	4 billion [13]
Ownership	Total (57%) [14], China National Offshore Oil Corporation (CNOOC) (28%), Uganda National Oil Company (UNOC) (15%)	Total (up to 57%), CNOOC (up to 28%), UNOC (15%), Tanzania Petroleum Development Company (TBD) [15]	UNOC (up to 40%), other investors TBD (up to 60%)

[17] Climate Policy Initiative (2020) *Understanding the impact of a low carbon transition on Uganda's planned oil industry*.

[18] East Africa Crude Oil Pipeline (2020) *Environmental and Social Impact Assessment, EACOP Project, Uganda* ESIA, p. 157, G3.3 Operational Phase – Bulk Heater Emissions at PS1 and PS2.

[19] Open To Export (undated, >2014) *Oil & Gas Sector in Uganda*, opentoexport.com/article/oil-and-gas-sector-in-uganda/

[20] Climate Policy Initiative (2020) *Understanding the impact of a low carbon transition on Uganda's planned oil industry.*

It is beyond the scope of this analysis to investigate the financial feasibility of oil field development in Uganda, but permit me to point out the pertinent analysis presented in reports by Climate Policy Institute, by BankTrack, and by Chatham House.[21]

For example, BankTrack, refers to CPI's analysis of "the impact of a low carbon transition on Uganda's planned oil industry. The report's key finding is that "since Uganda signed an initial agreement in 2013, the value of Uganda's oil reserves has fallen more than $40 billion or over 70% to $18.1 billion. Under a low-carbon transition aligned with the goals of the Paris Agreement, the value of the oil would drop further, to 88% of its value seven years ago."[22]

While the oil field operational emissions are beyond our scope (focused on the EACOP pipeline), Total estimates cumulative emissions (25-yr life) at 23.3 $MtCO_2e$, and averaging 0.89 $MtCO_2e$ for Commissioning and Operations. Site preparation (cumulative 0.24 $MtCO_2e$) and Construction and Decommissioning at each 0.764 $MtCO_2e$.[23]

Based on the crude oil flow rates provided in the Uganda ESIA report (Table 1), we calculate pipeline plateau flow rates at 78.8 million bbl (Mb) per year, and cumulatively as 848 Mb over the 25-year life of the project. See Table 1 below, and Table 11 in chapter 9 for annual flow rates.

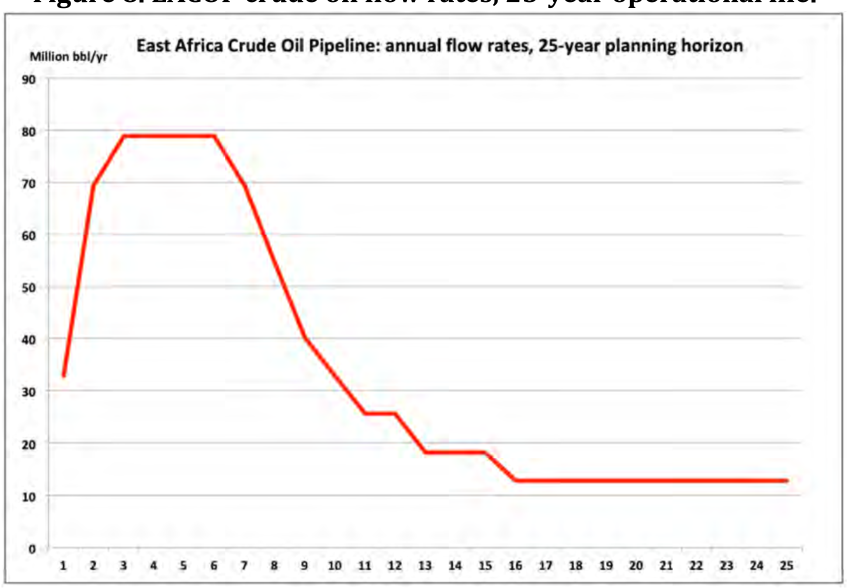
Table 1. ESIA Uganda Rpt, Table G3.3.1 EACOP Flow Rate Profile Over Operational Life[24]

Year	1	2	3	4	5	6	7	8	9	10	11	12	
Flow rate (kbod)	90	190	216	216	216	216	190	150	110	90	70	70	
Year	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
Flow rate (kbod)	50	50	50	35	35	35	35	35	35	35	35	35	35

"kbod:" thousand bbl of oil per day. For example, 216 kbod equals 78.8 million bbl per year.

CAI calculates annual crude oil flows based on Table 1, charted in Figure 6.

Figure 8. EACOP crude oil flow rates, 25-year operational life.



-#-

[21] Chatham House (2013) *Oil in Uganda International Lessons for Success.*

[22] BankTrack et al. (2019) *Your Bank's Role in Arranging Finance for the East Africa Crude Oil Pipeline.* BankTrack (2020) *East African Crude Oil Pipeline (EACOP) Uganda*, online update, 9 October.

[23] Total, CNOOC, Tullow (2019) *Tilenga Project: Env'l & Social Impact Assessment*: Vol. 2, Air Qual & Climate, Table 6-40.

[24] EACOP (2020) *Uganda ESIA report*, p. 157, G3.3 Operational Phase – Bulk Heater Emissions at PS1 and PS2.

< 5 >

EMISSIONS: PIPELINE CONSTRUCTION

The EACOP *Uganda ESIA* report estimates pipeline construction fuel consumption and emissions for non-road and road vehicles and stationary equipment (such as power generation for the main camp & pipe yards). See Table 2 for fuel and emission sources, Table 3 for activity and fuel consumption, and Table 4 for calculated emissions from estimated fuel use.

Table 2. Uganda ESIA Appendix G: Emissions Table G3.2.1 Construction Emission Categories

Category	Description	Type
1	The non-road construction equipment used to build the pumping stations	Non-road
2	The road vehicles used in the construction of the pumping stations	Road
3	The non-road construction equipment used on the pipeline spread	Non-road
4	The road vehicles used on the pipeline spread	Road
5	The power generators at the main camp/pipe yards (MCPY)	Stationary
6	The transport of workers to and from the camps, and their daily travel to and from the right-of-way (RoW)	Road
7	The transport of pipe and cable materials to the MCPYs and on to the RoW	Road
8	The transport of the mechanical and electrical equipment that forms a pumping station and the construction equipment and vehicles to build it. In the case of the construction equipment this means the mobilisation and demobilisation to and from the sites. The equipment's activity in building the PSs is captured in categories 1 and 2	Road
9	The transport of supplies to the MCPYs from local sources	Road
10	The transport of the construction equipment and vehicles used for a pipeline spread. This means the mobilisation and demobilisation to and from the sites. The equipment's activity in actually working the spread is categories 3 and 4	Road
11	The transport of the equipment for an MCPY (except the pipe, which is covered in category 7)	Road
12	The transport of murram from local sources for new roads and road upgrades	Road

Table 3. Uganda ESIA Appendix G: Emissions, Table G3.2.2 Activity and Fuel Consumption

Category		Activity	Activity Units	Diesel Consumption (Tonne)
Non-road				
1	Non-road equipment building the pumping stations	84,615	MWh engine output	21,160
3	Non-road equipment on the pipeline spread	203,144	MWh engine output	50,786
5	Generators at the MCPYs[1]	9,084	MWh engine output	1,969
Road				
2	Road vehicle use in building the pumping stations	162,000	km	19
4	Road vehicle use on the pipeline spread	2,727,000	km	303
6	Transport of workers	1,020,533	km	153
7	Transport of pipe and cables	1,288,846	km	271
8	Transport of equipment for pumping stations	375,797	km	77
9	Local supplies to the MCPYs	632,100	km	103
10	Transport of equipment for pipeline spread	217,296	km	37
11	Transport of equipment for establishment of MCPYs	296,819	km	62
12	Transport of murram for roads	75,000	km	16
Total (road km only for activity)		6,795,391	km	74,956

This analyst's assessment of the Uganda construction fuel and emission calculations is that the methodology is sound, although a detailed worksheet with the calculations are not available for review. Assuming that the fuel consumption data are reasonable (which we cannot fully assess) then the math is straightforward and accurate. To wit:

Total diesel consumption of 74,956 tonnes x emission factor of 3.186 tCO_2/tonne diesel = CO_2 emissions of 238,809 tCO_2. Table 4 adds minor quantities of associated methane and nitrous oxide emissions, for total GHG emissions of 241,893 tCO_2e.

Table 4. Uganda ESIA Appendix G: Emissions, Table G3.2.3 Emissions

Category		Air Pollutants (Tonne)					Greenhouse Gases (Tonne)			
		NOx	NMVOC	CO	PM	SO_2	CO_2	CH_4	N_2O	CO_2e
1	Non-road equipment building the pumping stations	212.1	11.2	132.3	3.3	2.1	67,417	0.3	3.0	68,308
2	Road vehicle use in building the pumping stations	0.1	0.0	0.0	0.0	0.0	59	0.0	0.0	60
3	Non-road equipment on the pipeline spread	650.0	26.6	314.4	10.0	5.1	161,804	0.6	7.1	163,944
4	Road vehicle use on the pipeline spread	1.3	0.1	0.2	0.0	0.0	967	0.1	0.0	978
5	Generators at the MCPYs	170.4	13.9	36.7	12.0	0.2	6,274	No factor	No factor	6,274
6	Transport of workers	0.4	0.0	0.1	0.0	0.0	487	0.0	0.0	494
7	Transport of pipe and cables	0.5	0.0	0.1	0.0	0.0	862	0.1	0.0	878
8	Transport of equipment for pumping stations	0.2	0.0	0.0	0.0	0.0	245	0.0	0.0	250
9	Local supplies to the MCPYs	0.2	0.0	0.0	0.0	0.0	327	0.0	0.0	334
10	Transport of equipment for pipeline spread	0.1	0.0	0.0	0.0	0.0	118	0.0	0.0	120
11	Transport of equipment for establishment of MCPYs	0.1	0.0	0.0	0.0	0.0	199	0.0	0.0	202
12	Transport of murram for roads	0.0	0.0	0.0	0.0	0.0	50	0.0	0.0	51
Total		**1035.4**	**51.8**	**483.8**	**25.3**	**7.4**	**238,809**	**1.2**	**10.2**	**241,893**

Tanzania report

In contrast to the Uganda report, the ESIA for Tanzania appears to ignore estimating fuel, electricity generation, and emissions for the construction phase of the EACOP project, despite pump stations 3 through 6, port facilities, crude oil storage tanks (heated to 63-68°C), and 1,147 km of the 1,443 km-long pipeline being constructed across the breadth of Tanzania.

Figure 9. Tanzania ESIA Section 8.22 Climate: scope of emissions[25]

8.22 Climate

This section includes:

- an assessment of the potential impacts on the global climate of the EACOP project, comprising:
  - a description of the use of global warming potential (GWP) as the basis for comparing emissions of different greenhouse gases (GHG)
  - an evaluation of the carbon intensity (emissions per unit of energy exported) of direct[36] project operations phase GHG emissions
  - a description of the project's main direct and indirect[37] GHG emissions during construction and commissioning
  - a description of the project's main direct GHG emissions during the operations phase
  - a comparison of direct project operational phase GHG emissions to total national emissions and Tanzanian reduction commitments, as described in Section 6.4.4
  - a description of indirect emissions during the operations phase
  - description of the key mitigation measures used to reduce GHG emissions
- an assessment of the effects of climate change trends on the project and how these have been considered in project design and implementation.

However, this analyst cannot find any calculations covering construction fuel use or emissions, unlike the Uganda reports detailed estimates.

Table 5: Construction phase emissions in Uganda and Tanzania ESIA reports

	Construction emissions
	$ktCO_2e$
Uganda:	241.89
Tanzania:	na
Total:	na

-#-

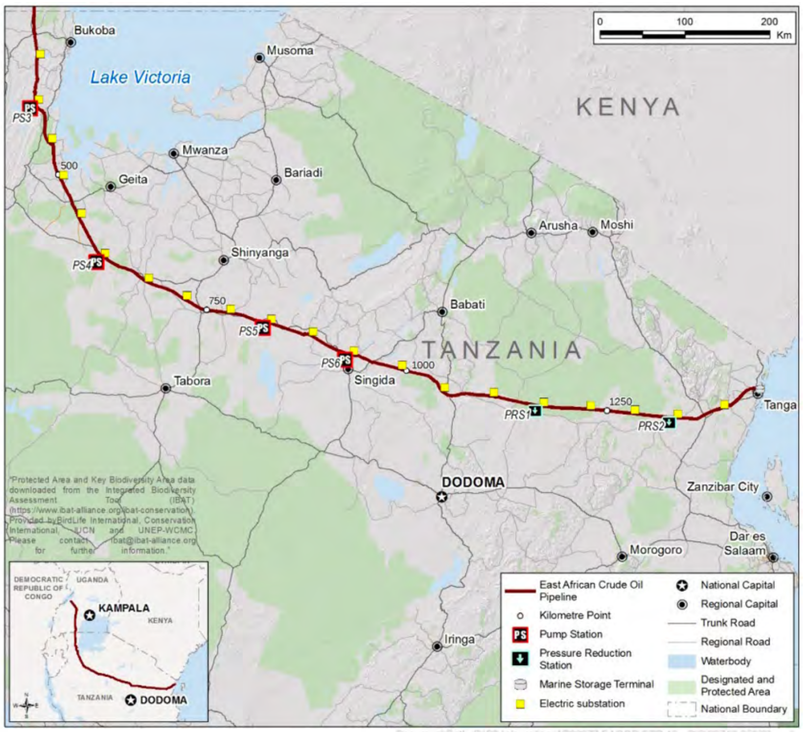
[25] East Africa Crude Oil Pipeline (2019) *Environmental and Social Impact Assessment, EACOP Project, Tanzania ESIA*, Section 8: Impact Identification & Evaluation – Normal Construction & Operations: Section 8.22: Climate, PDF p. 475.

< 6 >

EMISSIONS: PIPELINE OPERATIONS

Emissions from EACOP operation is from two primary sources: fuel used to generate power for the pump stations (and minor quantities for power for work camps and yards) and, chiefly, to power the bulk heaters and trace heaters in order to keep the crude oil above the oil's pour point (~40°C, specs call for heating to 45°C to 50°C to avoid wax deposition in the pipeline).

Figure 10. Corridor and Aboveground Installations, EACOP TZ Figure 2.3-1[26]



Uganda pipeline operations

The EACOP Uganda ESIA report is quite detailed regarding estimated CO_2 emissions from the bulk heaters at pump stations #1 and #2 (see Table 6). We chart this in Figure 9. Bulk heater duty cycles are zero at high flow rates (>200 kbpd) and up to 32 MW at low/medium flow rates.[27] Appendix G shows fuel consumption rate (at 170 kbpd) or 2.51 m^3/d/MW (cubic meters of crude oil used as bulk heater fuel per day per MW of duty). ESIA Appendix G provides an example:

> "Crude consumption for year 11 (flow rate 70 kbpd) at PS #1 is 4.4 MW x 2.51 m^3/d/MW x 365 days = 3,994 m^3.

Which is then multiplied by an emission factor of 10.29 $kgCO_2$/gallon (and small additions for methane and nitrous oxide emissions) and converted (using a crude oil density of 868 kg/m^3 and 0.003785 m^3/gal) to a composite emission factor of 3.14 tCO_2e/tonne of crude oil.

---

[26] East Africa Crude Oil Pipeline (2019) *Environmental and Social Impact Assessment, EACOP Project, Tanzania ESIA*, Project Description, page 2-7.

[27] Uganda ESIA, Appendix G. Table G3.3.2 shows "total bulk heating duty" as high as 32.2 MW (at flow rate of 70 kbpd), but table G3.3.3 Bulk Heater Capacities shows PS1 capacity of 11.99 MW and PS at 7.56 MW.

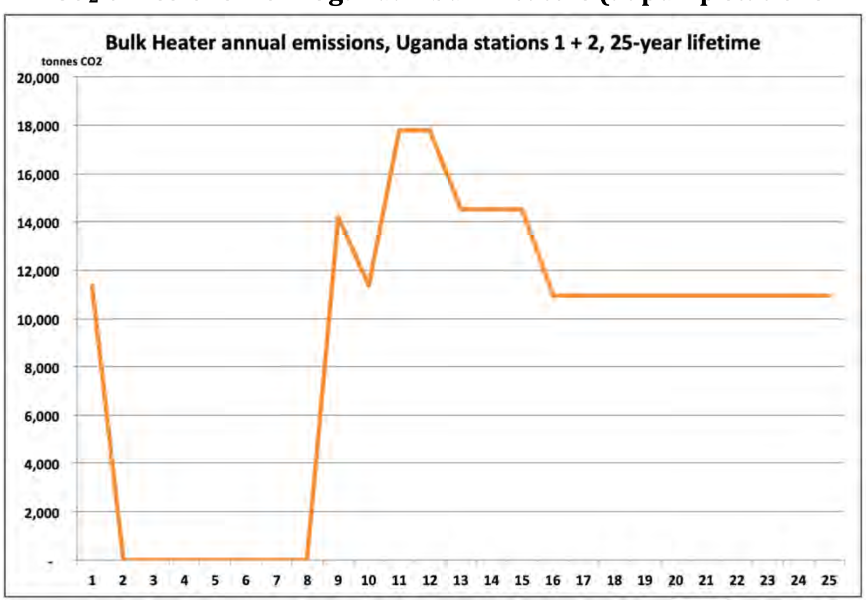
"The emissions are then calculated by multiplying the crude consumption in each year by this emission factor. For example, in year 11 for Pump Station #1: 3994 m^3 × 868 kg/m^3 × 3.14 tCO_2e/tcrude = 10,896 tCO_2e."

Table 6. Uganda ESIA Year by Year GHG Emissions Inventory, Bulk Heaters at PS1 and PS2[28]

Year	GHG emission (tonne CO_2e)		
	PS1	PS2	Total
1	11358*	0	11358*
2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	0
6	0	0	0
7	0	0	0
8	0	0	0
9	14179	0	14,179
10	11,358	0	11,358
11	10,896	6,870	17,765
12	10,896	6,870	17,765
13	8,899	5,611	14,510
14	8,899	5,611	14,510
15	8,899	5,611	14,510
16	6,700	4,224	10,924
17	6,700	4,224	10,924
18	6,700	4,224	10,924
19	6,700	4,224	10,924
20	6,700	4,224	10,924
21	6,700	4,224	10,924
22	6,700	4,224	10,924
23	6,700	4,224	10,924
24	6,700	4,224	10,924
25	6,700	4,224	10,924
Total	152,381	72,817	225,198

Cumulative 25-year emissions from the bulk heaters (at Pump Stations #1 & #2) total 225,198 tCO_2, averaging 9,000 tCO_2/yr over the 25-year lifetime of the EACOP. Bulk heaters are *not* required when the pipeline is flowing at full capacity and the flow is rapid enough to prevent the oil from cooling below the pour point. Notice that Figure 9 is basically the mirror image of Figure 6 on oil flow rates.

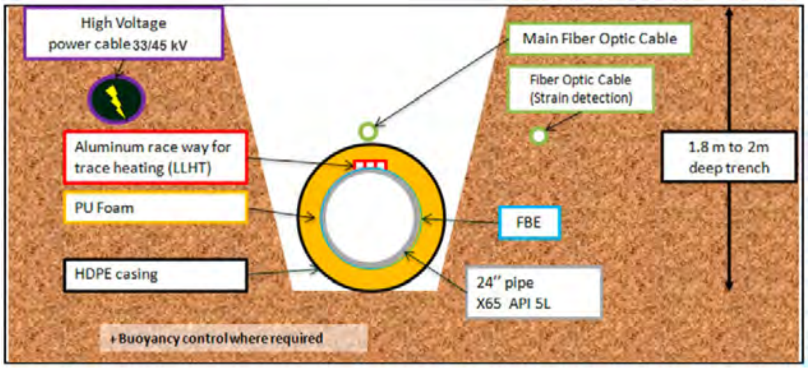
Figure 11. CO_2 emissions from Ugandan bulk heaters (at pump stations #1 & #2).



[28] East Africa Crude Oil Pipeline (2020) *Environmental and Social Impact Assessment, EACOP Project, Uganda ESIA*, Appendix G: Impacts Assessments, Table G3.3.5.

Note: the Uganda ESIA report does *not* quantify operational emissions from power generation,[29] which is likely a significant undercount, judging from the inclusion of power generation emissions in the Tanzania ESIA report (power generation is 60% and 84% of minimum and maximum operational emissions, respectively, in Table 8 below).

Figure 12. Tanzania ESIA report, Figure 2.3-2: Typical EACOP Pipeline Cross-Section



However, the emission calculations are not complete, and appear to this analyst to ignore fuel use and emissions from operating the pump stations. The Uganda report may also ignore the operation of trace heaters and its energy demand, though the data may be included but not specified. The data provided in the Uganda ESIA (and in the Tanzania ESIA) is insufficient for a thorough assessment of the adequacy and completeness of their energy and emissions estimates.

Tanzania pipeline operations

The Tanzania ESIA affirms high energy use for crude oil heating in order to maintain the temperature of the transported oil above the oil's pour point (45°C), and, "as much as possible, above its wax appearance temperature:"

> "During pipeline commissioning, the EHT will continuously heat the crude oil to maintain an internal pipeline temperature above 50°C. At plateau production, pipeline insulation will maintain crude temperature above 50°C without any additional heat supply. As production begins to decline, the transit time of the oil through the pipeline will increase and thus the crude oil will have more time to cool. Then, crude oil temperature will be maintained above 50°C using EHT and, potentially later in the project life, bulk heaters."[30]

The bulk heaters are designed to burn crude oil. In order to optimize capital expenditures and operating costs, it is planned to insulate the pipeline with polyurethane foam insulation, and add electric trace heating throughout the pipeline length (which lowers bulk heating stations from 35 stations to six stations).[31] This author has not found EACOP data on power demand for the EHT system, and while EHT may be operationally and CAPEX optimized, it too is fairly energy intensive. No data is presented, and an assessment of the energy demand and emissions cannot be evaluated.[32]

---

[29] To clarify, this analyst has not found CO_2 estimates from power generation to run pump stations #1 & #2 in the Uganda ESIA, Appendix G on emissions.

[30] East Africa Crude Oil Pipeline (2019) *Environmental and Social Impact Assessment*, EACOP Project, Tanzania ESIA, Project Description, page 2-3.

[31] EACOP (2019) *Executive Summary, Tanzania ESIA*, page ES7.

[32] As a scoping exercise, I use an *EHT Design Guide* (Chromalox, 2003), which shows demand of 25 W/m at a temperature differential of 23°C and 76 mm of insulation. A delta T of 23°C is probably high for the majority of the pipeline route, especially at a soil depth of 2 m, and considering that the EHT may only be required for heating part of the time, we assume 10 W/m for the 1,443 km pipeline length operating 50% of the time equals 63 GWh. Further assuming a conservative emission factor (454 $kgCO_2$/MWh) yields EHT emissions of 28,700 tCO_2 per year. Note: this is a scoping calculation only, with scant actual data, and outside the scope of our analysis. We ignore considerable heating requirements for the Marine Storage Terminal (crude kept at 63°C-68°C). Note: how are tankers supplied with aux heat?

Table 7. Tanzania ESIA report, Table 2.3-2: Pumping Stations

Pumping Station	KP	MW Installed Power	Manning
PS3	406	22.04	Manned
PS5	825	27.55	Manned
MST	1443	17.9	Manned

Figure 13. Tanzania ESIA report, Figure 2.3-5 Power Generation Architecture

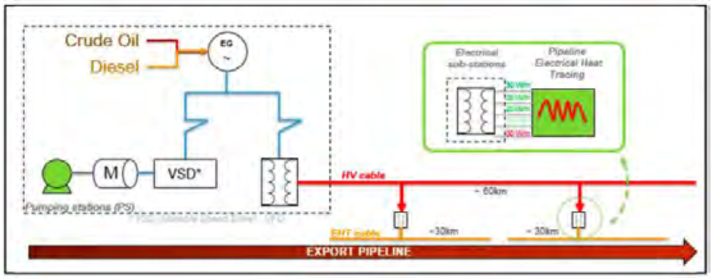


Table 8. Tanzania ESIA report, Operational Direct Greenhouse Gas Emissions Inventory[33]

EACOP Project
Tanzania ESIA Vol. 1 Section 8: Impact Identification and Evaluation – Normal Construction and Operations

Table 8.22-2 Operational Direct Greenhouse Gas Emissions Inventory

Site	Emission Source	Operational GHG Emissions (kilotonne CO_2e)	
		Minimum Annual	Maximum Annual
PS3	Power generation	30	78
	Bulk heating	0	29
PS4	Bulk heating	0	17
PS5	Power generation	31	91
	Bulk heating	0	17
PS6	Bulk heating	0	46
MST	Power generation	35	88
	Direct-fired heating	3	14
Subtotal	Power generation	121[1]	237[1]
Subtotal	Bulk and MST heating	9[1]	79[1]
Total – Tanzania		201[1]	282[1]

NOTE: [1]The maximum and minimum years for each site and for the different emission sources do not coincide, so the totals are not the sums of the rows above

The Tanzania ESIA chapter estimates minimum and maximum emissions – 201 to 282 ktCO_2e – for the 25-year life of project, despite highly variable annual flow rates and power demand, and provides no annual data by year, unlike the Uganda ESIA Rpt.

> "Direct operational emissions in Tanzania will range between 201–282 ktCO_2e/a throughout the 25-year life, which represents around 0.2–0.3% of Tanzania's total GHG emissions in 2030. The contribution of EACOP to national emissions will not affect Tanzania's ability to meet its emission reduction target published as part of the Paris Agreement."

> "Construction phase direct and indirect emissions *have not been quantified*, as they are minor relative to the operational emissions over the life of the project." (my italics; TZ p. 8-482.)

[33] East Africa Crude Oil Pipeline (2019) *Environmental & Social Impact Assessment, EACOP Project, Tanzania ESIA*, Section 8: Impact Identification & Evaluation – Normal Construction & Operations, Climate, table 8.22-2, PDF page 8-479 & 8-482.

The lack of operational detail, the obscurity of the data presented in Table 8 above, and the absence of data on the underpinning energy use patterns makes an evaluation of the reasonableness and completeness of the Tanzania operational emissions impossible. Furthermore, Tanzania's operational emissions are 27 times higher than Uganda's emissions; this large difference is not explained by the longer pipeline across Tanzania (1,147 km) vs Uganda (296 km, ignoring gathering lines) or crude oil storage at Tanga Port or other reasons discussed in either ESIA report.

Overall, the content and quality of the emissions reporting between the two reports diverge significantly, and reasonable comparisons cannot be made.

However, taking the Tanzania ESIA estimate of operational emissions at its face value – specifically the minimum and maximum range quoted above (201–282 ktCO_2e per annum), CAI ran a simple model, assuming maximum energy and emissions at years 1-2 and years 17-25 and a minimum at years 3-6 (at plateau volumes) gives an average of 252,800 tCO_2e/year and cumulative 25-year emissions totaling 6.32 MtCO_2e. Figures 14 & 15. The 25-yr total operational emissions in Uganda's EACOP assessment is 225,197 tCO_2e. (Tanzania's 6.3 MtCO_2e is 26.6 x Uganda's' 0.225 MtCO_2e.)

Figure 14. CAI's model of EACOP Tanzania operational emissions.

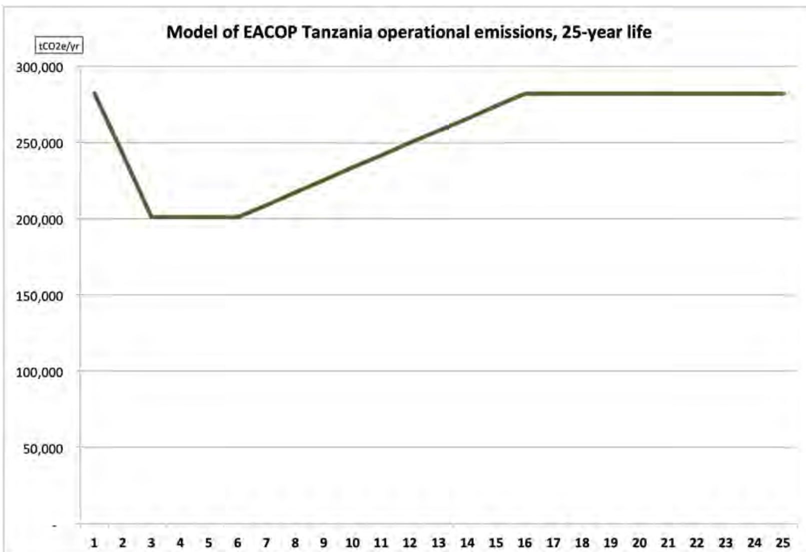
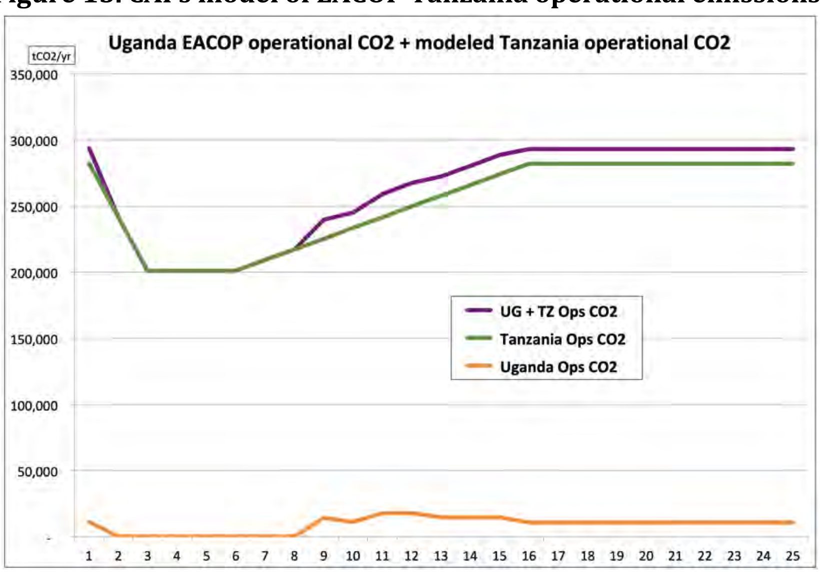


Figure 15. CAI's model of EACOP Tanzania operational emissions.



CAI assessment

In sum, neither ESIA report includes a full accounting of estimated energy use and resulting CO_2 (or methane) emissions. The Uganda report appears to ignore emissions from power generation (unless included but hidden within bulk heater energy and emissions estimates). The Tanzania ESIA report does not present credible estimates of operational emissions, and only presents a range of minimum and maximum annual emissions within a narrow range; the narrow range may be accurate, but not supported by calculation of individual emission sources. In any case, the Uganda ESIA credibly suggests that bulk heaters may not be required at plateau production and pipeline transport, whereas the Tanzania report makes no mention of this condition. Operational sums:

Table 9: operational emissions in Uganda and Tanzania from ESIA reports

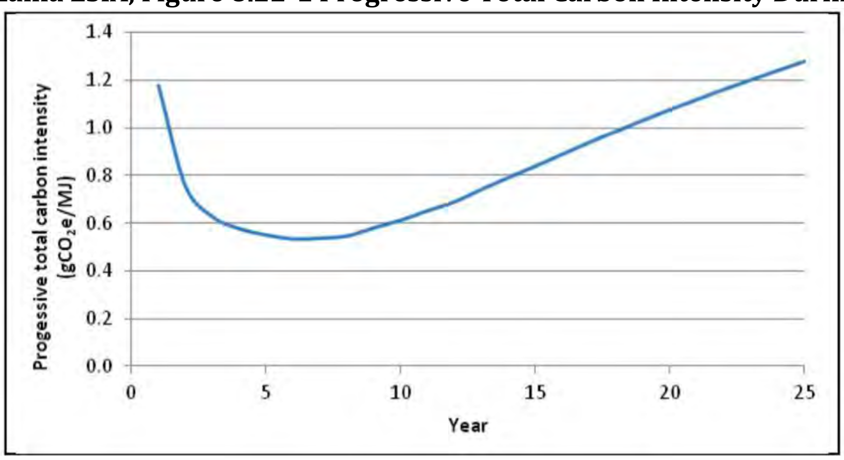
	Annual (average) emissions ktCO_2e	25-yr cumulative emissions ktCO_2e
Uganda:	9.01	225.2
Tanzania:	252.84	6,321.0
Total:	261.85	6,546.2

Note that CAI cannot estimate complete operational emissions: neither ESIA report contains the energy use data required for such an exercise.

Addendum on carbon intensity:

The Tanzania ESIA report, while it purports to calculate direct construction and operational emissions, does not do so. Instead, it publishes an inadequate, obscure, and unsupported estimate of overall project carbon intensity (Figure 14).

Figure 16. Tanzania ESIA, Figure 8.22-1 Progressive Total Carbon Intensity During Project Life[34]



Tanzania ESIA, Section 8.22.2. Carbon Intensity, explains:

> "Over the project life, the predicted average CI of all exported oil is 1.3 gCO_2e/MJ."

This is followed by an unclear, ill-defined table of "Operational Direct Greenhouse Gas Emissions Inventory" (see Table 8 above).

Note: no discussion in the Tanzania ESIA regarding the thermal demand or emissions associated with keeping marine storage terminal minimum storage tank oil temperature at 63°C to 68°C.[35] A single datum in table 8.

-#-

[34] East Africa Crude Oil Pipeline (2019) *Tanzania ESIA*, Section 8: Impact Identification and Evaluation – Normal Construction and Operations: Section 8.22 Climate, 8.22.2.2 Carbon Intensity, PDF page 477.

[35] East Africa Crude Oil Pipeline (2019) *Tanzania ESIA, Project Report*, page 2-2.

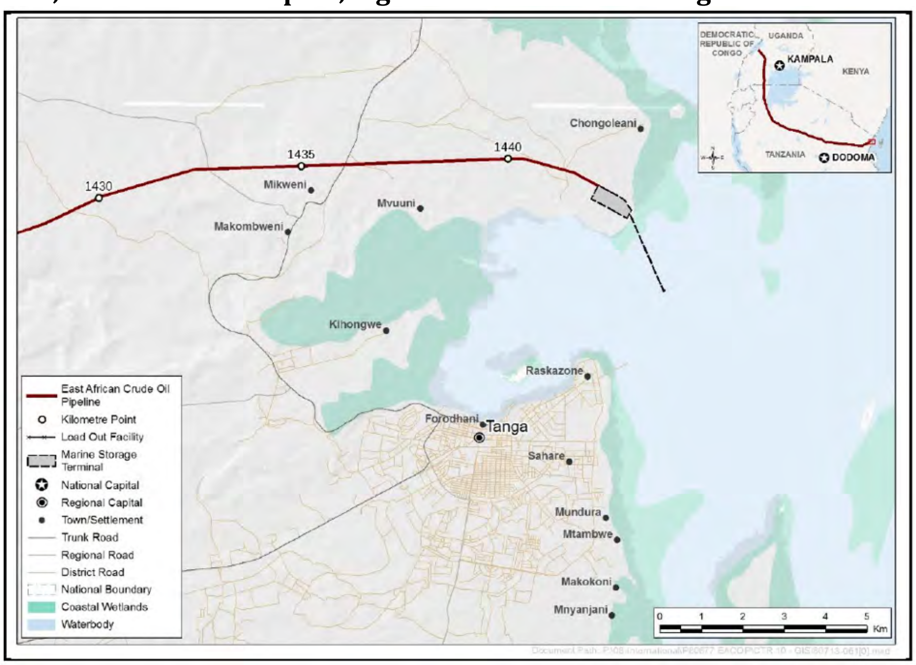
< 7 >

EMISSIONS: MARITIME TRANSPORT OF EACOP CRUDE OIL

The boundary and scope of this assessment includes preliminary consideration of bunker fuel consumption and emissions from maritime transit to Total's and CNOOC's refineries or other markets.

In order to provide a sense of relative scale of maritime crude oil shipping to markets we present a preliminary estimate of shipping emissions. Lacking any data on either Total's or CNOOC's maritime transport plans, we assume that all oil delivered to the Marine Storage Terminal (MST) at Port Tanga is exported by tanker to markets in Europe and China.

Figure 17, Tanzania ESIA report, Figure 2.3-10 Marine Storage Terminal Location[36]



Tanzania ESIA Report:

> "The Marine Storage Terminal (MST) design is based on a minimum overall storage capacity of 2 million barrels and the requirement to load a Suezmax type tanker (0.9–1.0 million barrels parcel) within 24 hours from the start to end of loading operation."[37]

Note: a Suezmax tanker can range up to 160,000 dwt, and carry ~0.8 to 1.1 Mb. A modern energy efficient design (such as the AET tanker *Eagle San Antonio*, built by Samsung) burns ~60 tonnes of fuel per day at design speed.[38] Transit from Tanga Port to Rotterdam via the Suez Canal is 7,227 nautical miles (nm).

---

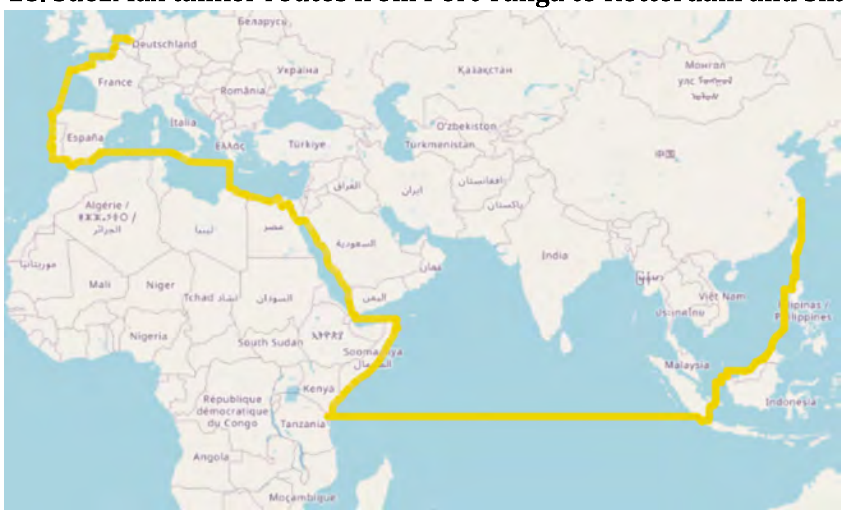
[36] East Africa Crude Oil Pipeline (2019) *Tanzania ESIA*, Project Description, page 2-19.

[37] East Africa Crude Oil Pipeline (2019) *Tanzania ESIA*, Project Description, page 2-18.

[38] MotorShip (2012) *First of Four Eco-Design Suezmax Tankers Joins AET Fleet*, 1 July.

We estimate bunker fuel consumption per voyage and cumulatively over the 25-year planning horizon, using data from oil tanker fleets and measured and reported fuel rates, modeling a 158,000 dead weight tonne (dwt) SuezMax tanker for the route to Rotterdam laden with 134,300 tonnes of cargo (design load is typically 85% of capacity), or 984,400 bbl of EACOP crude oil per shipment (1 tonne = 7.33 bbl).[39] We use fuel data from Adland et al., showing measured fuel consumption data for SuezMax tankers as a function of vessel speed, since fuel consumption increases dramatically with vessel speed, as well as headwinds, waves, currents, "laden" vs "ballast" (empty of cargo for repositioning back to Port Tanga), age and efficiency of its propulsion and hull design, and the shape of water-resistance of the hull (narrower ships are more efficient). We have no data from the EACOP consortium's *Environmental and Social Impacts* reports. We assume for modeling purposes that all the exported oil is shipped to Rotterdam for refining (shipping to Shanghai instead reduces shipping distance from 7,227 nm to 7,006 nm, or 3.1% less; see Figure 18). As a sensitive analysis, we model fuel rate (and emissions of carbon dioxide) per day for speed of 12 knots and 16 knots, for both laden and ballast voyages, and estimate the number of shipments per year (totaling 862 voyages over 25 years). See Tables 10-13.

Figure 18. SuezMax tanker routes from Port Tanga to Rotterdam and Shanghai.



In order to estimate fuel consumption and emissions per voyage and per year, we base the model on a 158,000 dwt tanker, 85% laden with Ugandan oil, traveling 7,227 nm for each voyage from Port Tanga to Rotterdam. Since vessel speed influences fuel consumption per voyage, we model two scenarios: vessel speed of 12 kn and 16 kn.[40] Both scenarios are based on transporting all of the 848.3 Mb of oil delivered to the Storage Terminal at Port Tanga over the 25-year planning horizon. We model the capacity and fuel consumption rates of a typical SuezMax tanker carrying an average cargo of 984,400 bbl, totaling 862 voyages over the 25-year life of the project. We do not model possible life-extension of the project, if additional oil reserves are discovered by either CNOOC or TotalEnergies.

At a speed of 12 knots, each voyage of 7,227 nm takes 25.1 days en route at a fuel consumption rate of 42.0 tonnes/day, and a per voyage fuel consumption of 1,054 tonnes (7,725 bbl).[41] Using EPA

---

[39] Lindstad, Haakon, & Gunnar S. Eskeland (2015) Low carbon maritime transport: How speed, size and slenderness amounts to substantial capital energy substitution, *Transportation Research Part D: Transport and Environment*, vol. 41:244-256.

[40] We ignore financial considerations such as the time value of tanker leasing contracts (Lindstad & Eskeland estimate time charter equivalent at ~$19k per day) or net out the fuel costs. ShipAndBunker.com report Rotterdam VLSFO fuel costs at $795 per tonne (accessed 15 May 2022).

[41] Adland, Roar, Pierre Cariou, & Francois-Charles Wolff (2020) Optimal ship speed and the cubic law revisited: Empirical evidence from an oil tanker fleet, *Transportation Research Part E: Logistics and Transportation Review*, vol. 140, August. Fig. 2. Correlation between fuel consumption and speed.

Emission Hub emissions factor of 11.27 kg CO_2/gallon (473.3 kgCO_2/bbl), we estimate emissions of 3,657 tCO_2 per voyage delivering 984,400 bbl of Ugandan crude oil.[42] We then estimate annual emissions from maritime transport based on the amount of oil transported through the EACOP pipeline to Port Tanga each year; at peak production (years 3 – 6) 78.8 Mb is transported, requiring 80 voyages, consuming 0.62 Mb of bunker fuel, and emitting 292,860 tCO_2. Over the 25-year life of the project, we estimate total bunker fuel consumption of 0.91 Mt (6.7 Mb) and emissions totaling 3.15 MtCO_2, delivering 848 Mb of crude oil.

Returning the tanker to Port Tanga for another laden voyage must also be estimated. A "ballast" voyage at the conservative speed of 12 kn consumes ~24% less fuel, since the tanker is not carrying cargo. Again, we use data from Adland et al., showing a "ballast" voyage using fuel at a rate of 32 tonnes per day (at 12 kn), the voyage also taking 25.1 days, burning 803 tonnes of bunker fuel (5,886 bbl), and emitting 2,786 tCO_2 per voyage back to Port Tanga. Over the 25-year life of the pipeline, this scenario consumes 0.69 Mt (5.1 Mb) and emits 2.40 MtCO_2.

The second scenario — our high estimate — again using the Adland et al. fuel consumption data on SuezMax tankers based on measured tanker fuel data. Here we model fuel and emissions using a vessel speed of 16 knots, which increases its fuel consumption rate to 73 tonnes of fuel per day but reducing the voyage duration to 18.8 days for the 7,227 nm voyage from Port Tanga to Rotterdam. Each outbound voyage consumes 1,374 tonnes of fuel (10,071 bbl), and per voyage emissions of 4,767 tCO_2. This "design speed" scenario increases total fuel consumption over the 25-year life to 1.18 Mt (8.68 Mb) and emissions to 4.11 MtCO_2. Each return voyage to Port Tanga burns 1,233 tonnes and emits 4,277 tCO_2, accounting for 1.06 Mt of fuel (7.79 Mb) and cumulatively emits 3.69 MtCO_2 over the project life.

Table 10: estimated maritime shipping emissions: 12 knot scenario

	Outbound "laden" voyage ktCO_2	Rebound "ballast" voyage ktCO_2
Per voyage:	3.66	2.79
Average year:	126.0	96.0
Peak year:	292.9	223.1
Cumulative 25 years	3,150.9	2,400.7

Table 11: estimated maritime shipping emissions: 16 knot scenario

	Outbound "laden" voyage ktCO_2	Rebound "ballast" voyage ktCO_2
Per voyage:	4.77	4.28
Average year:	164.3	147.4
Peak year:	381.8	342.5
Cumulative 25 years	4,107.5	3,685.5

Table 12: Twelve- and sixteen-knot scenarios, and the reference analysis results

	Outbound "laden" ktCO_2	Rebound "ballast" ktCO_2	Total ktCO_2
Per voyage 12 kn:	3.66	2.79	6.44
25-yr Cumulative 12 kn:	3,150.9	2,400.7	5,551.7
Per voyage 16 kn	4.77	4.28	9.04
25-yr Cumulative 16 kn	4,107.5	3,685.5	7,793.0
Per voyage (average)	4.21	3.53	7.74
25-yr Cumulative (ave.)	3,629.2	3,043.1	6,672.3

[42] U.S. Environmental Protection Agency (2020) *Emission Factors for Greenhouse Gas Inventories*.

These estimates are representative only, as we have no information on the disposition of crude oil delivered by EACOP to Port Tanga. Indeed, some coastal tankers may ship crude oil to regional ports, such as Maputo, Mogadishu, Toamasina, or Durban for local or regional refining. Or by tanker trucks to Mombasa or Dar Es Salaam and other domestic markets. Note that TotalEnergies' (or the EACOP consortium's) tanker leasing requirements (which are approximately four tankers in year 1 in the 16-knot scenario, rising to nine tankers in peak years 3 through 6 [twelve tankers in the 12 knot scenario], then falling to 2-3 tanker in years 13 through 25) and an financial analysis may influence whether the emissions- (and cost-) conserving scenario is chosen over higher vessel speeds and fuel savings vs tanker leasing costs.[43]

We average the high (16 knot) and low (12 knot) modeling results for our reference scenario. See Table 13 and Figure 19.

Table 13: reference scenario maritime shipping emissions: Port Tanga to Rotterdam & rt.

	Tanker shipping emissions $ktCO_2e$	Shipments, @0.98 Mb # voyages
Per voyage (roundtrip)	7.7	1
Peak year (roundtrips)	620.1	80
Cumulative 25 yrs (ave.)	6,672.3	862

Figure 19. Annual estimated maritime transport emissions: reference case (roundtrip)

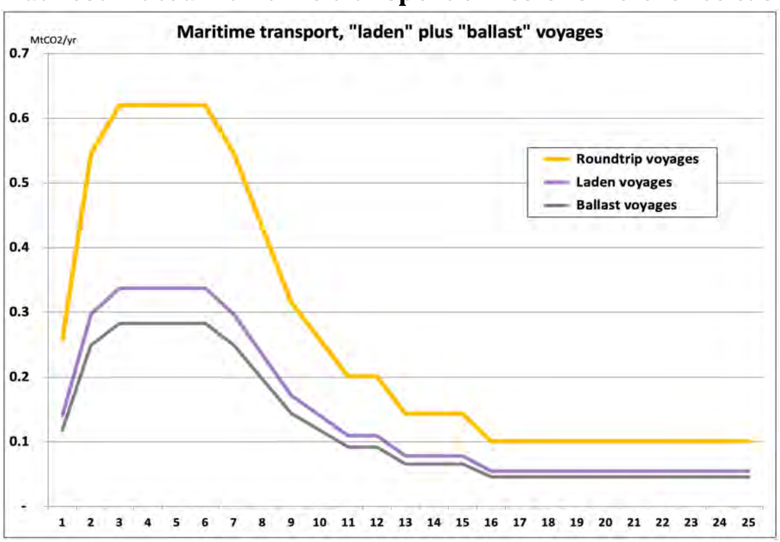


Figure 20. One of 571 operating Suezmax crude oil & petroleum product tankers

Suezmax tanker AST Sunshine, ordered and designed by Stena Bulk and Japanese Asahi Tankers, built at Samsung Heavy Industries, designed for energy efficiency, and launched in 2013. Flagged in Panama. Capacity is 159,000 DWT (1.16 Mb).

---

[43] We assume transit time of 18.8 days in the 16-knot scenario, times 2x for the return voyage, plus 2 days @ loading and unloading, and 25.1 days *2 + 4 days for the 12-knot scenario. At Rotterdam VLSFO fuel costs at $795 per tonne, the 12 kn vs 16 kn vessel speed saves 320 tonnes of bunker fuel and $254,300.

< 8 >

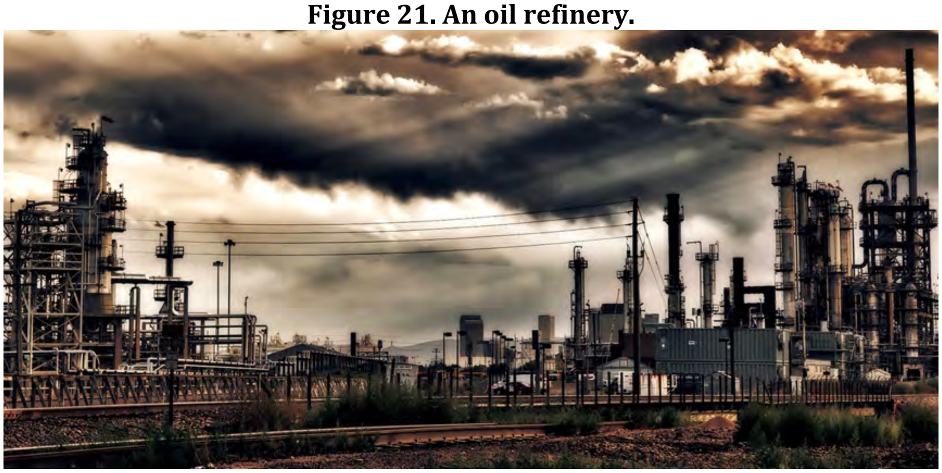
EMISSIONS: REFINING OF EACOP CRUDE OIL

Climate Accountability Institute calculates emissions from the refining of crude oil transported through the EACOP pipeline to the Marine Storage Terminal and shipped to refineries in Europe and China.

Neither of the EACOP reports on direct and indirect environmental and social impact reports include emissions from the crude oil delivered to refineries in Europe and/or China and refined into petroleum products such as petrol, diesel, heating oil, jet fuel, and other transportation or industrial carbon fuels.

CAI estimates refining emissions for the refining segment of the supply chain emissions. We base our estimate on the quantity of crude oil transported via the EACOP pipeline – 848 million bbl (Mb) over the 25-year planning horizon – and shipped by crude oil tankers from Tanzania's Port Tanga to refineries (see Chapter 7). The EACOP *Environmental & Social Impact Assessment* reports exclude discussion of any emission sources beyond the Marine Storage Terminal; more to the point, the ESIA reports contain no information or assay data on the characteristics of the crude oil produced by CNOOC and TotalEnergies, other than reference to light to medium oil, low sulphur, API gravity of 30-34, with a high pour point and wax appearance temperature. These characteristics will likely require higher energy input and emissions than average, blending with other crudes, import of hydrogen, and other energy-intensive processes leading to carbon-intensive refining emissions.

Figure 21. An oil refinery.

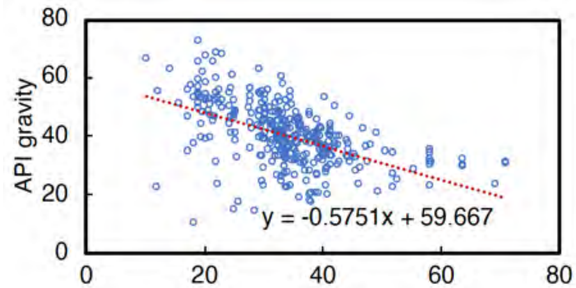


Lacking specifics on the Lake Albert crude oil assay, the crude characteristics, and the refineries that may process the crude into petroleum products, we initially used the global average refining carbon intensity (CI) of 40.7 kgCO_2e per bbl), from Jing et al. 2020.[44] This analysis results in total refining emissions of 34.5 million tonnes CO_2e (MtCO_2e) over the 25-year planning horizon, ranging from a low of 0.52 MtCO_2 (years 16-25) to a high of 3.21 MtCO_2/yr during plateau production in years 3 through 6. This is likely a conservatism, given that the crude from Lake Albert will probably require higher energy input and emissions than the global average emission rate used here.

[44] Jing et al. (2020) Carbon intensity of global crude oil refining and mitigation potential, *Nature Climate Change.* Note: refining emissions vary widely, depending on the processing technology, crude oil characteristics, crude blending, gas and electricity inputs, upstream methane rates, and so. Jing et al. document emissions ranging from 10 to 72 kgCO_2e per barrel at 473 refineries in 83 countries with inputs of 343 crude oils processed.

We therefore completed a more detailed analysis of refining emissions for the range reported in the *ESIA* report of API gravities ranging from 30 to 34. Refining emissions are estimated using the model developed in Masnadi et al. (2021), Supplementary Materials, Figure 17.[45] Refining the heavier API 30 gravity oil is estimated at 42.41 kgCO_2e/bbl refined, and for the lighter API 34 oil we calculate 40.11 kgCO_2e/bbl.[46] See Figure 22.

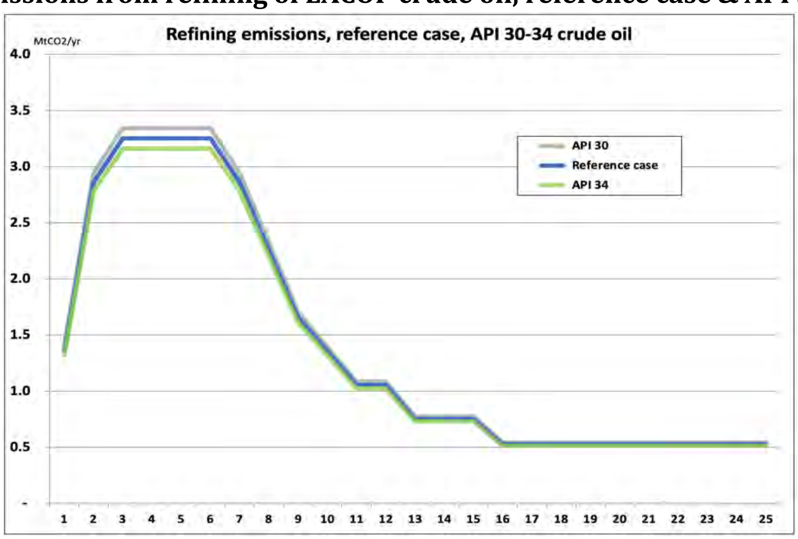
Figure 22. Correlation of API gravity and refining emissions.



Refining carbon intensity, kg CO_2e/bbl (x axis). Source: Masnadi et al (2021), SM, Figure 17.

The high estimate ("medium" API 30) results in cumulative emissions of 35.98 MtCO_2e (with emissions during peak production (yrs 3-6) of 3.34 MtCO_2e/yr. The low scenario ("light" API 34) results in 34.03 MtCO_2e, with a peak of 3.16 MtCO_2e/yr in years 3 through 6. We average the two for our reference scenario, which totals 35.0 MtCO_2e over the 25-year planning horizon. See Figure 23.

Figure 23. Emissions from refining of EACOP crude oil, reference case & API 30 and API 34



Assay data of Tilenga and Kingfisher crude oils from TotalEnergies and CNOOC would improve the refining emissions estimate. Details of TotalEnergies' or CNOOC's planned disposition of their crude oil supply from the EACOP project would also improve our analysis.

Note: if some of the oil is refined in Tanzania for domestic consumption (particularly of Tanzania Petroleum Development Corporation's share of EACOP), or sold to regional refiners, this will reduce maritime transport emissions accordingly, but may increase refining emissions. Currently, Tanzania imports all of its petroleum products, chiefly from India, United Arab Emirates, and Saudi Arabia.

---

[45] Masnadi, Mohammad S., Giacomo Benini, Hassan M. El-Houjeiri, Alice Milivinti, James E. Anderson, Timothy J. Wallington, Robert De Kleine, Valerio Dotti, Patrick Jochem, & Adam R. Brandt (2021) Carbon implications of marginal oils from market-derived demand shocks, *Nature,* vol. 599:80-87.

[46] Masnadi et al. (2021) Supplementary Materials, Fig. 17, page 43: formula is y = -0.5751x + 59.667. Ie for API 30: y = -0.5751*30 + 59.667: = -17.253 + 59.667 = 42.414 kgCO_2e/bbl. For API 34: -19.553 + 59.667 = 40.1136 kgCO_2e/bbl.

< 9 >

EMISSIONS: END USE OF EACOP CRUDE OIL

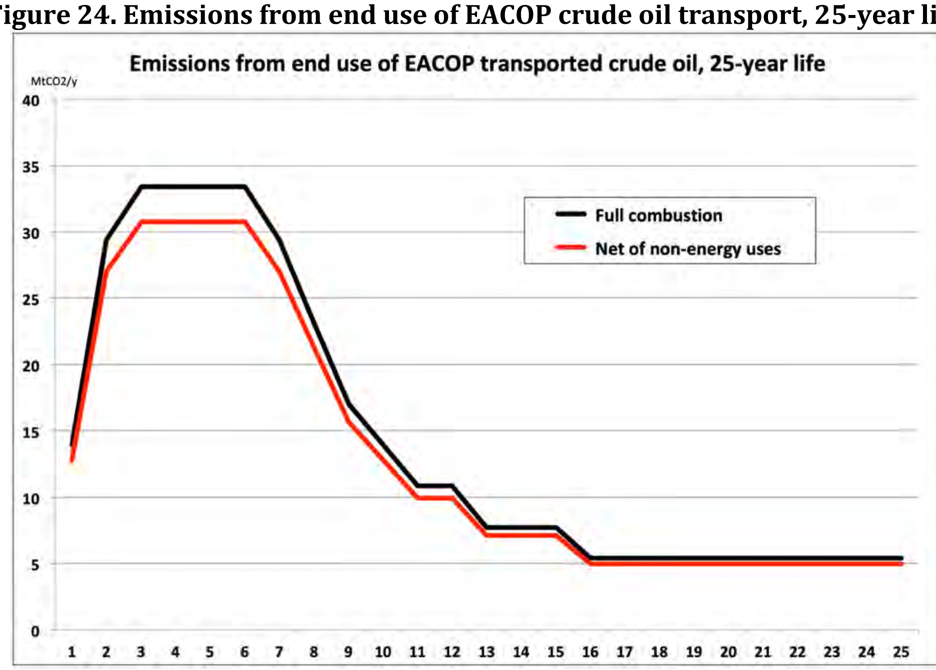
Climate Accountability Institute calculates emissions from end use of EACOP oil delivery

Neither of the EACOP reports on direct and indirect environmental and social impacts include emissions from the crude oil pipeline project in terms of the emissions from the end use of the transported oil. The disposition by geography or specific end uses are unknown.

Using CAI's peer-reviewed Carbon Majors methodology[47] we calculate end use emissions from the use of supplied carbon fuels on a per annum basis and cumulatively over the 25-year planning horizon. We use the EACOP crude oil pipeline flow rates as published in the Uganda ESIA (Table 1). Our model uses a standard barrel of crude oil that is, on average, refined into ~92 percent carbon fuels, such as petrol, diesel, jet fuel, bunker fuel, and ~8 percent for non-energy uses, such as road oil, petrochemicals, waxes, and lubricants.

The crude oil produced in Uganda and transported by EACOP from Port Tanga in Tanzania is, we assume, shipped to refineries in Europe and China and distributed to domestic, regional, or world markets. We estimated maritime shipping emissions in the chapter 7 and refining emissions in chapter 8.

Figure 24. Emissions from end use of EACOP crude oil transport, 25-year life.



The Carbon Majors methodology deducts for globally-averaged net non-energy uses of crude oil – 8.02 percent of the average barrel produced – which results in lower overall emissions from end use of refined carbon fuels. This is shown as the red line in Figure 19. Most analysts do not account

[47] Heede, Richard (2019) *Carbon Majors: Accounting for carbon & methane emissions 1854-2010 Methods & Results Report,* and Heede, Richard (2014) Tracing anthropogenic CO_2 and methane emissions to fossil fuel and cement producers 1854-2010, *Climatic Change*, vol. 122: 229-241; http://link.springer.com/article/10.1007/s10584-013-0986-y?view=classic

for typical non-energy uses of petroleum, however, which leads to inflated emission estimates, so for comparison reasons we also chart emission from full combustion of all EACOP crude oil in the black line.

CAI estimates annual and cumulative emissions from the crude oil transport discussed in chapter 3 on oil production (Figure 6). Plateau production of 216,000 bbl per day equals 48.8 Mb per year.

25-year cumulative EACOP crude oil transport totals 848 Mb.

The Carbon Majors emission factor of 389.87 kgCO_2/bbl times each year's crude oil flow rate yields annual product use emissions, net of non-energy uses.

The full-combustion factor is 423.85 kgCO_2/bbl.

Cumulative 25-year emissions, net of non-energy uses, totals 330.71 MtCO_2.

Cumulative 25-year emissions, full combustion, totals 359.53. MtCO_2.

Table 14. EACOP pipeline flow rates and estimated end use emissions

Year	**Crude oil flow rate** Million bbl Mb/yr	**End Use Combustion** Full end use MtCO_2/yr	**End-Use Combustion** Net of non-energy MtCO_2/yr
1	32.9	13.9	12.8
2	69.4	29.4	27.0
3	78.8	33.4	30.7
4	78.8	33.4	30.7
5	78.8	33.4	30.7
6	78.8	33.4	30.7
7	69.4	29.4	27.0
8	54.8	23.2	21.3
9	40.2	17.0	15.7
10	32.9	13.9	12.8
11	25.6	10.8	10.0
12	25.6	10.8	10.0
13	18.3	7.7	7.1
14	18.3	7.7	7.1
15	18.3	7.7	7.1
16	12.8	5.4	5.0
17	12.8	5.4	5.0
18	12.8	5.4	5.0
19	12.8	5.4	5.0
20	12.8	5.4	5.0
21	12.8	5.4	5.0
22	12.8	5.4	5.0
23	12.8	5.4	5.0
24	12.8	5.4	5.0
25	12.8	5.4	5.0
25-year total	**848.3**	**359.5**	**330.7**

< 10 >

EMISSIONS: SUMMARY

The emissions sources discussed in this report includes emission estimates provided in the EACOP *Environmental and Social Impact Assessment* reports for construction phase emissions and pipeline operation (both annually and the full 25-year project lifetime). These EACOP estimates are flawed, poorly documented, and incomplete, and neither report provides sufficient documentation allowing this analyst to provide a full quantification of missing, partial, or incomplete emission sources.

To fill these analytical and emission gaps, CAI has calculated emissions from sources omitted in the EACOP reports. The EACOP *ESIA* reports focus on the narrow and limited emissions and climate impacts of construction and pipeline operation, while ignoring the broader and far more substantial climate impacts of the intended use of the crude oil produced in Uganda and made available to world markets by virtue of the EACOP pipeline, subsequent maritime shipping, and refining of the transported oil. In other words, the EACOP ESIA reports omit emissions from the consumption of the petroleum products by end use consumers who use these carbon fuels as intended for heat and mobility. The inevitable result: large-scale emissions of carbon dioxide that far exceed emissions from pipeline construction and operation that comprise the limited scope in the ESIA reports.

Our additional estimates include emissions from maritime transport of crude oil delivered to Port Tanga (we assume shipping with Suezmax tankers to central Europe (a voyage of 7,227 nm; shipping distance to China is ~7,000 nm). We quantify emissions from refining of the transported crude oil into petroleum products, and the emissions from the consumption of petroleum products by TotalEnergies' and CNOOC's global customers.

See individual chapters for additional discussion and calculations.

Figure 25 shows the relative dominance of end use emissions.

Figure 25: full project emissions from construction to end use, 25-yr life

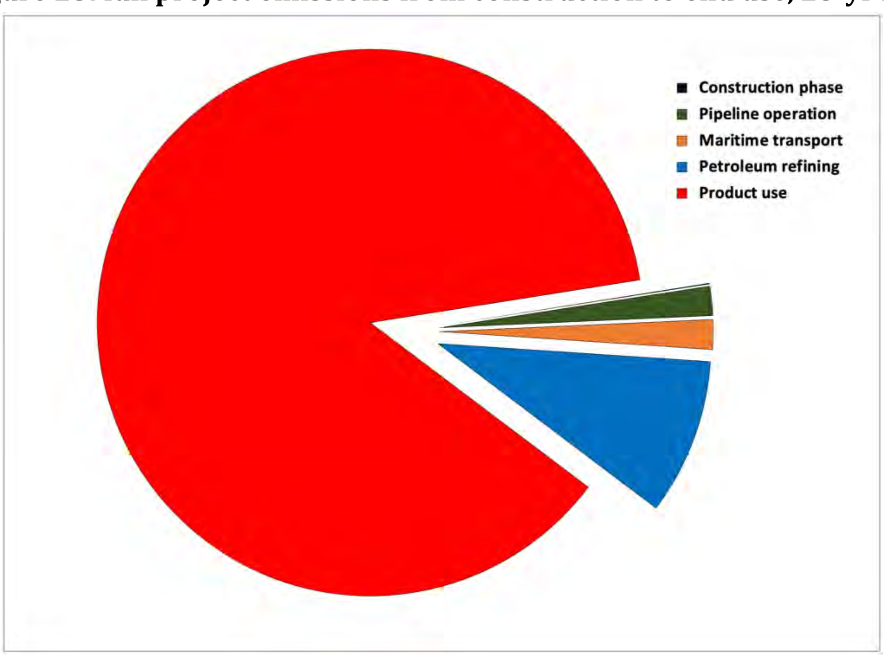
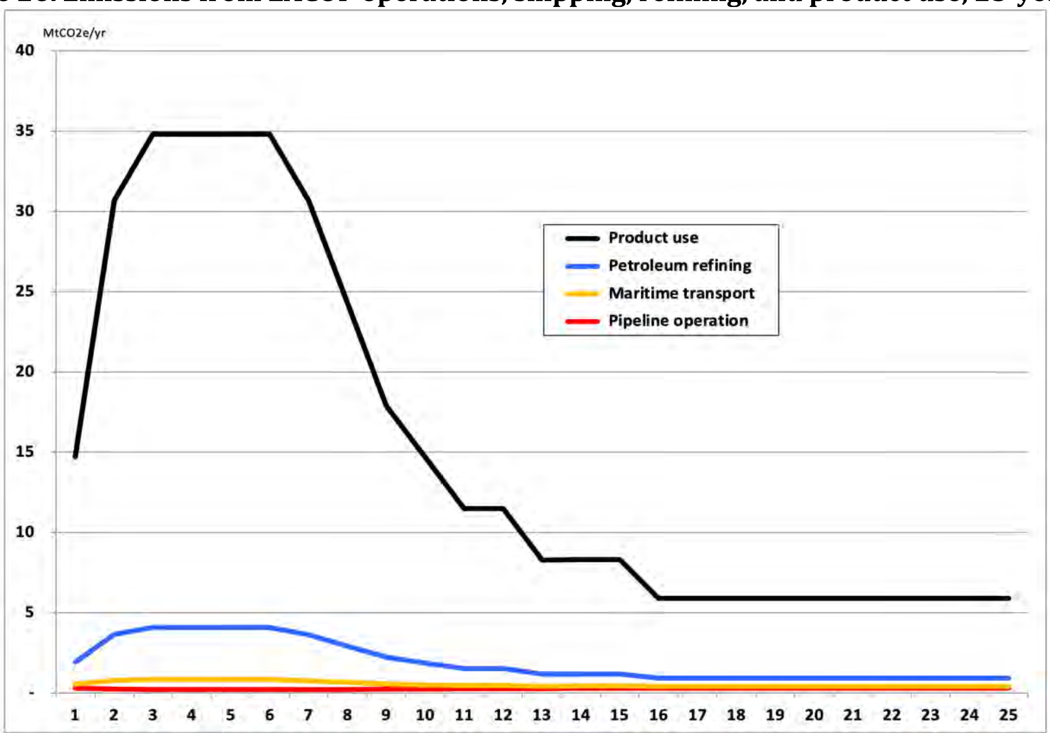


Table 15: value chain emissions: construction, operations, shipping, refining, & product use

	Project phase $MtCO_2e$	Percent	Comments
Upstream production			not included
Construction phase	0.24	0.06%	partial EACOP estimate, Uganda only
Pipeline operation	6.55	1.73%	relies on EACOP data, flawed?
Maritime transport	6.67	1.76%	preliminary estimate, CAI
Refining	35.00	9.23%	preliminary estimate, CAI
Product use	330.71	87.22%	end use estimate, net non-energy
Total:	**379.17**	**100%**	**379 million tonnes CO_2e**

Of the full lifecycle emissions (excluding production and field emissions[48]) detailed in this report, EACOP's estimated construction and operational emissions over the project's 25-year lifetime accounts for only 1.8% of the project total, as quantified here. Maritime shipping to Europe and/or China accounts for 1.5%, refining 9.1%, and product use, clearly the largest component, at 87.6%. (In product use we deduct for net non-energy uses, as discussed in chapter 9.)

Figure 26. Emissions from EACOP operations, shipping, refining, and product use, 25-year life



-#-

[48] Note that we cited Total's estimated production-related emissions in Chapter 4. Total estimates cumulative emissions (25-yr life) at 23.3 $MtCO_2e$, and averaging 0.89 $MtCO_2e$ for Commissioning and Operations. Site preparation (cumulative 0.24 $MtCO_2e$) and Construction and Decommissioning at each 0.764 $MtCO_2e$. Total, CNOOC, Tullow (2019) *Tilenga Project: Environmental and Social Impact Assessment*: Vol. 2, Ch. 6.

< 11 >

CONCLUSIONS

Climate Accountability Institute has been commissioned to evaluate the rigor and completeness of the climate impacts and quantitative aspects of the emissions attributable to the East Africa Crude Oil Pipeline (EACOP). The primary documents in which EACOP calculations are made are the two *Environmental and Social Impact Assessment* reports, one each for the Uganda and Tanzania sections of the pipeline.

Quality and completeness of the Uganda and Tanzania ESIA reports

A sound assessment of the climate impacts of any proposed fossil fuel development would include a complete, transparent, and fully documented identification of energy uses and emissions sources, followed by a thorough and transparent quantification of related emissions of carbon dioxide and methane for each source.

Neither ESIA report accomplishes this task, its lengthy reports notwithstanding.

Neither ESIA report fully identifies all emission sources, nor delivers detailed emission estimates for any but a few of the sources (the Uganda ESIA, for example, adequately quantifies emissions from diesel fuel consumed in trenching, road building, grading, camp construction, pipe laying equipment, etc.). The Tanzania report fails completely in presenting emission calculations over the pipeline's 25-year planning horizon, even though it is clearly acknowledged that annual emissions vary dramatically depending on such variables as crude oil flow rates through the pipeline, the variable need for bulk heaters and/or trace heaters, and the heating requirements of the oil stored in the Marine Storage Terminal at Port Tanga.

Numerous other shortcomings are described in earlier chapters of this study.

A complete supply chains emissions inventory

Even more significant is the ESIA reports' lack of discussion of indirect emissions from the delivery, maritime transportation, crude oil refining, and end use of the crude oil transported.

We find the scope of EACOP's ESIA reports inadequate. In terms of the emissions and attributable to the crude oil produced in Uganda and transported via the 1,443-km pipeline to Port Tanga in Tanzania, the ESIA reports omit the most significant elements of the project's climate impacts: the emissions from maritime transport to TotalEnergies' and CNOOC's (or third parties') refineries, substantial refinery emissions, and most importantly, emissions from the combustion of the finished carbon fuels supplied to world markets. This is, after all, the intended use of the extracted crude oil, and the profits from the sale of petroleum fuels underpins the financial rationale for the large capital expenditures already invested and committed to the pipeline construction and Marine Storage Terminal.

As we show in chapter 9 we estimate end use emissions from the global distribution of the full 25-year crude oil delivery of 848 million bbl (Mb) of oil. CAI uses two emission factors: one accounting for net non-energy uses, and the second based on full combustion of all crude oil. CAI believes the non-energy calculation is a better representation of real-world oil uses, that on average diverts ~8 percent of crude oil for road oil, petrochemicals, lubricants, and the like.

CAI quantifies 25-year project lifetime emissions – from pipeline construction, 25-year operation, maritime shipping, crude oil refining, and end use – totaling 379 million tonnes CO_2e, averaging 15 $MtCO_2$ per year (ranging from a peak at plateau production of 34.8 $MtCO_2e$ to a low of 5.9 $MtCO_2e$ in year 25). According to the Global Carbon Budget (GCP), Uganda emits 5.53 MtCO_2 and Tanzania emits 11.66 MtCO_2 from fossil fuels and cement (sum: 17.19 MtCO_2).[49] The GCP estimates are for fossil fuel and cement only (aka "industrial emissions"). Including other major sources from agriculture, land use change, forestry, and waste, increases Uganda's emissions to 70.7 MtCO_2e and Tanzania's to 175.6 MtCO_2e. The combined total is 246.3 MtCO_2e.[50]

The EACOP pipeline, averaging 15 MtCO_2/yr, if attributed to the two countries, is 88% of Uganda's and Tanzania's combined fossil fuel emissions, but only 6.1% of combined total emissions of 246.3 MtCO_2e. At plateau production (years 3 through 6), total emissions attributed to the EACOP pipeline – 34.8 MtCO_2e – is twice Uganda's and Tanzania's combined fossil fuel emissions in 2018.

If we allocate plateau crude oil production and pipeline maximum flow rate of 216,000 bbl per day, or 78.8 million bbl per year (Mb), to each operating company, then TotalEnergies' share of EACOP is 44.6 Mb, and CNOOC share is 22.3 Mb.[51] TotalEnergies' share of plateau production is 7.6% of the company's 2019 liquids production of 584 Mb, and CNOOC's allocation is 5.6% of its 2019 production of 400 Mb (crude oil production only; both companies produced substantial amounts of natural gas).[52]

Figure 27. The EACOP boundary definition and results (MtCO_2e)

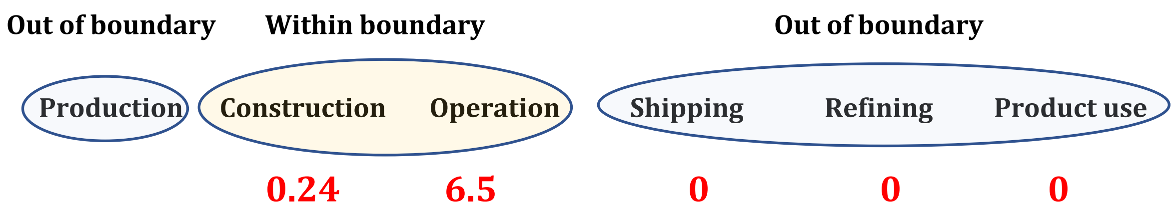
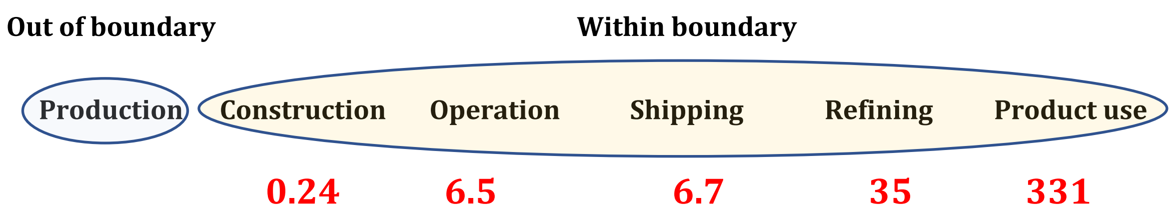


Figure 28. This report's boundary definition and results (MtCO_2e)



How TotalEnergies will integrate its Ugandan oil production, EACOP crude oil transport, shipping to its refineries (or sold to third parties), and the attributed sale and end use of its products with the company's commitment to reach net zero (including from the petroleum products "used by its customers") by 2050 will be an interesting exercise.[53]

-###-

[49] Friedlingstein, Pierre, et al. (2020) Global Carbon Budget 2020, *Earth Syst. Sci. Data*. Uganda 5.53 MtCO_2 plus Tanzania 11.66 MtCO_2 = 17.19 MtCO_2. Fossil fuel & cement only. The Uganda Nationally Determined Contribution (Uganda Ministry of Water and Environment (2015)) shows 2030 Business As Usual emissions of 77.3 MtCO_2e.

[50] ClimateWatch 2018 Uganda: Agriculture: 29.52 MtCO_2e, Energy: 22.43 MtCO_2e, Land Use Change & Forestry (LUCF) 15.84 MtCO_2e, Waste: 1.93 MtCO_2e, Industrial processes: 0.987 MtCO_2e; total: 70.71 MtCO_2e. 2030 BAU target: 77.30 MtCO_2e. www.climatewatchdata.org/countries/UGA. ClimateWatch data for Tanzania 2018: Agriculture: 58.23 MtCO_2e, Energy: 39.04 MtCO_2e, LUCF 70.19 MtCO_2e, Waste: 6.06 MtCO_2e, Industrial processes: 2.04 MtCO_2e; total Tanzania 2018: 175.57 MtCO_2e. 2030 BAU target: 170.00 MtCO_2e. Combined Uganda and Tanzania:

[51] Final ownership of the oil transported through the EACOP pipeline is difficult to verify. Assuming that Uganda National Oil Company will exercise its option to become a 15% partner, this will reduce Total SA's share from 66.66% to 56.66% and CNOOC's share from 33.33% to 28.33%. However, as far as this allocation goes, UNOC may have no reason to export its share via the EACOP pipeline, and if so, Total and CNOOC may transport 67% and 33% of the pipeline volume.

[52] Total SA (2020) *Fact Book 2019*, 134 pp. CNOOC (2020) *Annual Report 2019*, 172 pp, page 3.

[53] Total SA (2020) *Getting to Net Zero*, Paris, September, p. 10.

Annex A

References & Sources Consulted

Adland, Roar, Pierre Cariou, & Francois-Charles Wolff (2020) Optimal ship speed and the cubic law revisited: Empirical evidence from an oil tanker fleet, *Transportation Research Part E: Logistics & Transportation Rev.*, vol. 140, August.

Anon (undated) Kingfisher Oil Field Development, *NS Energy Business*, https://www.nsenergybusiness.com/projects/kingfisher-oil-field-development/

Armstrong, Victor N. (2013) Vessel optimisation for low carbon shipping, *Ocean Engineering*, 15 November.

BankTrack (2020) *East African Crude Oil Pipeline (EACOP) Uganda*, online update, 9 October, https://www.banktrack.org/project/east_african_crude_oil_pipeline/pdf

BankTrack et al. (2019) *Your Bank's Role in Arranging Finance for the East Africa Crude Oil Pipeline, letter to Sumitomo Mitsui Banking Corporation, Stanbic Bank Uganda,, and Standard Bank,* signed by 19 African & 10 international NGOs, 18 May, 5 pp. https://www.banktrack.org/download/letter_from_banktrack_and_inclusive_development_international_to_standard_bank_on_standard_banks_role_in_arranging_finance_for_the_east_african_crude_oil_pipeline/190515_eacop_to_lead_arrangers.pdf

BP (2021) *Statistical Review of World Energy 2021*, 70th edition, London, June, 72 pp. https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf

Brandt, Adam R., Mohammad S. Masnadi, Jacob G. Englander, Jonathan Koomey, & Deborah Gordon (2018) Climate-wise choices in a world of oil abundance, *Env'l Research Letters*, vol. 13(4): online. Also Supplementary Materials, 20 pp.

CDP (2016) *Guidance methodology for estimation of scope 3 category 11 emissions for oil and gas companies*, Paul Griffin, CDP, with Climate Accountability Institute, 32 pp.

Center for Strategic Litigation (2021) *The Proposed East African Crude Oil Pipeline (EACOP): Risk analysis from a Tanzanian perspective*, by Brian Cooksey, 72 pp.

Chang, Ching-Chih, & Chih-Min Wang (2014) Evaluating the effects of speed reduce for shipping costs and CO2 emission, Transportation Research Part D: Transport and Environment, August.

Chatham House (2013) *Oil in Uganda International Lessons for Success*, Ben Shepherd, London, February, 30 p. https://www.chathamhouse.org/sites/default/files/public/Research/Africa/0113pr_ugandaoil.pdf

China National Offshore Oil Company (2020) SEC Form 20-F.

CNOOC (2018) *Kingfisher Oil Development Environmental and Social Impact Assessment: Kingfisher Oil Development Physical Environment Report,* Report 4A, 746 pp. https://cnoocinternational.com/en/related-content/uganda/environmental-and-social-impact-assessment

CNOOC (2018) *Kingfisher Oil Development: Main Rpt*, vol. 2, Table 6.5.1 Hydrocarbon Emissions, p. 32.

Choquet, Pierre-Louis (2019) Piercing the corporate veil: Towards a better assessment of the position of transnational oil and gas companies in the global carbon budget, *Anthropocene Review*, July.

Chromalox (2003) *Electrical Heat Tracing Systems Design Guide*, Pittsburgh PA, 42 pp. https://www.arcoengineering.com/chro/Chromalox_Heat_Trace_Design_Guide_AE.pdf

Climate Policy Initiative (2020) *Understanding the impact of a low carbon transition on Uganda's planned oil industry*, by Matthew Huxham, Muhammed Anwar, Eoin Strutt, & David Nelson, San Francisco, 62 pp.

Cloke, Ian, Shane Cowley, & Robin Rindfuss (Tullow Oil) (2018) Hydrocarbon Exploration History of Uganda, *GeoExpro*, vol. 15(5), https://www.geoexpro.com/articles/2018/11/hydrocarbon-exploration-history-of-uganda

East Africa Crude Oil Pipeline (2020) *Environmental and Social Impact Assessment, EACOP Project, Uganda* ESIA, Executive Summary, and Section 2: Project Background and Description (73 pp), and Appendix G: Impacts Assessments (161 pp.); https://eacop.com/uganda-esia-report

East Africa Crude Oil Pipeline (2019) *Environmental and Social Impact Assessment, EACOP Project, Tanzania ESIA,* Executive Summary, and Project Description (73 pp), and Section 8: Impact Identification and Evaluation – Normal Construction & Operations (493 pp.), August. https://eacop.com/esia-tanzania/

Energy Facts (2020) Total acquires Tullow entire interest in the Uganda Lake Albert Project, *Energy Facts*, 24 April, https://www.energyfacts.eu/total-acquires-tullow-entire-interest-in-the-uganda-lake-albert-project/

Esau, Iain (2022) Plenty to ponder: 'Sky rocketing prices' drive cost of TotalEnergies' EACOP pipeline to $5 billion as schedule slips, *Upstream*, 21 April. https://www.upstreamonline.com/exclusive/plenty-to-ponder-sky-rocketing-prices-drive-cost-of-totalenergies-eacop-pipeline-to-5-billion-as-schedule-slips/2-1-1202222

Friedlingstein, Pierre, et al. (2020) Global Carbon Budget 2020, *Earth Syst. Sci. Data*, vol. 12:3269–3340. https://www.globalcarbonproject.org/carbonbudget/20/data.html

Heat Trace (2009) *Electric heat tracing: Neil Malone discusses electric heat tracing of long pipelines*, Heat Trace UK, https://www.heat-trace.com/admin/news/100_Heating of Long Pipelines - World Pipelines (Sept09).pdf

Heede, Richard (2019) *Carbon Majors: Accounting for carbon and methane emissions 1854-2010 Methods & Results Report*, ISBN 978-3-659-57841-0, re-issued 2014 edition, OmniScriptum, Riga, 148 pp.

Heede, Richard (2014) Tracing anthropogenic CO_2 and methane emissions to fossil fuel and cement producers 1854-2010, *Climatic Change*, vol. 122:229-41. http://link.springer.com/article/10.1007/s10584-013-0986-y?view=classic

International Petroleum Industry Environmental Conservation Association (2016) *Estimating petroleum industry value chain (Scope 3) greenhouse gas emissions: Overview of methodologies*, June, 84 pp.

Isabirye, Moses (2020) Environmental Sustainability: An Afterthought or a Key Objective for Uganda's Oil Sector? pp. 225-238 in: Langer et al. 2020, *Oil Wealth and Development in Uganda and Beyond.*

Jing, Liang, Hassan M. El-Houjeiri, Jean-Christophe Monfort, Adam R. Brandt, Mohammad S. Masnadi, Deborah Gordon, & Joule A. Bergerson (2020) Carbon intensity of global crude oil refining and mitigation potential, *Nature Climate Change*, vol. 10:526-532. Also: Supplementary Materials, 47 pp.

Langer, Arnim, Ukoha Ukiwo, & Pamela Mbabazi, eds. (2020) *Oil Wealth and Development in Uganda and Beyond: Prospects, Opportunities, and Challenges*, Leuven University Press, 394 pp. https://www.jstor.org/stable/j.ctvt9k690

Lindstad, Haakon, & Gunnar S. Eskeland (2015) Low carbon maritime transport: How speed, size and slenderness amounts to substantial capital energy substitution, *Transportation Research Part D: Transp. & Env.*, vol. 41:244-256.

Masnadi, Mohammad, Hassan El-Houjeiri, Joule Bergerson, Deborah Gordon, Jonathan Koomey, Steven Przesmitzki, Inês, McGlade, Nathan Meehan, Sonia Yeh, Fengqi You, Michael Wang, & Adam R. Brandt (2018) Global carbon intensity of crude oil production, *Science*, vol. 361:851-853.

Musoke, Ronald (2020) Total promises to fast track Uganda oil project, *The Independent*, Kampala, 22 Sep.

MotorShip (2012) First of Four Eco-Design Suezmax Tankers Joins AET Fleet, 1 July, www.motorship.com/news101/ships-and-shipyards/first-of-four-eco-design-suezmax-tankers-joins-aet-fleet

Netherlands Commission for Environmental Assessment (2017) *Review of Scoping Report and Terms of Reference for the Environmental and Social Impact Assessment for the EACOP - Uganda*, September, 16 pp. https://www.eia.nl/en

Netherlands Commission for Environmental Assessment (2019) *Advisory Review of the Environmental and Social Impact Assessment for the East Africa Crude Oil Pipeline (EACOP)-Uganda*, June, 18 pp. https://www.eia.nl/en

Netherlands Commission for Environmental Assessment (2020) *Advisory Review of the resubmitted Environmental and Social Impact Assessment for the EACOP - Uganda*, October, 30 pp. https://www.eia.nl/en/projects/7228

Oxfam, Civic Response Env & Dev, Global Rights Alert, & Northern Coalition for Extractives & Env (2020) *Empty Promises Down the Line? A Human Rights Impact Assessment of the East African Crude Oil Pipeline*, September, London, 109 pp.

Oxfam, International Federation for Human Rights (2020) *Oil in East Africa: Communities at Risk*, London.

Psaraftis, Harilaos N., & Christos A. Kontovas (2013) Speed models for energy-efficient maritime transportation: A taxonomy and survey, *Transportation Rsrch Part C: Emerging Technologies*, January.

Reclaim Finance & Greenpeace (2021) *Pipeline of Pollution: Total responsible, finance complicit?* by Lucie Pinson & Florence de Bonnafos, February, 32 pp. https://reclaimfinance.org/

Science Based Targets Initiative (in progress) *Guidance on setting science-based targets for Oil, Gas and Integrated Energy companie*s, CDP, Technical Review Group, 67 pp.

Stewart, Robert R. (2010) An assessment of natural and man-made vibrations in Lake Kivu, Rwanda, *CREWES Research Report,* vol. 22, University of Houston, January 2010, 25 pp.

Stigter, C. J., Y. B. Mjungu, P. B. M. Lutege, J. M. Waryoba, C. O. Othieno, & A. R. Mwampaja (1984) Relationships between soil albedos and soil and air temperatures, *Netherlands J. of Agricultural Science*, vol. 32:33-42.

Total SA (2020) SEC Form 20-F

Total SA (2020) *Getting to Net Zero*, Paris, Sept, 60 pp.

Total (2020) *Factbook 2019*, 134 pp. page 62.

Total, CNOOC, Tullow (2019) *Tilenga Project: Environmental and Social Impact Assessment*: vol. 2, Ch. 6: Air Quality & Climate, Submitted to Uganda NEMA, 700 pp. https://ug.total.com/sites/g/files/wompnd1236/f/atoms/files/tilenga_esia_volume_ii_28-02-19_reduced_size.pdf

Total SA (2016) *Integrating Climate into our Strategy*, Paris, May, 44 pp.

Tran, Nguyen Khoi, & Jasmine Siu Lee Lam (2021) Effects of container ship speed on CO2 emission, cargo lead time and supply chain costs, *Research in Transportation Business & Management*, online October.

Tullow Oil (2020) *Annual Report and Accounts 2019*, London, 168 pp.

Uganda Ministry of Water and Environment (2015) *Uganda's Intended Nationally Determined Contribution* (INDC), Kampala, 15 pp.

US AID (2015) *Greenhouse Gas Emissions in Uganda*, October, 2 pp. https://www.climatelinks.org/

U.S. Energy Information Administration (2016) *Country Studies: Uganda*, www.eia.gov/international/analysis/country/UGA

U.S. Environmental Protection Agency (2020) *Emission Factors for Greenhouse Gas Inventories*, EPA Center for Corporate Climate Leadership, Emission Factors Hub, 26 March, 5 pp. https://www.epa.gov/sites/production/files/2020-04/documents/ghg-emission-factors-hub.pdf

White, Maddy (2021) Macron pushes East African oil pipeline as French banks shun project, *Global Trade Review*, 5 May.

Woody, Todd (2013a) The World's Greenest Oil Company? *The Atlantic*, theatlantic.com, 6Dec. (France's Total is hedging against a low-carbon future by investing in solar and biofuels.)

World Resources Institute and World Business Council for Sustainable Development (2011) *Corporate Value Chain (Scope 3) Accounting and Reporting Standard*, October 2011, 148 pp.

World Resources Institute & World Business Council for Sustainable Development (2004) *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard*, Rev. Edition, 112 pp., www.ghgprotocol.org

Worldwide Oil & Gas (2020) Total acquires Tullow Oil Uganda assets for $575 million, *Worldwide Oil & Gas*, April, https://www.worldwideoilandgas.com/blog/5304/total-acquires-tullow-oil-uganda-assets-for-575-million

Young, Ben, Troy Hottle, Troy Hawkins, Matt Jamieson, Gregory Cooney, Kavan Motazedi, & Joule Bergerson (2019) Expansion of the Petroleum Refinery Life Cycle Inventory Model to Support Characterization of a Full Suite of Commonly Tracked Impact Potentials, *Env. Sci. & Techn.*, vol. 53:2238-2248.

Annex B

SuezMax tankers: correlation btw vessel speed and fuel consumption

See chapter 7 for discussion.

Figure 29. fuel consumption vs tanker speed, SuezMax tankers (from Adland et al. 2020)

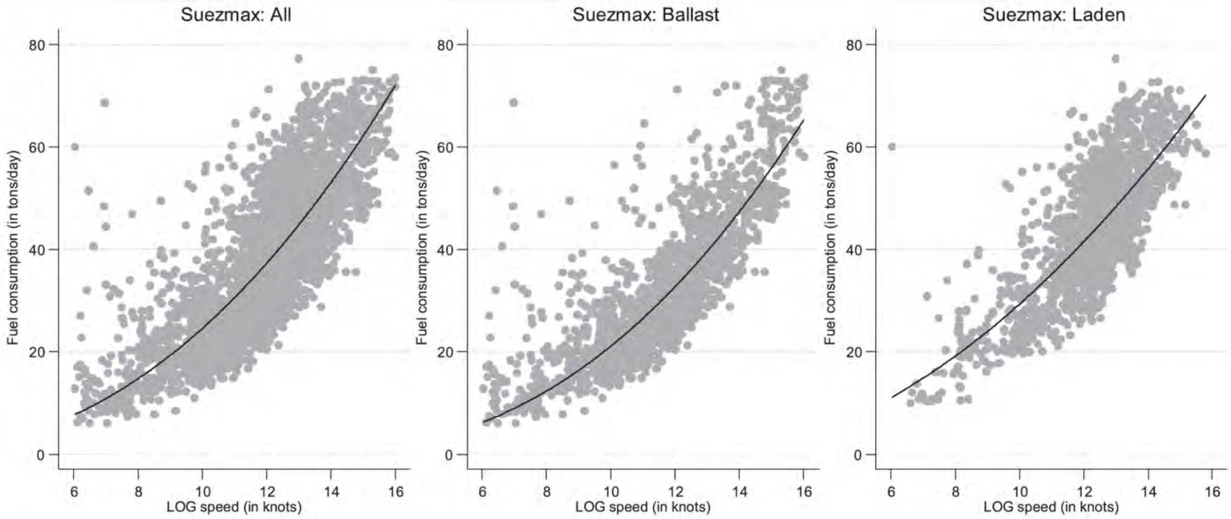


Fig. 2. Correlation between fuel consumption and speed. Source: Data from a tanker company, authors' calculations. Note: The solid curves plot estimates from nonlinear least squares regressions explaining fuel consumption as a power function of speed. The sample is restricted to average daily speeds between 6 and 16 knots.

Adland, Roar, Pierre Cariou, & Francois-Charles Wolff (2020) Optimal ship speed and the cubic law revisited: Empirical evidence from an oil tanker fleet, *Transportation Research Part E: Logistics & Transportation Rev.*, vol. 140, August.