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Review article

Examining prospects and challenges of Ghana's petroleum industry: A systematic review

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ABSTRACT

Established petroleum energy system comprises primary energy, conversion, transportation & distribution through to the final petroleum useful sectors. And disparate literature in such industry may not contribute to future research direction and policy development. Therefore, this study examines challenges and prospects of the petroleum industry in Ghana with innovative and transparent systematic literature review technique. Scholars developed procedural framework; first formulating the review question, identification and selection of literature. Researchers further establish scientific research criteria and accepted some relevant studies. The study then appraises the selected literature where scholars evaluated previous studies into qualitative and quantitative literature. Researchers finally, analyze and synthesize the literature with both narrative and triangulation techniques. The result reveals in both that previous literature has been disjointed and mainly focus on two topics; descriptive content petroleum policy and somehow on descriptive petroleum statistics. However, those studies have contributed immensely to the petroleum revenue management, local content, and petroleum production bills into applicable laws. Furthermore, this paper reveals that Ghana is petroleum import-dependent of 17%, 37% for natural gas, and 78% for petroleum products as of 2016. As of 2018, petroleum consumption accounted for about 80% of final energy excluding biomass in Ghana. And, the local petroleum production only contributes 5% of this total with importation share of 95%. This work finally observes that the literature had some research gaps after quantitative analysis with inferential statistics in broad petroleum issues and some critical topics such as petroleum infrastructure development. Thus, petroleum industry researches could not be examined with factor & discriminant analysis, logistic & probit regression, and path analysis to identify significant variables challenges and prospects. This study contributes knowledge in bringing the literature to current state of the art with systematic review technique. And further recommends strategic policy designs and future research path in the industry.

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1. Introduction

The petroleum industry in Ghana currently is the oil and gas sector. The petroleum value chain includes the processes of exploration, production, conversion, refining, and transporting. Furthermore, it includes management & regulatory framework, marketing of the final products to consumers and the associated infrastructure development (Peirce, 1986). Petroleum industry provides so many products ranging from crude oil and gas, petrochemical products through to the last by-product, bitumen. It is in fact, very critical to many sectors of the Ghanaian economy and hence its relevance to growth and development. The petroleum industry by far in Ghana is the largest industry currently in infrastructure monetary terms. That is, according to Dobbs et al. (2013), the value of any country's overall infrastructure stock adding to energy without roads or waterways on average amounts to 70% of its gross domestic product (GDP). In the same disposition, International Energy Agency (IEA) estimated that about 1.5% of global GDP is needed on yearly basis for energy-related infrastructure until 2035 in order to expand supply with demand and existing energy policy goals (International Energy Agency, 2012)

Ghana discovered economic oil and gas in large quantities in 2007 (Ghana National Petroleum Corporation, 2008) and later in 2010, the country commissioned the production of crude oil and natural gas. The all-important natural resource fines over the years have contributed and added up to the total exports of Ghana, which yields hard currency in a form of revenue for economic growth and development. According to Ghana Statistical Service (2015) the GDP of Ghana had recorded double-digit growth (14%) in 2011 after two years of exporting oil, thus from a single-digit growth rate (4.8%) in 2009. Oil and natural gas find and petroleum operations in every economy provide three significant economic benefits. The first benefit includes revenue and income to the government through the sale of commodities and corporate taxes. Secondly, the creation of employment opportunities to the citizenry both direct and indirect and thirdly, delivery of primary energy to the economy for domestic consumption. Currently, the petroleum industry in Ghana has provided the economy with both the first and second economic benefits mentioned above to some reasonable degree.

Moreover, International Energy Statistics (2015) observed that Ghana is still a net importer of petroleum products even though been petroleum producer. This is not because of insignificant production but put purely, no available midstream sector infrastructure facilities to engage in petroleum processing, refining, and storage of raw and transport final products for the country to achieve energy sufficiency and security. Currently Ghanaian economy dependents hugely on petroleum, thus, contributes 80% to total energy mix excluding biomass for growth and development, since 2000. However, the local production only accounted for about 5% of this total, with imported petroleum contributing approximately 95% as of 2016 (Ghana Energy Commission, 2016). In other words, Ghana is challenged with the importation of petroleum products notwithstanding producing petroleum in large quantities, besides the robust prospects, (processing and storage facilities). That is, the petroleum sub-sector is challenged with government attention and private sector investments to develop the midstream to downstream infrastructure to enhance petroleum processing, storage, and transportation for the support of domestic market demands.

Historically, there is a lot of literature on the petroleum industry which typically has been fragmented in nature and most explicitly focuses mainly on new topics and in narrative nature without consolidating the previous works to direct future works. Over the years the new empirical research without synergies and systematic review have resulted in disjointed and contradictory research outcomes. And these outcomes have not contributed more to research improvement and policy in the petroleum industry over the years. And hence the motivation of this paper is to identify and consolidate disjointed researches in the petroleum sector with an innovative and transparent methodology, systematic review (Denyer and Tranfield, 2009) and further recommend future research direction for academia and policymakers. This study therefore, would contribute sufficiently to new knowledge in bringing the petroleum sector literature to reflect the current state of the art. As this may avoid further research duplication. The systematic literature review (SLR) may also provide a methodological framework for future reviews in Ghana and beyond since the model is relatively new in petroleum research. Thus, the approach could also be duplicated, which would give confidence to practitioners and academia in the industry to perform reviews on other topics worldwide. Moreover, this study recommends insightful strategies to policy designers, and private sector organizations in the petroleum industry in Ghana and others that share similar characteristics.

Finally, the remaining parts of the paper are structured as follows; section two, covers the main methodology (formulation of review question, identification, and selection). Section three presents the study analysis, synthesis of literature and final section four, summaries research gaps & policy strategies and conclusion.

2. Methodology

This section presents a systematic review methodology framework. According to Denyer and Tranfield (2009), Rousseau and others (2008), Durach et al. (2017), Littell (2006) and Perroni and others (2015) systematic literature reviews are prominently applied in pure science, for example, medicine and health. However, its usage is equally appropriate in the social sciences and organizational context as well. The application of systematic review in social science and developmental phenomena has become progressively beneficial in assessing the impacts of interventions in the 21st-century literature development globally (Malletta and others, 2012). The Fig. 1 below represents the framework of the study. Session

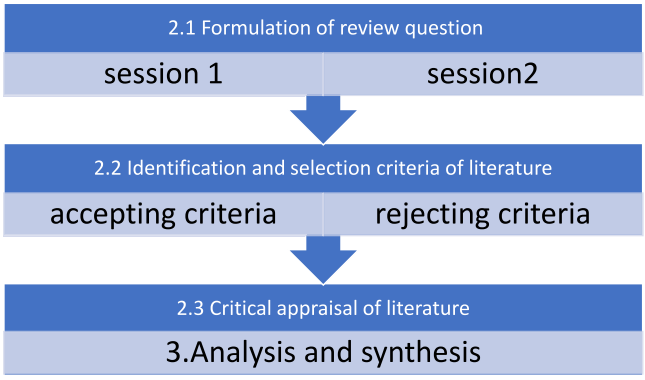


Fig. 1. Systematic review framework.

2.1. Step One: Formulation of review question/ topic

First and foremost, researchers presented the topic at two research seminar sessions (energy policy frontier), where, scholars presented the review topic to doctoral students. The students asked questions and helped in reshaping the formulated topic to suit examining challenges and prospects of Ghana's petroleum industry. Some two critical questions that were asked are; what are the common literature review techniques in the petroleum industry? Researchers answered them subject to the sorted literature. That is, the common literature review is narrative technique. The second question is that what is the uncommon literature review methodology? Researchers did answer them per the available relevant studies in the industry. The uncommon techniques are systematic review, meta-analysis, meta-ethnography, preferred reporting items for systematic reviews and Meta-Analysis (PRISMA). However, the study followed the works of Durach et al. (2017), Perroni and others (2015), Malletta and others (2012) and Tranfield and others (2003) as they suggested that SLR suits well in examining energy reviews, because of its cumulative impacts on other sectors.

2.2. Step Two: Identification and selection criteria of scientific literature

Giving to Perroni and others (2015) and Tranfield and others (2003) the work developed a protocol for selecting appropriate and relevant literature. In line with this, authors then planned our review with the tools to use and the type of applicable studies to be included, in the appraisal and synthesis stage (Davies and Crombie, 1998). This protocol ensures that our systematic review was transparent, objective and replicable (Malletta and others, 2012; Torrance, 2004) in nature, and could be challenged, criticized and or even revise for improvement purposes. Under our criteria selection, scholars agreed as a protocol to include both relevant published and unpublished literature to ensure our conclusion was enlightening, all-encompassing and devoid of researchers' bias (Torrance, 2004; Gough and Elbourne, 2002) and also reflects the petroleum state of the art literature. Therefore, our literature sources include; journal and conference papers or articles, books, chapters, annual reports, and serials. Other sources are ResearchGate's, Elsevier journals, internet websites, citation searches, public speeches, and television (TV) documentaries. Scholars first conducted a free text search on the Google Scholar with title key phrase search for "petroleum industry challenges and prospects" and further searched on the energy-related database on IDEAS/RePEc, and bibliographies references for literature (Noyes et al., 2008; Greenhalgh and Peacock, 2005). In all searches, researchers got about 261 previous studies on the topic and later excluded 213 after the screening, because they were not on Ghana, and some were duplicated and not relevant to the topic and finally saved 48 specific literature and five TVs documentaries[1,2,3,4,5] for the review process. Thus, the included literature had specific relevance under the petroleum upstream, midstream and downstream covering wider issues. However, other literature which was so generally on oil and gas-related issues were excluded, for example, the operational impacts of oil and gas on socioeconomic and environmental. This study did not also analyze literature according to journal types, authors, years of publication, and methodologies which would not have assisted the paper to identify the prospects and challenges in the sector.

2.3. Step Three : Appraisal of scientific literature

This study appraised literature in line with Perroni and others (2015). The researcher applied systematic review and further suggested the relevance of the technique in energy field since such studies focus on current research and knowledge and also identifies barriers for future research. Thus, scholars employed both quantitative and qualitative techniques since some papers and articles were parametric and non-parametric in nature (Briner and others, 2009; Vander Knaap and others, 2008). Researchers then categorized the literature according to two main topics (petroleum policy and supply chain & petroleum economics) for further analysis as shown in section three. The two main topics cover petroleum exploration, production, supply, exports, import, refinery, storage, transporting, marketing, regulatory framework, and infrastructure development. The SLR technique offered us the skills to interpret, explain and analyze the literature in a systematic manner. Firstly, authors qualitatively examined the individual study scope and conclusions, integrate them and their cumulative findings together with the synthesis narrative approach (Martyn, 2001; Popay and others, 2006) under Section 3. Secondly, authors further scientifically extracted some relevant data and summarized them in tables and figures in a quantitative manner for triangulation (Denyer and Tranfield, 2009) to descriptively test how well conclusions of previous works reflect the petroleum sector reality and identify some research gaps thereby.

3. Scientific analysis and synthesis of literature

The rationale for the synthesis was to summarize and consolidate the results of diverse literature into an integrated result. In the synthesis process, scholars discussed and interpreted the various findings with the skills of meta-ethnography and systematic (Perroni and others, 2015). Authors also conducted meta-ethnography because some literature refutes and reciprocates the results of others. These, therefore, makes the literature review difficult in identifying and inclusion of relevant literature as shown in the methodology section.

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1 GNPC CEO; Alex Mould talks about benefits and acknowledged the partners on project. https://www.youtube.com/watch?v=hYfb2R_51Bk.

2 GNPC Deputy CEO, Thomas Manu; talks about TEN project discovery, exploration and production. https://www.youtube.com/watch?v=hYfb2R_51Bk.

3 CCTV, Ghana Oil Outlook. Ghana could become African's 4th biggest producer by 2020. https://www.youtube.com/watch?v=hYfb2R_51Bk.

4 MyJoyNews (25-9-17). Drilling oil in Keta Basin/ Swiss Africa Oil Exploration https://www.newsghana.com.gh/swiss-africa-to-begin-oil-exploration-in-the-keta-basin/.

5 TV3, President, John Dramani Mahama. Ghana's Newly Discovered Oil Industry and Building of Refinery (Injection of Gas); https://www.youtube.com/watch?v=Kd0p9d9Bl-c.

3.1. Narrative qualitative synthesis

In general, they are a lot of literature in the petroleum industry in the world about challenges and prospects but this review included relevant literature mainly on the Ghanaian economy under Section 2.2 above that has been conducted so far in the petroleum industry. Therefore, this segment presents relevant previous studies under the petroleum industry, with emphasis from 2007, when Ghana found petroleum resources. This narrative literature section comprises two main topics: the petroleum section policy and supply chain petroleum economics.

3.1.1. Petroleum section policy

The work of Quaye-Foli (2006) conducted research in the petroleum sector with the main focus of organizing information and data for energy policymakers, regulators, politicians, academicians, media, and research institutions. The information gathered includes fundamentals of natural gas utilization in terms of the world and Ghana with emphasis on key regulators, actors, and other energy agencies. Also, in 2009, Adams (2009) added new knowledge to the industry discussion. He found that the industry was challenged at the upstream development in terms of investment, the economics of petroleum, no established clear environmental laws and fiscal petroleum policy. The article then recommended that Ghana at the time should engage international oil companies for both investment, technology, environmental laws should be revised, and the new Petroleum Regulatory Authority should be established to avoid Ghana National Petroleum Commission (GNPC) from being both a player and regulator in the petroleum sector. Furthermore, Research (2015) conducted a study on the topic: Fueling Ghana's growth, oil and gas industry. The study examined oil production, exports, contribution to the gross domestic product, market structure, and industry regulation. The paper found that the downstream sector was underdeveloped in refining petroleum, challenged with an inadequate skilled workforce, and maritime boundary challenges. The paper further revealed that the local industry was lacking investments to explore new petroleum fields. Moreover, African Trade Policy Notes (2011) examined the issues concerning institutional, public financial management & macroeconomic challenges, and policy tradeoff. The paper revealed and recommended that Ghana should increase transparency in oil revenue management, restore fiscal sustainability, responsibility and remove bottlenecks in non-tradeable sectors, and increase the portion of agricultural goods.

Besides, White (2011, 2015) and Bedwei (2017) conducted studies on the tax policy guide for petroleum operations especially on income from oil and gas in Ghana. The papers mainly focused on the tax policy of Ghana, right from the upstream to the downstream sector. That is, the studies consolidated all the tax policies together without necessarily discussing their implications on the whole industry. Thus, these studies did not add new knowledge to the industry in terms of policy recommendations in policymaking. In a related manner, Kastning (2010) investigated the basic overview of Ghana's emerging oil industry. The paper basically focused on the petroleum revenue management bill, oil policy of the government and main operators at the upstream sector. The study found that since it was the first time Ghana had found oil. There were higher expectations amongst the citizenry, and that it was impossible to directly attract investment from oil revenue into the infrastructure in the industry. The paper also noted that Ghana was already conforming to the Extractive Industries Transparency Initiative (EITI). In addition, Energy Group Africa Region World Bank (2013) examined the topic energizing economic growth in Ghana: making the power and petroleum sector rise to the challenge. This study was conducted by the Energy Group Africa Region, World Bank in 2013. This study mainly centered on the electricity demand & supply, generation, transmission bottlenecks, and reforms in the power distribution. They also studied the natural gas sector. Thus, demand and supply analysis, institutional challenges on Ghana National Gas Company (GNGC) and Bulk Oil Storage and Transportation (BOST) and finally, upstream oil and gas sector. The study found that the government had delayed investment in the gas supply and power generation and that Ghana could not attract private sector investment in the sector because the prevailing gas pricing policy was not attractive. The study further revealed that the State-Owned energy agencies were not efficient in operation. However, the paper could not contribute new sufficient knowledge to the petroleum midstream subject matter also.

Again, Adam (2014), Amoako-Tuffour (2011), Ofosu-Peasah (2017, 2018), Centre for Policy Analysis (CEPA) (2010) and United Nations (2012) papers discussed the petroleum revenue management act, annual budget funding amount, domestic investments and crude oil prices. The investigations revealed that Ghana petroleum revenue management had been recommendable and consistent with the 2011 act, petroleum revenue management. However, they found poor accountability on the implementing agencies under the policy.

3.1.2. Supply chain petroleum economics

Also, reference (Prempeh and FCA, 2010; Tanoh, 2016) discussed at length the supply chain of the oil and gas industry in Ghana and an overview of Ghana's petroleum downstream sector. These articles provided descriptive study without insights on the prospects and challenges, especially under the petroleum midstream to the downstream sector. In a related manner, Adams (2014) conducted a study which covers, oil production, and petroleum economics found that the government had commercialized the oil revenue against two billion United States dollars($2billion). The study concluded that the government at the time justified petroleum economics was to improve the fiscal terms, exploration, production, and also to enhance the capacity of State-Own participation in the oil and gas operation at the upstream. The government also added petroleum economics-related bills which was to enhance local expertise, goods, services, and businesses along the petroleum value chain and at the same time regulates expatriate workers in the industry. The study concluded with the experts sampled in the survey opinion that the government was justified in both the local content bill and the commercialization or petroleum economics decision. The survey additionally revealed that there were still some challenges in the oil revenue management because the oil operations had affected fishing communities' livelihoods and the law does not suggest any remedy.

Furthermore (Marbuah, 2014) also conducted a study in the field which basically focused on the relationship between crude oil importation on one side and on the other hand economic growth and price of crude oil by applying autoregressive distributed lag modeling (ARDL) approach. He found that crude oil imported had a significant negative impact on the local economy not only on the exchange rate but also, affecting the country's manufacturing sector competitiveness. The study, however, could not recommend any strategic policy for the development or investment in the midstream to the downstream sector to process the raw material locally to spur the country of importation. The paper, however, recommended investments in alternative energy sources, which contribute not up to 2% to the total energy mix in Ghana. Per the findings, authors think the paper would have addressed relevant questions like, why cannot Ghana process its own crude oil? and how long can Ghana continue to import petroleum products, which burden the economy? Also, Mensah (2014) conducted an investigation on modeling demand for

liquefied petroleum gas (LPG) in Ghana: current dynamics and forecast. The study also applied the ARDL bounds test and partial adjustment model. The result reveals, income, price, and urbanization as the main drivers of the demand for LPG. The study then, projected demand for LPG to a minimum of 5.9 million metric tons by 2022. The study therefore, suggested that these statistics would have serious challenges on the supply side, because of inadequate infrastructure development of the industry to meet local market demand. Additionally, Gyampo (2010) conducted a study on measures to prevent resource curse, expectations of Ghanaians, regulatory, legal and policy framework, preparation towards oil production. The paper found that there were challenges with licensing to upstream companies, and with oil revenue collection, sea-use conflicts between oil companies and fishermen, and regulation difficulties.

Yet also, NEXANT (2010) also discussed the general gas demand and utilization options for the power generation, fertilizer and methanol production, industrial, residential/commercial and transportation sectors. Other issues within the petroleum value chain include, gas demand and supply and different production scenarios were estimated, and natural gas pricing. This paper, in effect discussed gas infrastructure development; West African Gas Pipeline (WAGP) and Jubilee Gas Project (GNGC). The paper finally, concluded with recommendations largely on the regulation of the petroleum industry. Thus, the marketing, ownership structure and legal structure. However, the work did not examine the petroleum industry holistically, particularly in considering the challenges and prospects. In like manner (Ministry of Energy, 2012) conducted study mainly on natural gas demand, supply, pricing policy, challenges on natural gas pricing, policy direction, and institutional arrangements. They concluded that natural gas price policy in 2012, typically focused on the pricing and marketing arrangements of natural gas. They intimated that the policy document within the petroleum economics mainly regulates (1) GNGC shall be the aggregator in trading, processing, transporting and storing of natural gas, (2) BOST shall be responsible for natural gas transmission and its infrastructure to connect consumers to suppliers in the sector. The policy also concluded on the institutional arrangement under the sector. Nevertheless, the policy document could not include the entire petroleum industry for its development in considering how oil and gas interconnection.

Moreover, energy statistics are significant information in petroleum economics decision-making and hence (Ghana Energy Commission, 2016; Ghana National Petroleum Corporation, 2016) conduct studies every year on the development progress of the entire petroleum and energy industry in the country. Specifically, Ghana Energy Commission (2016) reports on the energy indicators and energy balance, primary and final energy consumption on electricity, petroleum and other sources of energy. The reports mainly focus has always been to present energy statistics with more emphasis on petroleum demand and supply conditions. Other issues include oil production, import, and exports. The reports over the years also, present data on natural gas supply, petroleum products imports and exports in the country. Nonetheless, these reports have not conducted study on the policy implication of the petroleum industry in terms of development challenges and prospects. In simple terms, the reports only present data and information without any critical analysis and strategic policy directions under the petroleum subsector. In a related development, NEXANT (2010) and Ghana Energy Policy (2010) examined the Ghanaian energy sector national energy statistics and policy frame. In these papers, the issues discussed include, energy indicators and energy balance, primary energy supply and final energy consumption, electricity, petroleum, biomass and energy prices. Under the petroleum sector in the papers, they only presented demand and supply data, exports, and imports of both petroleum and petroleum products. The studies are without analysis of how Ghana was challenged under the petroleum sector and the prospects thereafter. The papers could not also, comprehensively discuss the upstream to the downstream sector challenges and prospects in terms of infrastructure development. One of the first critical studies in the petroleum sector is Amponsah and Opei (2014) which examined the downstream petroleum industry and the key players. They found that the industry players faced many challenges amongst which were, poor infrastructure, lack of capital, weak local currency, the inefficiency of Tema Oil Refinery (TOR) in production, lack of maintenance culture, and government interruption in paying of under-recoveries. The study recommended that BOST and TOR should be revamped where they could be more self-sustaining. But the paper could not demonstrate how the recommendation should be done to avoid inefficiency in the operations. Added to that the paper could not also, suggest how BOST and TOR challenges could be turned into opportunities for the country. Also, they further recommended that the private sector should be encouraged to import more petroleum products. Authors therefore, humbly think that this recommendation was not good enough to address the industry development challenges subject to the study findings. Because that suggestion could not lead to solving the poor infrastructure challenge identified. To make issues more clarified, how could private sector importation solve poor infrastructure challenges in the petroleum industry? Authors think this could have added to more challenges in the sector.

Finally, these works (World Bank Team, 2015; Ablo, 2015; Institute of Statistical Social and Economic Research (ISSER), 2015) investigated at length the sub-petroleum sector under the energy policy of Ghana. They emphasized on the upstream sector local content development, natural gas utilization, inadequate infrastructure challenges, petroleum sector reforms, and availability of petroleum products. The policy document, however, could not study the challenges and prospects of the sub-petroleum sector and ultimately, no recommendations to that effect were suggested. Also, (Asumadu-Sarkodie, 2016) conducted a broader review of the energy industry. The paper discussed petroleum; crude oil production, export, import and natural gas import. The study further included petroleum products' production, export, and import. The paper also discussed other energy statistics like electricity, biomass. The authors could not review holistically the whole petroleum industry to include the upstream, midstream to the downstream.

3.2. Triangulation technique analysis

To ensure that the narrative literature presented in Section 3.1 was robust, credible and truly reflects the data of the petroleum industry, researchers applied the triangulation technique (Creswell, 1998; Patton, 1999; Bhattacherjee, 2012) to supplement the SLR technique. That is, scholars qualitatively scrutinized and investigated the petroleum industry infrastructure development, first with the aid of the American Petroleum Institute's (API) twenty assets infrastructure checklist (American Petroleum Institute, Report, 2013; American Petroleum Institute's Report, 2017). The sample of the petroleum value chain components can be seen in Figs. A.1 & A.2. Authors also applied international set down standards in the literature (Perroni and others, 2015) for this review process in the assessment of challenges and prospects under the regulatory and marketing framework in the industry. Also, secondary data was further extracted from the literature for the triangulation purpose as discussed in section two. Following the works of (Johnston, 2014, 2017; Russell, 2001), they argued with the suggestion for the application of

secondary data in review processes because of its associated significance and prevalence in review works (Johnston, 2014, 2017). Researchers therefore, obtained secondary data in the relevant literature sources; annual reports, series and papers, Ghana Energy Commission, GNPC, World Bank Energy Team Project and the Ministry of Petroleum policy document. Authors approach of identifying secondary data further follows the works of Russell (2001) and Creswell (2009) in new topics but must also, consider previous data on the topics (Dale et al., 1988) and Doolan and Froelicher (2009). That is, the evaluated data do reexamine the appropriateness of previous studies (Johnston, 2014, 2017) that were retrieved. The secondary data in our synthesis procedure aided in discovering current research gaps and future data and research directions. This subsection is divided into two microsections. The first sub-section, 3.2.1 covers petroleum market policy development & infrastructure in four topics; petroleum infrastructure development analysis; petroleum market; petroleum framework; petroleum production regimes. And the second sub-section, 3.2.2 covers petroleum statistics analysis in five topics; petroleum products balance, petroleum reserves & upstream operation, local petroleum production & supply, natural gas importation and potential demand for natural gas by sectors

3.2.1. Petroleum market development & infrastructure

3.2.1.1. Petroleum infrastructure development analysis. Oil and natural gas industry, technically consist of two main sectors or markets (upstream and downstream), however, there is also a third sector, midstream which is highly interconnected within the two which plays a very significant role in the industry (Peirce, 1986). The Table 1 below illustrates a detail assessment of the midstream to the downstream infrastructure state of the petroleum industry in Ghana with the aid of API twenty assets infrastructure checklist technique (American Petroleum Institute, Report, 2013; American Petroleum Institute's Report, 2017) and petroleum value chain components (Figs. A.1 & A.2). Infrastructure hereby refers to the physical asset-installations starting from the upstream exploration and production sites connected to the midstream to aid the processing of the petroleum through to the downstream. In Table 1 below, authors used the APIs checklist to assess the petroleum industry. Thus, scholars asked the twenty questions (see Table 1; number 1–20). For example, question one, does the Ghanaian petroleum sector install natural gas gathering infrastructure? If installed authors coded it YES and if not coded as NO. Researchers further ask if yes, which company? Researchers went through the literature to find the company name. This helped to know the participation of the private sector in the petroleum industry. Also, scholars ask again, is the company operating at the period of the review (November 2017–September,2018)? If operating coded as YES and if not coded as NO. Authors then developed an ordinal based appraisal indicator. That is, all checklist questions were executed with the use of the literature in an excel sheet. Under the ordinal based appraisal indicator column, researchers coded let YES +YES = 2, representing prospect. Also, let YES + NO = 1, representing low challenge and let N/A + NO denotes serious challenge. Authors executed the same process for all the twenty-checklist questions in Table 1. Researchers used the selected available literature to execute the API checklist question.

According to the API checklist designed in evaluating the petroleum industry, scholars made the following findings and observations. Out of the twenty assets examined under the mid-downstream sector, it reveals that nine have been installed and out of which few were not yet operational and optimal. Thus, the API checklist of the industry falls below 50% (9/20), which reveals some prospects and challenges. These infrastructure or assets prospects and challenges are discussed below. According to American Petroleum Institute, Report (2013) and American Petroleum Institute's Report (2017) for the petroleum industry to be considered developed, it must be equal to or above 90% of the twenty assets infrastructure list in Table 1 above in order to support the petroleum industry. The measurements (Table 1) above and the crude oil and natural gas value chain components evaluation at (Figs. A.1 & A.2) reveals the current development of the Ghanaian petroleum industry. That is, the results from the evaluation in Table 1 together with the aid of (Figs. A.1 & A.2), researchers observe that the petroleum industry is relatively new. However, the industry has already prospected with the following infrastructure development for instance, natural gas gathering facility, gas processing facility, and natural gas pipeline. The three infrastructure installations belong to GNGC which began in 2011 and subsequently were commissioned in 2014. The natural gas facility has an installation capacity of 150 million cubic feet day (mmcfd). It processes both dry and wet (liquid) gas, where the dry gas is transported via the pipeline from Atuabo to feed the thermal plants at Aboadze and the liquid is processed into LPG for local consumption. Furthermore, the study observes that the GNGC facility has a Phase 2 of about 300 mmcfd capacity with some other facilities including gas storage at Domunli, but has still not been expanded since 2014. GNGC is the largest prospect for the natural gas sector in the industry by far. Another significant prospect observed in the gas sector is the off-system distribution companies or common infrastructure; Quantum Ghana Ltd, BOST, and other private companies transport the LPG from GNGC to their distribution centers in Takoradi, Accra, Kumasi and other parts of the country and other petroleum products. More so, this review reveals yet another important infrastructure for the petroleum sub-sector which is the port storage, loading and offloading. The study reveals that in 2015, the government of Ghana and other Multinational Companies established a contract to construct a 700-million-dollar Free Port at Atuabo in the Western region of Ghana to facilitate the oil and natural gas industry (Anon, 2017d). The government contracted China Harbor Engineering Company (CHEC) for the construction of the Port in 2015, see (Fig. A.3). The project is a multifaceted one that also offers other services including Rig and floating production storage and offloading (FPSO) vessel repairs locally.

Additionally, the review finds another key important prospect in the industry, which is Bulk Oil Storage and Transportation (BOST). BOST was established in 1993 for the purposes of storage, transportation, and distribution of petroleum products across the country. Prempeh and FCA (2010) the government of Ghana in 2009, appointed BOST as the Sole Unit to develop and operate the interconnecting system to all supply sources and including WAGP. The study, however, observes that BOST as of 2017 has not yet integrated into the local crude oil and gas production system. This could be the result of inadequate funds and lack of technical know-how (Energy Group Africa Region World Bank, 2013). The study finds BOST as a fundamental prospect for the midstream and downstream sectors of the oil and gas industry development in Ghana and hence must be harnessed for this purpose within a reasonable time frame. The study further accounts that, GNPC and Quantum Power Company have signed a build, own, operate, and transfer contract for the construction and operation of liquefied natural gas storage, regasification and delivery infrastructure with a capital outlay of 550 million dollars in Tema, known as Tema LNG Project (Anon, 2017a). The Project, when completed, would have the capacity to receive, regasify, and deliver, at a constant rate in the ranges of 3.4 million tons of LNG per year, which equivalates to 500 million standard cubic feet of gas per day. The facility would be a multifaceted modern floating storage and regasification unit, fixed off-shore Tema and with an associated sub-sea and onshore pipeline, which would deliver the

Table 1
Petroleum sector examination with the American Petroleum Institute's twenty asset infrastructure checklist technique.
Source: Adopted API, checklist 2013 and 2017.

Infrastructure type	Install	Company name	Operating	Appraisal indicator
1. Natural Gas Gathering	YES	GNGC	YES	2
2. Gas Processing	YES	GNGC	YES	2
3. Natural Gas Pipelines	YES	GNGC/WAGP	YES	2
4. Natural Gas Storage	N/A	N/A	NO	0
5. LNG Processing and Regasification	YES	TEMA LNG	YES	2
6. LNG Marine	N/A	N/A	NO	0
7. NGL&LPG Processing	YES	GNPC	YES	2
8. NGL&LPG Pipelines	N/A	N/A	NO	0
9. NGL&LPG Storage & Rail	N/A	N/A	NO	0
10. NGL&LPG Marine	N/A	N/A	NO	0
11. Crude oil Gathering	N/A	N/A	NO	0
12. Crude oil Pipelines	N/A	N/A	NO	0
13. Crude oil Storage	N/A	N/A	NO	0
14. Crude oil Marine	YES	GNPC	YES	2
15. Crude oil Rail	N/A	N/A	NO	0
16. Refineries	YES	TOR	NO	1
17. Pipeline Refined Product	N/A	N/A	NO	0
18. Refined Products Storage	YES	BOST/BDCs/OMCs	YES	2
19. Refined Product Marine	N/A	N/A	NO	0
20. Common Infrastructure	YES	FREEPORT	YES	2

Note: N/A means not available and the appraisal indicators definitions are at Appendix B.

natural gas to the aggregator (GNPC) and its customers onshore. This study shows the LNG project commenced construction in 2016 and expected completion in December 2018, which would supply a guaranteed volume of 250 million standard cubic feet per day for local consumption and the rest for exports. This investigation, therefore, rates this project as one of the game-changers petroleum infrastructure, especially on the natural gas supply side. Finally, scholars observe that the industry has good prospects in the local distribution companies, because of the high demand for petroleum products in the country, oil and gas downstream have had a lot of distributions companies. All these projects present better prospects for the petroleum industry in Ghana and needed more infrastructure investments, as was undertaken by the US to build its petroleum industry.[6]

On the challenges side, the petroleum industry has operated for about twelve years so far in oil and gas exploration, development, production, transportation, distribution, and marketing. And it is noted with some crucial setbacks in the industry. That is, the midstream to the downstream sector of the petroleum industry in Ghana is challenged and characterized by the following unavailable infrastructure; crude oil gathering facilities, crude oil pipelines and storage facilities, crude oil and natural gas distribution networks to connect the manufacturing industries and other regions. Some others include NGL&LPG pipelines, rail, and storage facilities, natural gas storage facilities, and GTL&CNG facilities support petroleum business in Ghana. This review further finds that the only oil refinery facility in the country has not been effective and could not operate beyond 4% in 2016–2017, for example. In effect, the TOR infrastructure has been challenged. Technically, the facility could not process petroleum products to support the local economy and this presents a low challenge for the industry. Also, the study of African Development Bank and the Africa Union (2009) concluded that TOR seldom functions up to production rate which pressures the country to depends solely on imported petroleum products. Historically, Tema Oil Refinery (2013) TOR was incorporated in 1960 as a limited liability company and was finally commissioned in 1963 to refine imported crude oil into final petroleum products for the domestic market and exports. TOR at the time was wholly owned by Ente Nazionale Indrocarburi, Group of Italy, and Ghana later became a 50% shareholder after eleven years of operations. Subsequently, Ghana became a 100% shareowner in 1977, where the name was changed from Ghanaian Italian Petroleum Company to TOR limited. The study reveals that TOR currently has 45,000 barrels per day (bpd) capacity to refine liquefied petroleum gas, gasoline, gas oil kerosene, fuel oil, cracked fuel oil, naphtha, and aviation turbine kerosene. TOR also offers the following services; Product Quality Analysis, Storage Tankage Services, Loading Rack Services and Maintenance Services. The current development of TOR in the processing of crude oil for the local economy has collapsed below the efficient level in the evaluation process by this paper and hence has some low prospects for the industry. This review reveals in 2015, the TOR production performance rate was 3.5% and subsequently, in 2017 have not produced any reasonable petroleum products for the whole year (Ghana Energy Commission, 2016).

3.2.1.2. Petroleum market analysis. Market liberalization in the petroleum industry has been noted over the years as a fundamental criterion in ensuring efficiency and effectiveness in the industry. Authors observe that the Ghanaian natural gas sector market lacks private sector participation & investments and hence monopolistic in nature in favor of the government. In simple economic terms, demand and supply forces are not the determinants for the discovery of market-clearing points of natural gas in the local market. Unlike, Europe and U.S natural gas market, where the price is usually benchmarked on gas-to-gas price, oil-linked price, or prices indexed to other energy commodities. The natural gas market in Ghana is identified 100% control by the government through its own agencies or aggregators (e.g. GNGC and GNPC), with predetermined prices in the market. The absolute control of the gas market is a result of no private sector participation and investment. Thus, the transportation, storage, processing and other important facilities are owned by the State via its agencies, except two oncoming facilities, which are on joint venture and build, owned, operate, and transfer (BOOT) arrangements. This review, therefore, concludes that the natural gas market is a monopoly market, operating in Ghana under the petroleum industry and a challenge. The review further reveals that the pricing methods of natural gas are either pooled-pricing or cost-plus which is been used over in determining gas prices in the local market. For example, in 2012, the government developed a natural gas pricing policy, which never permits demand

[6] Capline finished construction in 1969 and was originally envisioned as a means of moving Louisiana offshore Gulf Coast production to the U.S. Midwest. By the 1980s and 1990s, it was largely being used to move imported crude oil barrels to those same refineries. https://www.loopllc.com/About/History.

and supply forces operation. These market dynamics have not given an allowance to producers to make a reasonable rate of return, which presents no incentivize more investment in the sector. A policy document according to Tanoh (2016) states among other clauses that (1) non-associated gas for domestic utilization shall be purchased at no more than the weighted average import parity cost market price system to the aggregator. Also, (2) the actual price of non-associated gas purchased shall be at a level that compensates upstream producers for the cost of producing for sale to both domestic and international markets with an acceptable rate of return on capital invested (cost-plus formula). Further, (3) LNG shall be purchased at a $/MMBtu price as close as possible to WAGP landed price. And (4) gas sales from the aggregator (GNGC) shall be at least pay for its gas purchases and aggregator fees. (5) All-natural gas shall be sold by the aggregator at no less than import parity prices to all users. (6) The import parity shall be determined by the government Of Ghana (GOG) on the advice of public utility regulatory commission (PURC). (7) Contracts shall provide for a review of the price on a bi-annual basis to reflect only, inflation and exchange rates. And (8) other considerations under transportation, aggregator's tariff within the downstream. The policy clauses do not give room for determination of price in the natural gas market and which would inevitably discourage investment from the private sector in the industry and, thereby challenging the industry. However, the local crude oil market in Ghana proxies international oil pricing and therefore, the government has little or no role in terms of price settings in the local oil industry. This review also notes that the local petroleum products market is different from the natural gas market. Thus, it has been deregulated since 2015 by the regulator. National Petroleum Commission (NPA) is mandated per law to regulates and monitor all petroleum downstream operations in the country.[7] Besides NPA, PURC also plays a coordinating role in determining petroleum product prices in the industry together with other industry players. The law permits NPA in the market to set the prices in the country on a quarterly basis, taking into account key oil price determiners such as international crude oil prices, exchange rate, petroleum retail prices, taxes, and refinery cost.

3.2.1.3. Petroleum regulation framework. The regulatory framework mainly controls petroleum exploration, extraction, processing or refining, distribution, and marketing in the industry (Peirce, 1986). This study recognizes that hydrocarbon resources and reserves in Ghana are owned by the people and vested in the government, according to law, the 1992 Constitution, Article 257(6).[8] And as such, the government therefore, mandates the Ministry of Petroleum to formulate comprehensive and cogent policies to control and manage the operations under the industry. The Petroleum Ministry is the head and further supported by other regulatory agencies in various capacities for the management of the sub-petroleum sector policies, see (Fig. 2), conceptional regulatory framework. First and foremost, the framework shows the upstream sector is regulated by the National Petroleum Commission and Ghana National Petroleum Corporation (GNPC), which also operates as an upstream petroleum producer. Historically, GNPC came into being through an act, GNPC Law (PNDC, 64) and act 84 gives the power to engage in exploration, development, and production of hydrocarbons in Ghana and beyond[9] and amended act 2016,(Act 919).[10] Also, the National Petroleum Commission (NPC) came into effect by an act, act 2011 (Act 821).Durach et al. (2017) NPC regulates petroleum upstream operations in the participation of companies, licensing and further oversees the total conduct of companies involved in the exploration, development, and production of fossil fuels or hydrocarbons in the country. Researchers also note that the Energy Commission and PURC regulate petroleum operations under the midstream sector which includes transporting, storage, and processing. Another important institution is the National Petroleum Authority (NPA) which regulates petroleum products distribution, marketing, and installation of facilities. Finally, the following institutions also play quasi roles in the industry; Environmental Protection Agency (EPA) and Ghana Atomic Energy Commission regulate the health, safety, and environment in the petroleum industry. Furthermore, other relevant institutions include; Maritime Authority, Navy, and Security Services. These institutions also regulate and ensure the security of maritime boundaries on petroleum platform installations such oil fields, FPSO and the petroleum resources borders within Ghana. Finally, this paper observes and concludes that the industry is well governed with the petroleum regulatory institutions and hence presents better prospects for future petroleum development and productions.

3.2.1.4. Petroleum production regimes. Throughout the world in petroleum production, there are four main types of agreements that ideally operate under the petroleum upstream. They include production sharing agreements, concessions, service contract, and risk management type (Peirce, 1986) which are petroleum economics decisions as well. Mostly, every country uses different agreements depending on the country's own risks and the international oil and gas companies involved under the operations. This review reveals that Ghana uses a combination of them; concessions (licensing and permits) are issued to international oil companies for exploration purposes with further contracts governing rights of oil and gas discoveries and production. Thus, the government through the ministry applies three combinations of agreements; concessions for exploration, production sharing agreements for the production of petroleum in the industry. And furthermore, the study finds, risk management contract, where the National Oil Company also takes part in the production process for example, GNPC.[11] Thus, the review reveals that all oil and gas projects are under production sharing agreements and risk management contracts, where GNPC is a production partner to all the projects under the upstream sector. Researchers conclude that the application of production sharing agreements by the government is a result of the lack of experts together with capital outlay to develop the petroleum resources. Finally, this review concludes that the country has a very stable political regime and regulatory environment together with better fiscal terms over the years with petroleum operators under the upstream sector, which presents good prospects for the industry in Ghana.

3.2.2. Petroleum statistics analysis

In this subsection, authors further extracted the data from the previous studies for syntheses analysis under ordinal data techniques. This subsection is presented five topics; petroleum products balance, petroleum reserves & upstream operation, local petroleum production & supply, natural gas importation and potential demand for natural gas by sectors. Authors then presented these data in tables and figures for synthesis (Rousseau and others, 2008).

[7] National Petroleum Authority (NPA Act 2005, Act691 (accessed on 20-01-2018). http://www.npa.gov.gh/about-npa/the-npa.

[8] 1992 Constitution of the Republic of Ghana (accessed on 29-01-2018). https://www.ghanaweb.com/GhanaHomePage/republic/constitution.php.

[9] Ghana National Petroleum Commission Law (PNDC 64) (accessed on 19-12-2017). https://www.tandfonline.com/doi/full/10.1080/02646811.2017.1349186?src=recsys.

[10] Petroleum exploration and production law (2016) Act919. http://www.petrocom.gov.gh/assets/Petroleum(Exploration%20and%20Production)Act2016.pdf.

[11] Petroleum Exploration & Production Act (2016). Accessed on 19-12-2017. gheiti.gov.gh/.../index.php?petroleum-exploration...production-act-2016-act...acts.

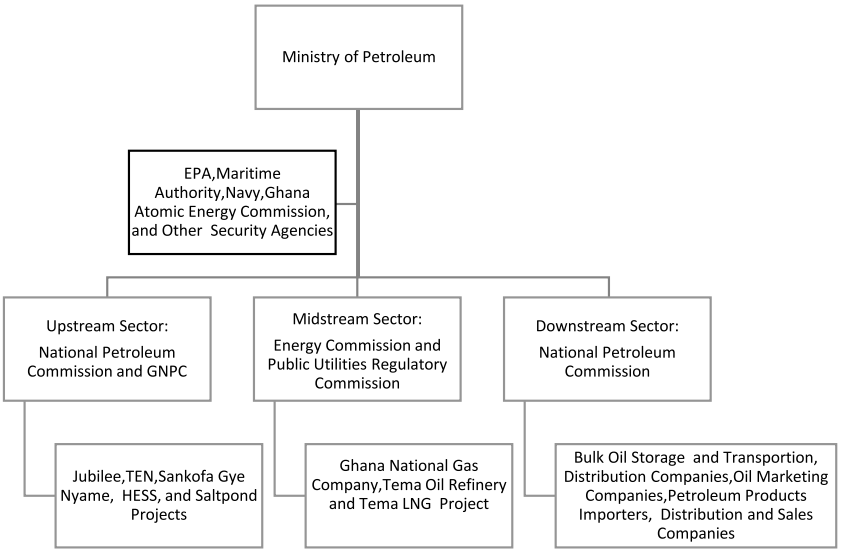


Fig. 2. Conceptional framework: Regulatory structure of petroleum industry.

Table 2
Daily gas imports from Nigeria via WAGP for 2012 to 2013.
Source: Ghana Energy Commission (2016).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	74	43	61	57	57	49	82	83	0	0	0	0
2013	0	0	0	0	0	0	48	58	67	55	73	79

Note: Gas imported is measured in mmcfd.

3.2.2.1. Petroleum products balance; demand & supply. The review analysis reveals that Ghana is a net importer of crude oil, petroleum products, and natural gas in the history of petroleum consumption. The supply of natural gas in Ghana has never met its demand targets over the years thus, total supply from both imports and local production was 164 mmcfd against the total demand of 300 mmcfd of natural gas as of 2016 (Ghana Energy Commission, 2016). These figures show a deficit of 136 mmcfd (45%) of natural gas. Energy Commission report further said that the unavailability of natural gas coupled with the reduction in water level from Akosombo and Bui Dam to generate hydropower caused the country to even import electricity of about 511GWh in 2016. The demand for natural gas keeps increasing and the power sector demand is estimated not less than 1500 mmcfd following the increase in total plants installation to 4635 MW (see details in Table 4). Also, the petrochemical and fertilizer industries are another sector that requires about 230 mmcfd, and other industries also requiring 60 mmcfd. These demands are totaling 1,790 mmcfd of natural gas on average and that is most likely not to be met by the suppling in 2019 and beyond. For instance, Ghana Energy Commission (2016) said the natural gas import through WAGP to Ghana in 2016 merely average 60 mmcfd, and the delivery have had been erratic over the periods, see Table 2 for example. A careful analysis of the data below shows no available supply of natural gas for the period of September 2012 to Jun 2013. The natural gas pipeline (WAGP) for these periods was damaged in Togo borders but later restored in July 2013 which saw a continue supply of gas.

Thus, estimated local production and import of natural gas are estimated to amount to 950 mmcfd (see Table 3) by 2019. These supplies are supposed to come mainly from Jubilee fields with 104 mmcfd, Tweneboa-Enyenra-Ntomme (TEN) fields with 50 mmcfd, Sankofa fields with 180 mmcfd, and HESS fields with 50 mmcfd. Some extra supply is estimated to come from imports: WAGP with an average supply of 60 mmcfd and LNG of 500 mmcfd. This means that demand as at 2019 would outstrip supply of about 840 mmcfd. That is, domestic production together with imports could only cover only 53% of the domestic demand level. For instance, available data in 2015 alone, Ghana Energy Commission (2016) shows the natural gas demand deficit was 18,200 mmcfd in that year, which translated into about 50.55mmcfd. The deficits situation presents economic challenges of the petroleum sector on the economy. The demand and supply of natural gas challenges would have the ability to trigger natural gas prices from the 2017 levels of $3/MMBtu to about $6MMBtu in the economy.

Furthermore, the domestic demand for crude oil ranges 1400–1600 kilotons per year (0.957457–1.094238 million barrels of oil equivalate), only for the power generation sector and TOR refinery as well. Moreover, almost all the petroleum products consumed in Ghana for example in 2016 was about 78% have been imported to feed the domestic market.

For instance, in 2016, Ghana imported 3,320.2 kilotons of petroleum products and however, exported petroleum products amounting to 651.6 kilotons (Ghana Energy Commission, 2016; Asumadu-Sarkodie, 2016), see also Fig. 3. Also, Ghana imported crude oil in a volume of 1,445.6 kilotons in 2016, and at the same time exported 3,722.6 kilotons for the same period. This represents total petroleum imports of 4,765.8 kilotons which is equivalent to 3,422,989 barrels of oil including international maritime bunkers) to Ghana, which is more than what is currently exported (4,374.2 kilotons, equivalent to 3,061,940 barrels of oil) and hence a net importer of petroleum, Ghana Energy Commission (2016). The petroleum products import dependency rate (net imports divided by total petroleum supplied in the local economy X 100%) is 78% for 2016 and also the petroleum export confidence rate is 61% by the application of the same measure. In effect, the total petroleum dependency rate is about 17%. The import dependency situation in Ghana is growing exponentially over the years due to the underutilization of TOR and the growing demand for the products. These however, suggest that Ghana can be petroleum sufficient and energy secure if the country could put critical measures in place. From Fig. 3 above, the rate of petroleum products import trend in the country has been growing at 32%, year on year basis for over ten years now excluding 2010 and 2016, where imports reduce by small margins (Asumadu-Sarkodie, 2016). This petroleum consumption development presents a challenge to

Table 3
Total daily petroleum supply in Ghana from 2014–2020.
Source: Data Source: World Bank Energy Team Projects and Oil and Gas Producers.

Year	Project name	Oil production	Gas production	Oil import	Oil export	Gas import	Gas export	Total oil	Total gas
2014	Jubilee	100	0	0	100	60	0	100	60
2015	Jubilee	100	83	0	100	60	0	100	143
2016	Jubilee & TEN	100 + 60	104	0	100	60	0	160	164
2017	Jubilee & TEN & Sankofa	100 + 80 + 80	104	0	260	60	0	260	164
2018	Jubilee & TEN & Sankofa	120 + 80 + 80	104 + 50 + 180	0	280	60	0	280	394
2019	Jubilee & TEN & Sankofa	120 + 80 + 80	104 + 50 + 180	0	280	560	0	280	894
2020	Jubilee & TEN & Sankofa	120 + 80 + 80	98 + 50 + 180	0	280	560	0	280	888

Note: The oil is measured in thousands of barrels per day (bdp) units and gas in millions of cubic feet per day (mmcfd).

Table 4
Total installed power plants that depend on natural gas by 2020.
Source: Information Source: Ghana Energy Commission (2016).

Thermal power plant	Installed capacity (MW)	State function
Takoradi Power Company, (TAPCO)	330	Operational on natural gas/oil
Takoradi International Company (TICO)	220	Operational on natural gas/oil
Sunon-Asogli Power	200	Operational on natural gas/oil
Tema Thermal Plant-TT1PP	110	Operational on natural gas/oil
Tema Thermal Plant-TT2PP	50	Operational on natural gas/oil
Takoradi 3 (T3)	132	Operational on natural gas/oil
CENIT Energy Ltd	126	Operational on natural gas/oil
Mines Reserve Plant	80	Operational on natural gas/oil
Osagyefo Power Barge	125	Operational on natural gas/oil
Amandi	200	Operational on natural gas/oil
Jacbson	360	Operational on natural gas/oil
EDF/VRA	200	Operational on natural gas/oil
Ghana 1000	375	Operational on natural gas/oil
Globel Q	375	Operational on natural gas/oil
Karpowership	235	Operational on natural gas/oil
APR Emergency power rental	250	Operational on natural gas/oil
Ameri Power Plant	250	Operational on natural gas/oil
Trojan	25	Operational on natural gas/oil
Genser	30	Operational on natural gas/Coal
Sunon-Asogli Power Plant 2	180	Operational on natural gas/oil
Kpone Thermal Power Plant	220	Operational on natural gas/oil
Kumasi Reserve Power Plant	35	Operational on natural gas/oil
Cenpower	340	Operational on natural gas/oil
Early Power Phase 1	147	Operational on natural gas/oil
Total MW Installed Power as at 2019	*4,635*	

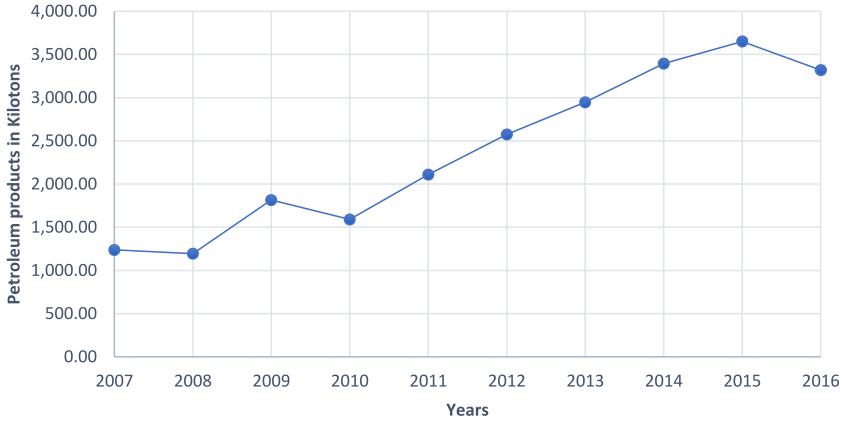


Fig. 3. Daily petroleum products import from 2007 to 2016.

the industry and Ghana as well, especially during exchange rate depreciation against the US dollar. Historical observation shows that the consumption of petroleum products in Ghana is always mainly on gasoline, premix, residual fuel oil, premium oil, Kerosene, liquefied petroleum gas (LPG), heavy gasoline, naphtha, aviation turbine kerosene (ATK). Thus, in 2016 the economy of Ghana consumed 8% of LPG, 32% of gasoline, 53% of gas oil, 2% of premix, 0.2% of kerosene, 0.8% of residual fuel oil, 4% of aviation and turbine kerosene (Asumadu-Sarkodie, 2016). According to Ghana Energy Commission (2016) petroleum products consumption in Ghana has been the largest energy share in final energy in Ghana with 3,320.2 ktoe, follow by biomass with 2,783.4 ktoe and electricity with 982.0 ktoe in 2016, see Fig. 4 below. The continuous increase in the final demand for petroleum products in the country without corresponding infrastructure for processing petroleum products presents a challenge in the country in terms of the exchange rate depreciation.

This paper, therefore, projects importation of petroleum products to continue increasing in the near future unless unforeseen supply-side twists take place in the international market, like

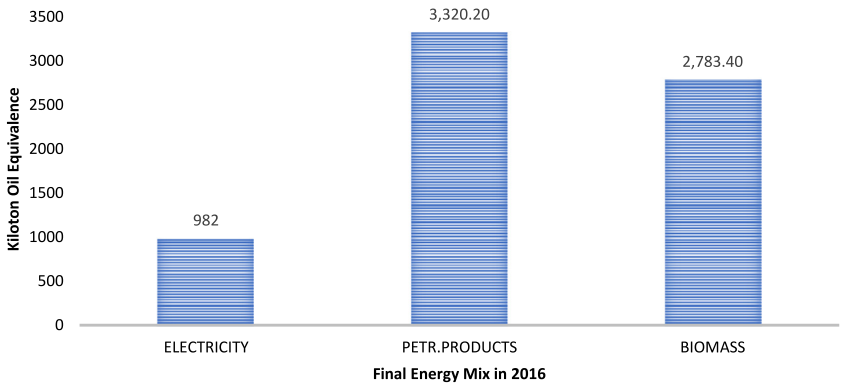


Fig. 4. Total final energy consumption in Ghana for 2016.

geopolitical or revamping of TOR and building of new refinery facility in the country. The study further, projects petroleum products demand also to increase from 32% to about 40% after 2018 onwards, following the country industrialization plans and other petroleum-related projects. This paper further notes that the consumption and application of petroleum products in Ghana have already grown and had been the highest energy share penetration in all the sectors of the economy. All these outlooks present nagging challenges in the industry.

3.2.2.2. Petroleum reserves and upstream operation. According to Tranfield and others (2003) the upstream sector of Ghana basically comprises four projects; HESS, ENI, TEN and JUBILEE (see Fig. 5). And the total proved recoverable reserves in Ghana as of 2015 amounted to approximately 2.5 trillion cubic feet of natural gas excluding the SaltPond field. Thus, the Jubilee field has 500 billion standard cubic feet, TEN with 360 billion standard cubic feet, HESS 650 billion standard cubic feet and Sankofa with 1.1 trillion standard cubic feet. Also, the recoverable reserves of crude oil in Ghana amounted to approximately 1500 million barrels also without the SaltPond field. That is, the TEN field has 300 million barrels, Jubilee field with 600 million barrels, Sankofa field with 162 million barrels and HESS field with 370 million barrels. The reserves are said to be recoverable within twenty to twenty-five years according to projects planned production schedules and the field production structures. Furthermore, the Ghanaian major crude oil and natural gas basins are all in offshore with a depth range from 600–4000 meters depth below sea level in the Western regions, specifically at Sekondi-Takoradi, Ahanta West, Jomoro, Nzema East and Ellembelle Districts. Fig. 5 below shows oil and natural gas basins and fields; the TEN basin represents the blue sphere on the map, the Jubilee basin also represents the pink sphere. Also, the HESS basin is at the southern part of both TEN and Jubilee basins with the name DW Tano CTP and the Sankofa Gye-Nyame basin represents the broken-yellow sphere.

Factually, since 1896 Ghana had engaged in exploration and development of petroleum business and natural gas production have been liked with the development and production of crude oil fields, but with the exemption of Sankofa project, which is currently the largest non-associated natural gas field in Ghana and started operation in the third quarter of 2018. The minor and oldest crude oil reserve in Ghana is the SaltPond basin, which is located northern part of Sekondi. The field commenced operations in the 1970s until 1984 and finally shut down in 1985 due to declined productions (Ghana National Petroleum Corporation, 2015). The field, later on, was rehabilitated in 2001 through enhanced and fracturing technology operations and however, the production over the years had been erratic and low. For instance, there was no production in the whole of 2016–2017. And Ghana National Petroleum Corporation (2016) concluded that the total current estimated reserves stood at 1.2 million barrels of crude oil and 20 billion standard feet.

Consequently, in 2017, the Public Interest and Accountability Committee (PIAC) recommended the field to be decommissioned because it was not more economically. Moreover, the Ghanaian upstream sector is made up of three big international oil and gas companies. Those companies engaged in exploration, development, and production under the TEN, Jubilee, HESS and Sankofa Gye-Nyame Projects. The operators under the TEN and Jubilee Projects are Tullow Ghana and other partners including GNPC, Anadarko, Kosmos Energy, and PetroSA. Also, Sankofa and Gye-Nyame Projects are operated by ENI Ghana, and other partners include GNPC and Vitol Upstream. Also, the HESS project is operated by HESS Exploration Ghana as the major operator with other minor partners including GNPC, Lukoil, and Exploration & Fueltrade (Anon, 2017c).

Finally, this study reveals that the upstream petroleum sector is fully developed in terms of petroleum infrastructure operations. That is the recommended petroleum infrastructure according to American Petroleum Institute, Report (2013) and American Petroleum Institute's Report (2017) under the upstream sector that must enhance petroleum exploration and production are so far available in Ghana. For example, the upstream sector has installed sophisticated and high technologies for exploration, development and production infrastructures such as 3D Seismic Surveys and Vessels, advanced Software for data analysis, Rigs, Production Platform, Oil Tankers, Transportation and Disposal Facilities, and Floating Production Storage and Offloading (i.e. Dr. Kwame Nkrumah and Prof. Atta Mills FPSOs). In summary, the upstream sector reveals higher prospects for more petroleum discoveries and production. Currently, there are exploration activities ongoing in the industry including Keta basin in the Volta regions, where the government have already approved for exploration works in 2016.[4]

3.2.2.3. Local petroleum production and supply. As of 2017, the Jubilee fields had produced and supplied 100,000 bpd of crude oil for exports and also supplied 104 mmcfd associated natural gas to the domestic market for power generation on a daily basis. The production levels over the period have been constant for both crude oil and natural gas since 2010 by Jubilee fields and it has been the only project in active production as of the third quarter of 2017 (Anon, 2017c), see also Table 3. Also, the TEN fields started operation in the third to the fourth quarter of 2017. Furthermore, the operation of the TEN Project was earlier affected by maritime boundary disputes in 2014 between Ghana and Cote d'Ivoire. The government of Cote d'Ivoire accused and petitioned International Tribunal for the Law of the Sea (ITLOS) against Ghana for encroaching its territorial boundaries to explore and

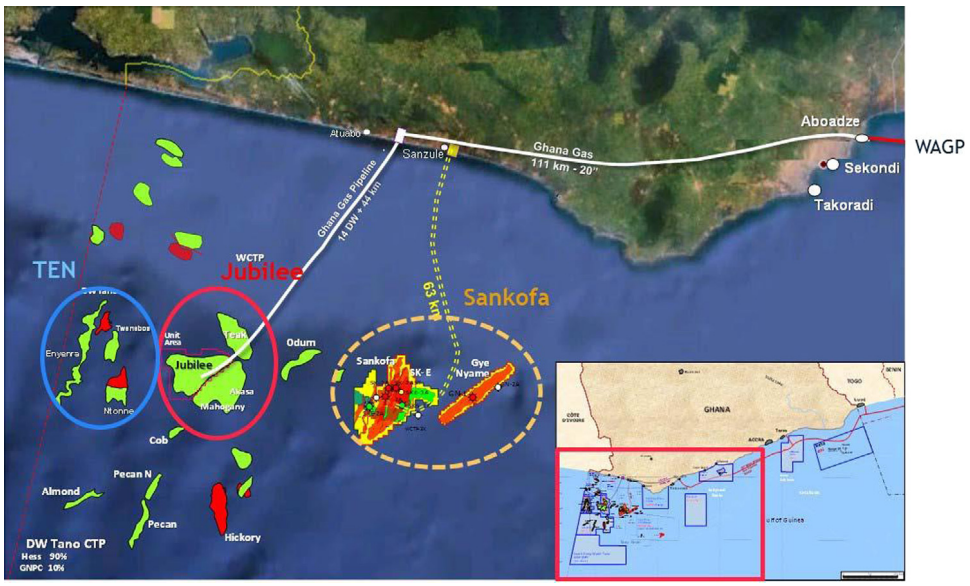


Fig. 5. Oil and gas basins in Ghana.

produce petroleum. Fortunately, for Ghana in September 2017, ITLOS, delivered its ruling in favor of Ghana, which further allowed the TEN Project to continue operations (Anon, 2017b). Therefore, production and supply levels doubled after 2018 for petroleum production. That is, the total natural gas production and supply increased from current 104 mmcfd to about 334mmcfd in 2018 and 328 mmcfd in 2020, local petroleum production[12], see also Table 3. Also, the crude oil production estimates increase from the current 2017 level of 100,000 bpd to about 280,000 bpd after 2018 to 2020, see Table 3. However, the total natural gas production is expected to increase to about 500 mmcfd at plateau level by 2025. In like manner, the other three main projects (Jubilee, TEN and Sankofa) are expected to also reach the plateau in 2025 and thereafter. Thus, the productions are expected to decline by about 30% and 20% for crude oil and natural gas respectively until the year,2030 (Ghana Energy Commission, 2016). And the Sankofa project per the company's estimates would still be the leading producer of natural gas in the local economy and the Jubilee project would also continue to lead crude oil production. Finally, HESS Project is scheduled to start operation after 2019.[13] The petroleum production in plateau level after 2025, the three main projects production are estimated to fall below 450 mmcfd and crude oil below 250,000 bpd by the year 2030 including HESS production (World Bank Team, 2015; Ghana National Petroleum Corporation, 2015; Equatorial Guinea, 2018). These petroleum production development dynamics therefore, presents higher prospects for the petroleum industry in Ghana in short to medium-term but not in the long run.

3.2.2.4. Natural gas importation to Ghana. From Table 3 above authors observe that after 2018, Ghana would import additional natural gas from three main sources to supplement local production for domestic consumption. The first comes from the Tema LNG Project with an estimated average volume capacity of 250 mmcfd. Also, the Governments of Ghana and Equatorial Guinea have signed another LNG contract in August 2017. The contract completion after 2019 would supply the country with natural gas in a volume of 250–500 mmcfd (Equatorial Guinea, 2018). Details of these contracts are covered in other topics below. The third source of natural gas is the West African Gas Pipeline Company (WAGPCo). The public–private partnership in the petroleum sector would boost more supplies in the country. These supplies scenarios present the petroleum industry with higher prospects for growth. For illustration, the estimated average from all the three sources accounts 560 mmcfd of natural gas after 2019, see Table 3 for details.

3.2.2.5. Potential demand for natural gas in Ghana by sectors. There are three main sectors for the demand for natural gas which include power generation, petrochemical & fertilizer and other sectors with industry. Researchers note that the total natural gas consumed in Ghana as of 2016 is 164 mmcfd, which came primarily from the Jubilee field with 104 mmcfd plus the average import of 60 mmcfd from Nigeria via the WAGP. Scholars further observe that the consumption of natural gas in Ghana has been growing rapidly and estimated to grow after 2019 to about 200% above the 2016 levels. Firstly, the power generation sector is the biggest consumer. The demand for natural gas in power generation is expected to increase following the increase in electricity. According to (Ghana Energy Commission, 2016), the consumption of natural gas in Ghana grew by about 150%, (from 60 in 2010 to164 mmcfd in 2016). They concluded that the increase in growth rate was possible following supply from GNGC. The estimated thermal power generation in the country increase drastically from the 2000 MW to over 4000 MW by the year, 2020, which would cause the demand for natural gas in the country to increase further, see Table 4. Already, the government of Ghana has negotiated with IPPs in Takoradi for a cumulative generation of power to about 1800 MW (Durach et al., 2017; Littell, 2006; Perroni and others, 2015; Malletta and others, 2012; Tranfield and others, 2003; Davies and Crombie, 1998; Torrance, 2004; Ghana Energy Commission, 2016) also see Table 4. Also, an additional 1000MW of power generation is expected to be added at Tema through a combination of IPPs and expansion of existing Volta River Authority (VRA) plants (World Bank Team, 2015).

The table above shows total installed power plants for both VRA and Independent Power Producers (IPPs) across the country would increase install thermal power capacity to about 4,635MW from 2018–2019. And all the existing and newly installed thermal plants operate on dual-purpose systems. Meaning their fuel use

[12] Ghana seen producing 350,000 b/d in 2018. https://www.ogj.com/articles/2016/11/ghana-seen-producing-350-000-b-d-in-2018.html.

[13] GNPC Lecture Series,2016/2017: Introduction of Ghana oil and gas industry; History, Current and Future Trends (accessed on 07-07-2018). https://www.gnpcghana.com/speeches/gnpcug.pdf.

may be determined by the economics of fuels in the country, for example, the prices, supply, quality and possibly government energy policy. In total the power generation sector alone demands about 900–1500 mmcfd of natural gas to operate after 2019 on average. The power generation demand for natural gas presents challenging dynamics for the petroleum industry to meet with huge financial investments.

Secondly, petrochemical & fertilizer is yet another significant sector demanding on natural gas. The study observes that the government of Ghana in 2010 announced industrialization and development strategy to boost the application of natural gas in the country and among which included methanol and ammonia projects. It was estimated that a standard methanol plant with a size of 1.6 million tons per year would require about 170 mmcfd of natural gas of at least 20 years. Specifically, in line with Prempeh and FCA (2010) and Tanoh (2016) the ammonia factory project is located in the Western region and when completed would require not less than 60 mmcfd of natural gas in order to achieve its target of 660,000 tons per year over the 20 years period. The petrochemical project was initially scheduled completion by close of 2010, but GNPC at the time was then the lead agency that could not mobilize the required one billion dollars ($1b) for the commencement of the project. Subsequently, the government of Ghana and Indian Investor signed a joint venture agreement,52%: 48% share move to establish a 1.3 billion fertilizer plant at Nyankom in the Western region to produce fertilizer for domestic and international markets. The project also has some multifaceted functions. Thus, it would provide feeds to Nwuli lime and Clinker Factory, Ghana Cement Factory in Takoradi and other uses. The fertilizer industry demand of 60 mmcfd for natural gas also presents challenges on the petroleum industry in terms of investment matrix in the industry.

The third sector on the demands of natural gas is the manufacturing and transportation sectors. Natural gas is one of the most efficient energy for transportation e.g. compressed natural gas vehicles (CNG). The CNG has less carbon dioxide emissions with higher energy output compared to other hydrocarbons. Also, natural gas can be applied in the residential and commercial sectors for heating and cooking purposes. For example, these sectors in America, Canada, and Europe account for higher consumption shares. Take the case for America, (Energy Information Administration, 2012) about 21% of the natural gas was consumed in the United States during 2013 in the residential sector. For the same period, about 14% of natural gas was utilized in the U.S in the commercial buildings. The power generation sector was the highest consumer however, of natural gas in 2013 with about 34%. And the manufacturing sector accounted for about 31% of total consumption in the States in the same period. Researchers note that natural gas has got so many uses besides power generation, petrochemical and fertilizer. Therefore, the demand development of natural gas application of natural have the potential to support economic growth and development in manufacturing industries, residential and commercial sectors. The government petroleum energy policy would motivate and incentivize public demand and investments in this direction. The study reveals that the manufacturing industries and residential sectors alone required about 90–200 mmcfd to produce goods and services in 2018. These other sectors demand also presents a challenge to the petroleum industry.

3.3. Summary of literature review

In summary, the literature review show that both qualitative and quantitative techniques have been applied in conducting studies on Ghana petroleum sector over the years. The studies are mainly in both descriptive content and descriptive statistics in nature. On the whole, the literature has contributed to petroleum polices in petroleum management, local content and exploration and production laws. However, the studies have been fragmented and consequently, could not recommend some core petroleum sector strategies to aid Ghana from petroleum importation following oil & gas discoveries and how to improve midstream petroleum infrastructure. Finally, some identified research gaps and major findings are specified in both Sections 4.1 and 4.2 respectively.

4. Research gaps, conclusion and policy implications

This systematic review framework summaries up with this section four. Researchers report and draw a conclusion with identified gaps from the relevant previous literature to inform future research direction. In this section, scholars further recommend policy strategies in the petroleum industry.

4.1. Research gaps and future research direction in the petroleum industry

In conclusion, all the relevant literature selected for the review in the petroleum industry reveals well-established unsolved research areas and gaps, which needed to be filled in order to boost petroleum sector literature and policy development. First and foremost, the previous literature has contributed significantly to two petroleum industry topics; descriptive content petroleum policy and partly on petroleum descriptive statistics. However, the literature has been disjointed and could not systematically analyze over time quantitatively in inferential statistics to cover critical topics that could analyze challenges and prospects for future research direction and policy. Topics like petroleum infrastructure development analysis; petroleum market analysis, petroleum economics, petroleum products balance, local petroleum production & supply, natural gas importation and sectoral demand are left out. The petroleum industry literature could not also analyzed in terms of factor & discriminant analysis, logistic & probit regression, path analysis with time series, cross-sectional panel form. Almost all the literature has been qualitatively descriptive and content in character over the years and hence making it difficult for policymakers to relate in comparative terms. And as a result, the available research could not stimulate investments both from private and governments to improve the industry to process petroleum locally. For example, similar studies in Europe by Brogan (2015) have attracted the attention of the European 2020 Project Bond Initiative; a joint credit enhances the program by the European Commission and the European Investment Bank, designed to stimulate capital market financing for infrastructure delivery under project finance structures in the oil and gas sector. The previous literature could not address fascinating questions like; (1) At what stage of infrastructure development can the petroleum industry add value to the petroleum products for domestic consumption in Ghana? and (2) Can Ghana possibly reduce the level of importation of petroleum products after having found petroleum and be energy sufficient? These unanswered questions, therefore, could motivate future innovative studies to reveal viable and bankable prospects not covered by previous literature in the petroleum industry of Ghana. For instance, Jim Yong Kim in 2014 during the launch of the new global infrastructure facility said that "the real challenge is not a matter of money but unidentified bankable projects- a sufficient supply of commercially viable and sustainable infrastructure investment".[14]

[14] World Bank Group Launches New Global Infrastructure Facility. http://www.worldbank.org/en/news/press-release/2014/10/09/world-bank-group-launches-new-global-infrastructure-facility.

Besides the identified topics above, future research could focus on the following broad fields to better shape the Ghanaian petroleum industry to contribute to economic growth and development in research. The broad areas include petroleum financing methods that Ghana could adopt to develop the midstream sector of the petroleum industry; economics of the midstream to downstream sector of the petroleum industry; the importance of the midstream sector in economic growth and development; petroleum conversion economics and management in Ghana. Another area is the policy strategies of the government to reduce its petroleum product's import dependency rate to become energy sufficient.

4.2. Conclusion

This paper conducted a systematic literature review on Ghana's petroleum industry prospects and challenges. Authors developed a methodological framework by first formulating the review question, identification and selection of literature. Scholars developed a research protocols and accepted relevant studies. Researchers further appraised the selected literature and evaluated the previous studies into qualitative and quantitative studies. Scholars finally, analyzed and synthesized the literature with both narrative and triangulation techniques. The paper found that most of the studies mainly focus on descriptive-content petroleum policy and somehow on descriptive petroleum statistics in the areas of revenue management, taxation, upstream fiscal regime and regulation, gas pricing and local content. Those studies have contributed immensely to the petroleum revenue management, local content, petroleum exploration, development, and production bills into applicable laws in Ghana (Amoako-Tuffour and others, 2010). Furthermore, this paper revealed that Ghana is petroleum import-dependent of 17%, 37% for natural gas, and 78% for petroleum products. This development situation presents some serious socio-economic challenges on the industry and the country at large in terms of macroeconomic management. Also, the annual demand growth rate of petroleum product as of 2016 was above 30%, and natural gas, 173%. Since the year 2010, the petroleum subsector has contributed over 80% to the total final energy mix excluding biomass. However, the local supply has only accounted for merely 5% of this total, with imported petroleum contributing approximately 95% in 2017. In other words, Ghana is challenged with the importation of petroleum products, even though producing petroleum in large quantities, besides the robust prospects. Additionally, the review disclosed that the petroleum industry is challenged with inadequate infrastructure investment from both government and the private sector especially for the petroleum midstream to the downstream sector. Unlike, in the United States where for example, a study conducted by (World Pensions Council Report, 2014) suggested that large U.S and Canadian pension funds, Asian, and MENA countries have become predominantly involved in investing in natural gas commodities and its infrastructure since 2005. Also, Tolliver (2012) and Goldthau (2014) have realized that infrastructure investment has become significant in the energy and petroleum sector industry to spur for socioeconomic development. Authors finally observed that previous literature has been fragmented and could not some analyze quantitatively in inferential statistics broad petroleum areas and some critical topics such as petroleum infrastructure development analysis; petroleum market analysis, a petroleum economics and some others. The petroleum industry researches could not also be examined with factor & discriminant analysis, logistic & probit regression, and path analysis.

4.3. Policy implication and recommendation

In the estimation of this paper, TOR would only become efficient and effective, if the government could introduce public–private partnership agreement in its operation and management. This, if effectively executed would reduce the accumulated debts drastically on TOR. This policy strategy would suffice the current recovery debt levy, which has been introduced since 2004 and yet the debt keeps on accruing. The introduction of partnership agreement would lead to TOR expansion from the current capacity of 45,000 bpd to about 9000–10,000 bpd and this would make it capable of refining the local crude oil and thereby reduce imports from 95% in 2017 to at least 40%. This may reduce the pressure on the government from import dependency. This paper further recommends the government extend similar public–private partnership agreements into BOST, which also over the years has been inefficient and underutilized. The implication of the challenged petroleum sector operators may not help Ghana to achieve its energy sufficiency targets. Authors therefore, suggest that BOST and TOR should be revamped and expanded to make them national strategic oil and gas stockholding, and also establish some oil reserves facilities in major cities like Takoradi, Kumasi and Tamale. All these could be possible if the ownership and management of TOR and BOST are transformed. Secondly, this study recommends the government, financial institutions, multinational organizations, international and local oil companies to invest some appreciable amount of capital on infrastructure to augment processing, refining, and storing of petroleum in the country. This study further recommends GNGC to speedily expand its natural gas pipeline to connect WAGP in Takoradi and also Prestea pipeline to link Kumasi, which would facilitate inland domestic natural gas to other regions and manufacturing industries. Government and GNGC should both expedite action to facilitate the construction of the NGL storage facility at Domunli by close of 2020 to facilitate natural business in the industry to enhance growth. Finally, the government should facilitate the LNG contract which was signed in 2017 with Equatorial Guinea to supply Ghana with natural gas in the ranges of 250–500 mmcfd as was recommended by Equatorial Guinea (2018). This paper further encourages the government to satisfy all contractual obligations so, that the contract does not become like the one between Ghana and Nigeria deal.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

See Figs. A.1–A.3.

Appendix B. Definition of terms, symbols, and abbreviations

IEA: International Energy Agency
GDP: Gross domestic product
GNPC: Ghana National Petroleum Commission
EITI: Extractive industries transparency initiative
BOST: Bulk oil storage and transportation
LPG: Liquefied petroleum gas
WAGP: West African gas pipeline
WAGPCo: West African gas pipeline company
GNGC: Ghana National gas company
TOR: Tema oil refinery
LNG: Liquified natural gas

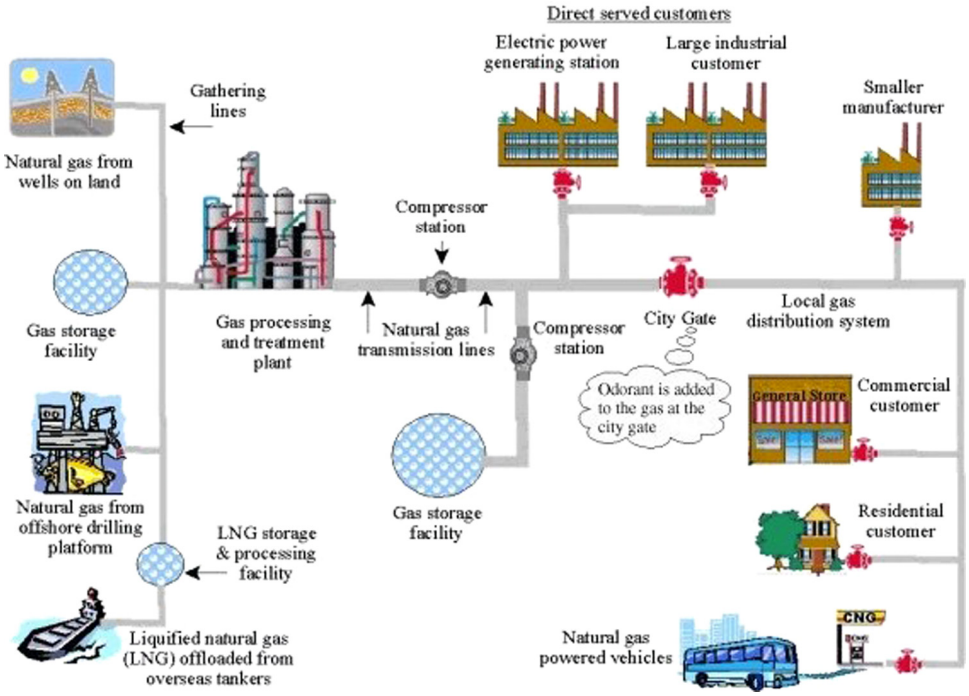


Fig. A.1. Natural Gas Value Chain Infrastructure for Midstream and Downstream Sector.
Source: w.w.w. explore oil refinery.

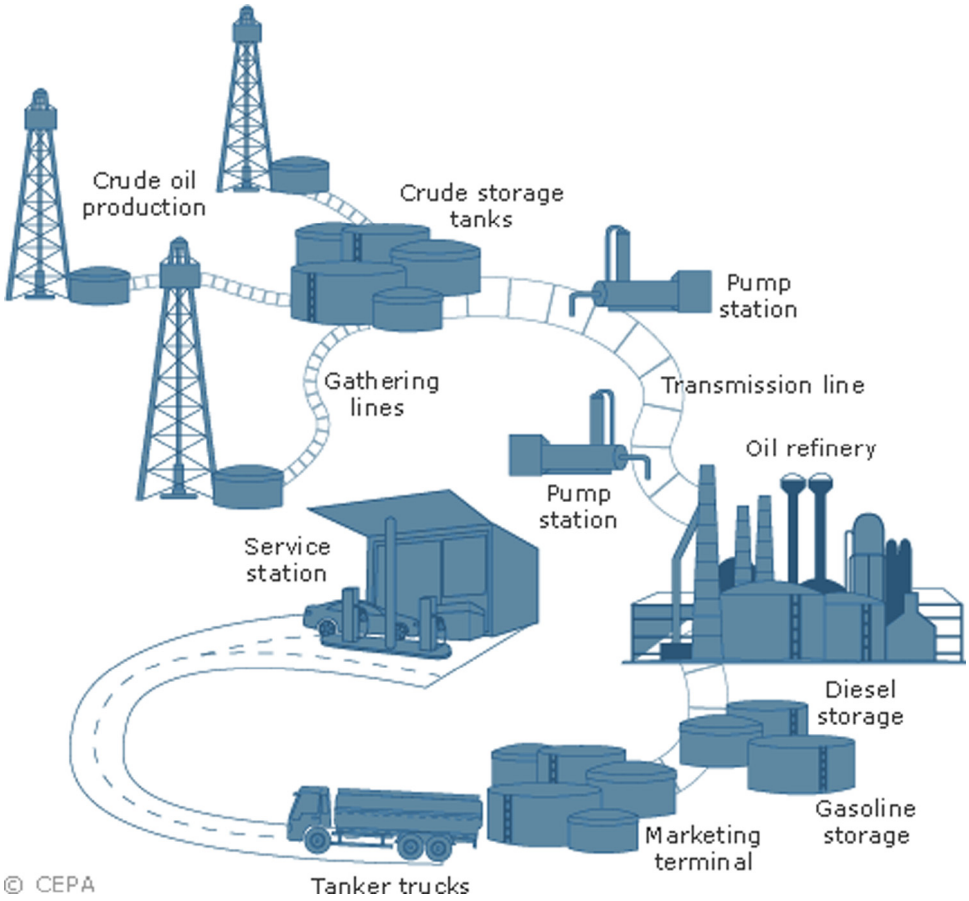


Fig. A.2. Crude Oil Value Chain/System.
Source: w.w.w. explore oil refinery.



Fig. A.3. Atuabo Free Port Layout. *Source:* https://www.graphic.com.gh/features/features/atuabo-free-port.

FPSO: Floating production storage and offloading
N/A: Not available
API: American Petroleum Institute
0: Indicator zero, representing serious challenges
1: Indicator one, representing a low challenge
2: Indicator two, representing prospect
LPG: Liquefied petroleum gas
NGL: Natural gas liquid
NTL: Natural to liquid
CNG: Compressed natural gas
BDCs: Bulk distribution companies
OMCs: Oil and marketing companies
CHEC: China Harbor Engineering Company
BOOT: Build, owned, operate, and transfer
MMBtu: One million British thermal units
GOG: Government of Ghana
PURC: Public utility regulatory commission
NPC: National petroleum commission
NPA: National petroleum authority
EPA: Environmental protection agency
MMSCF: Millions standard cubic feet
MMCFD: Million cubic feet per day
BPD: Barrel per day
ENI: "Ente Nazionale Indrocarburi"
VRA: Volta River Authority
IPPs: Independent power producers
Ktoe: Kiloton oil equivalence

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