GHANA

STEAM PRODUCTION SYSTEMS IN FOOD, BEVERAGE AND PALM OIL INDUSTRIES

AN ASSESSMENT

IN CONTRIBUTION TO THE NDC PARTNERSHIP
ACCELERATING CLIMATE AND DEVELOPMENT ACTION

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Steam Production Systems in Food, Beverage and Palm Oil Industries: An Assessment

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Abbreviations

APOMOAG	Artisanal Palm Oil Millers and Outgrowers Association Ghana
APO	artisanal palm oil
EPA	Environmental Protection Agency
FAB	food and beverage
GHG	greenhouse gas
GH¢	Ghana cedi (currency)
GRATIS	Ghana Regional Appropriate Technology Industrial Service
IIR	Institute of Industrial Research
LPG	liquified petroleum gas
MSME	micro, small and medium enterprise
MESTI	Ministry of Environment, Science, Technology and Innovation
MOTI	Ministry of Trade and Industry
NDC	Nationally Determined Contribution
PEF	Private Enterprise Federation
RFO	residual fuel oil
UNDP	United Nations Development Programme

Executive summary

This report presents the methodology and findings of the assessment of boiler operations in food and beverage (FAB) and artisanal palm oil (APO) processing facilities. It evaluates the state of industrial boiler and artisanal cooking systems and associated challenges. The study adopted mixed approaches involving a desktop study, field visits, interviews using questionnaires and workshops. A stakeholder committee was formed to solicit feedback from the industry players. The survey was conducted in the Greater Accra and Eastern regions, where most of the formal industry and artisanal millers are located. In the formal industry, 30 food and beverage companies responded to the questionnaire. Among the artisanal palm oil millers, the survey sampled 279 respondents.

The findings showed that installed capacity of the sampled FAB companies ranges from 700 tons/year to 630,000 tons/year. Their range of manufactured products includes water, beverages and oil. The types of waste generated by the surveyed companies include bio-degradable, plastic, scrap metal and paper of all types. Some of the waste management practices used by these companies include waste recycling, re-use and disposal at a landfill site.

Most of the sampled companies used fire tube and water tube boiler technology. Of the total sampled companies, 91 percent reported operating fire tube boilers while the remaining 9 percent use water tube. The boilers use biomass, diesel, residual fuel oil and liquefied petroleum gas as fuels. The boiler steam has a wide range of applications in heating and cooking equipment. Almost half of the companies reported 5 percent or less of steam losses due to various engineering setbacks. These are faulty steam traps, damaged steam tracers, leaking steam coils, steam pipe leakage, weak steam pipes, steam valves, pipelines not lagged, leaking joints in overhead leaking pipes, process lines, etc.

It is also worthwhile to note that most companies have also put in place pollution control measures to ensure a reduction in emissions discharged from the boilers. The FAB companies carry out annual statutory maintenance and report to the Department of Factories Inspectorate. Maintenance costs are between Ghana cedi (GH¢) 6,000–104,000 (US$ 1,074–17,744) annually. A few companies expressed their desire to upgrade, which costs from GH¢ 30,000–3,495,934 ($ 5,119–596,472). The total greenhouse gas emissions of the sampled FAB companies were estimated at 4.1 $MtCO_2e$. The reported raw material consumption of APO facilities ranged between 1 and 80 tons per day of fresh fruit bunches, and production levels ranged from 40 to 10,000 litres per day of palm oil and palm kernel oil. While the APO facilities do not use steam boilers in their operations, they have manually operated cooking systems that perform the same function of providing steam.

APO millers most often burn the waste generated by their process, which can result in bush fires when not properly controlled. The fuel type used by the APO millers is mainly biomass, which they have in abundance. The cost of maintenance ranges from GH¢ 100–23,000 ($ 17–3,924), depending on the part being serviced. A total of 61 percent expressed the need to upgrade their operations and machinery. Many facilities (81.1 percent) require engineering support for installation, operation, servicing and maintenance of machinery and equipment and technical training for their staff to improve operational performance. Overall, 4.3 percent of the facilities indicated the need for financial support to implement the improvement options identified, while 11.1 percent did not indicate the type of support they require.

1 Chapter One:

BACKGROUND

1.1 Industrial boilers in the food and beverage sector

The steam boiler is the most cost-efficient way to produce and transfer heat for industrial processes. It is a key material input for the food and beverage (FAB) supply chain, particularly, for cooking, drying, warming, sterilization and general cleaning activities. Steam requirements for the FAB industries are obtained from fuel-powered steam boilers. The dominant boiler fuels in the industry include diesel, residual fuel oil (RFO), liquefied petroleum gas (LPG) and biomass or a blend of diesel and RFO. Fuel impurities could affect boiler performance and thus require appropriate treatment.

Studies have shown that most boilers in the country are not fitted with monitoring systems to assess steam generation and utilization efficiency, fuel use and other parameters.[1] Their efficiencies are not solely determined by the steam-to-fuel ratio but also the fuel consumption per unit production. Fuel consumption measurements are generally also based on inaccurate dip-stick measurements in fuel tanks instead of fuel meters with preheaters that give accurate and consistent flow rate metering. The study further revealed that, often, most steam boilers perform below industry efficiency benchmarks due to the use of old technology, improper fuel treatment, inadequate maintenance practices and lack of boiler efficiency monitoring systems. The identified technical setbacks lead to inefficient boiler performance, gross pollution and high maintenance cost. In the artisanal palm oil (APO) industry where most of the workers are women, the cooking systems employed in the processing operations are highly inefficient and pose huge environmental and health challenges.

Nevertheless, there are technical options for improving boiler operations, and that is why Ghana's Nationally Determined Contributions (NDCs) to the Paris Climate Agreement adopted the promotion of industrial energy efficiency. The industrial energy efficiency NDC aims at curbing the rising greenhouse gas (GHG) emissions in the industrial sector. In the FAB sub-sector, GHG emissions are mainly associated with predominant fossil-fuel use and inefficient steam boilers. Thus, under the NDC Support Programme, the Ministry of Environment, Science, Technology and Innovation (MESTI), the Environmental Protection Agency (EPA) and the United Nations Development Programme (UNDP) are piloting the industrial boiler programme. The programme seeks to promote boiler efficiency in FAB and APO processing companies through the adoption of alternative clean fuels and performance optimization practices.

The industry steam boiler inventory is an initial task to survey boilers in the FAB sub-sector as well as APO processors. Specifically, the inventory aims to assess the current state of boiler operations and associated challenges in selected manufacturing companies in the FAB and APO processing companies. The inventory results will feed into the development of a technical and financial support package for the industry and will be a useful input to the ongoing NDCs update for the industrial sector.

1 https://www.pheebesconsult.com/steam-efficiency-optimization.

1.2 Objectives and outputs of the inventory

1.2.1 Objectives

The overall goal of the inventory is to assess the performance of industrial boilers in the FAB and APO processing industries and identify improvement options. The specific objectives of the inventory are to

- conduct an assessment on steam boiler and cooking systems in FAB and APO processing companies;
- create awareness of the need to ensure high steam boiler and cooking system performance and to adopt cleaner fuel and efficiency practices; and
- assess the kind of technical and financial support needed by micro, small and medium enterprises (MSMEs) to improve efficiency and reduce and document emissions.

1.2.2 Outputs

The deliverables of the inventory are as follows:

- Conduct a steam boiler assessment to ascertain the true state of boilers and challenges in the FAB companies and among APO millers
- Promote high steam boiler performance through the adoption of cleaner fuel and efficiency practices
- Recommend technical and financial needs to serve as input into the design of a financial mechanism to support the sector

1.3 Scope of the inventory

The key task was to undertake a comprehensive assessment and mapping of: (i) steam boiler operations in the FAB industry sector and (ii) cooking systems in the APO processing facilities to ascertain the true state of boilers and challenges in the FAB companies, as well as APO millers. Specifically, the tasks included the following:

- Conduct a desktop study to gather available information on the industry. Findings from the desktop review served as inputs into the preparation of a survey questionnaire.
- Prepare two sets of questionnaires for the formal FAB sector and APO processing facilities.
- Administer questionnaires to 279 APO processing facilities and over 50 formal MSMEs in the FAB sector.
- Conduct follow-ups to ensure the questionnaires were completed within two weeks.
- Undertake field visits to verify responses and have first-hand information on the boiler operations.
- Analyse completed questionnaires to sift out the key findings from the survey.
- Prepare a report on the state of industrial steam boiler operations in the FAB and APO processing sector.
- Organize a workshop for stakeholders to validate the report. Feedback from the workshop will feed into the design and establishment of the beneficiaries' technical and financial support.
- Finalize the report to guide the development of the support package for the industry.

2 Chapter Two:

INVENTORY APPROACHES

2.1 Strategy for the industry boiler inventory and stakeholder committee

The study adopted mixed approaches to plan, collect and analyse the data on steam boilers. The EPA formed a multisector stakeholder committee to provide technical inputs into the exercise. As part of the inventory, a stakeholder committee was established to provide technical advice. The committee members were drawn from government institutions and key industry players. The institutions that constituted the committee are as follows:

- Association of Ghana Industries
- Department of Factories Inspectorate
- Oil Palm Development Association of Ghana
- Rural Enterprises Foundation
- Ghana Regional Appropriate Technology Industrial Service (GRATIS) Foundation
- Solidaridad West Africa
- Artisanal Palm Oil Millers and Outgrowers Association Ghana (APOMOAG)
- Ministry of Trade and Industry
- Private Enterprise Federation
- MESTI
- Institute of Industrial Research (IIR)
- EPA

2.2 Methods

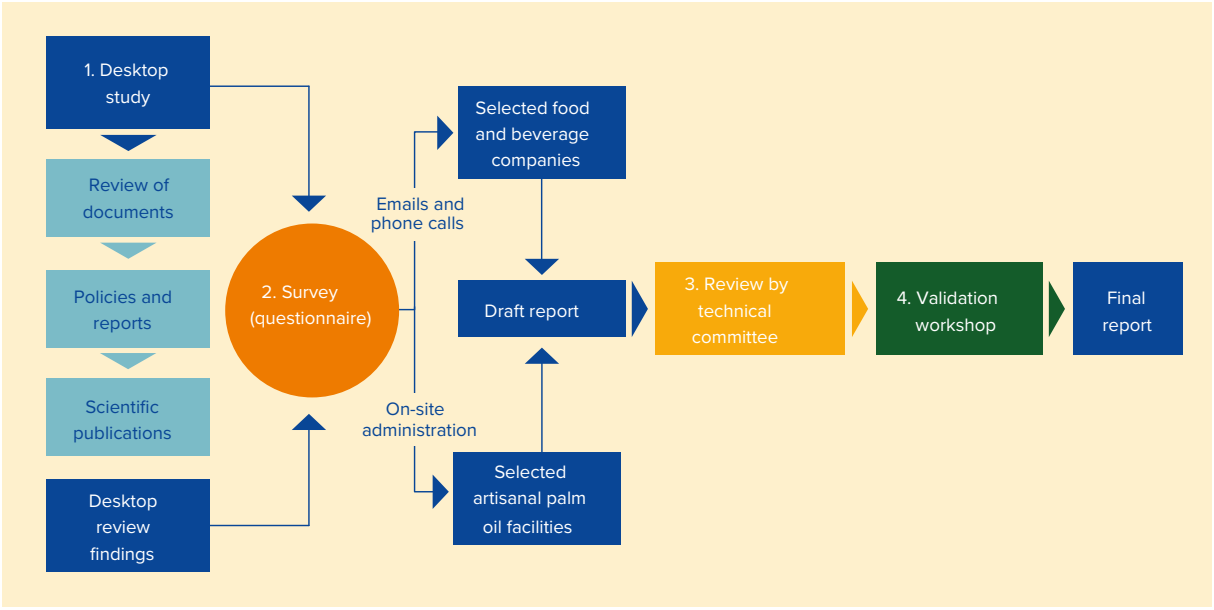
The desktop study, survey and workshops were the methods the study adopted for the inventory (Figure 1). MESTI and EPA led the desktop study which covered reviews of policies and strategies, reports and scientific literature. It also included studying international best practices on boiler operations and support systems. The findings from the desktop study informed the issues covered in the questionnaire.

Two sets of questionnaires[2] were developed for the FAB and APO processing facilities respectively. The questionnaires were tested with a limited sample of selected companies to evaluate how it could help to elicit critical responses from the manufacturing companies. After the testing, the questionnaires were then distributed to 50 FAB and 279 APO processing facilities[3] for the collection of the required information. The team selected FAB companies using the EPA database. For APO facilities, the selection was based on interactions with the Oil Palm Association of Ghana and the EPA's knowledge of the area.

2 Attached as Annexes 1 and 2.
3 Attached as Annexes 3 and 4.

Owing to the health emergency of COVID-19 and its associated measures, the EPA administered the questionnaires via email to the selected FAB companies. For the informal operators who do not have internet access, the questionnaire was administered on site. The team followed up on the completion and submission of the questionnaire via phone or email reminders. Site visits were also conducted to the selected industries to verify the information provided. A draft report was then prepared and reviewed by the technical committee after which a validation workshop was organized for key stakeholders, including members of the finance committee and industry representatives, to solicit feedback on the major findings. The finance committee will use the findings from the report to design a financial package and criteria for beneficiary industries.

Figure 1: Flow chart of the inventory methodology



3 Chapter Three:

RESULTS AND DISCUSSIONS

3.1 Formal food and beverage processing sector

3.1.1 Overview of the formal sector

The formal sector inventory focused on FAB companies to understand the steam boiler operations and identify opportunities for engineering and management improvements in the factory. The inventory covered 50 industries in Accra and Tema, but only 30 responded. Of the 30 industries, 21 are located in Tema and nine in Accra (Table 1). The majority of the surveyed companies (47 percent) are in the Tema Industrial Area and manufacture products such as fruit juices, food products, vegetable oil, shea butter, cocoa products, alcohol, beer and soft drinks for the local and export markets.

Table 1: Geographical coverage of the sampled industries in Tema and Accra

Survey area	Location	Number of companies
Tema and environs	Tema	14
	Kpone	3
	Spintex	6
Accra	Agbogbloshie	1
	North industrial area	2
	Old Fadama	1
	Akweteyman, Lapaz	1
	Madina	1
	Pokuase	1
	Total	**30**

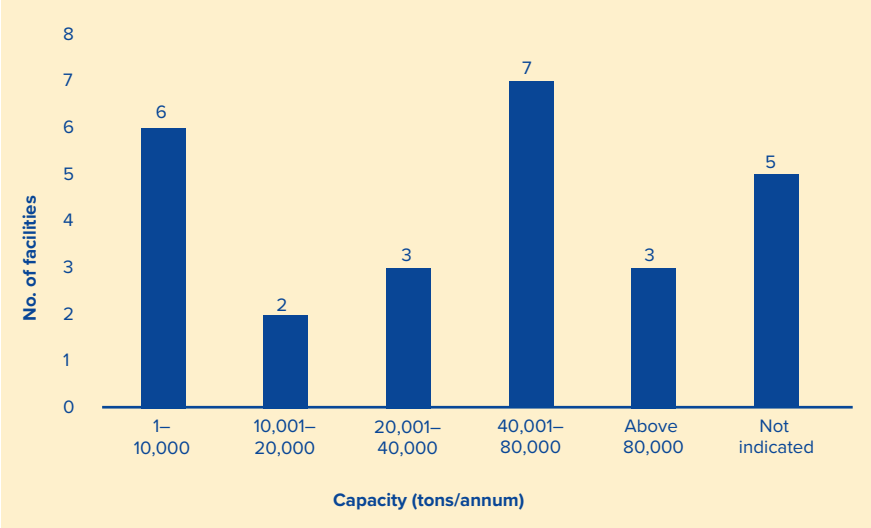
3.1.2 Raw materials

The companies source a variety of raw materials from local and international suppliers for their production. The main raw materials for the edible and vegetable oil companies include palm fruits and crude palm oil, edible oil and soya bean oil, while those involved in food production use gari, tuna, palm wine, egg powder and raw tomato paste. Those that produce for the targeted market use cocoa beans, cocoa powder, shea nuts and shea butter and different forms of sugars, syrups, buttermilk, skimmed milk and starch as raw materials. Generally, the alcoholic and non-alcoholic beverage producing companies use corn, malt, herbs, cassava flour, wheat flour and gin concentrate. Chemical raw materials used by these companies include hexane, acetone, alcohol, carbon dioxide, citric acid, ascorbic acid, phosphoric acid, high-density polyethene and low-density polyethene.

3.1.3 Plant capacity

Generally, the installed capacities expectedly varied from plant to plant. The results showed that plant installed capacities of the surveyed companies ranged from 27,600 m^3 to 210,000 m^3 per annum for the four beverage companies. The capacities for the 26 remaining companies are presented in Figure 2.

Figure 2: Ranges of plant capacities in the surveyed companies

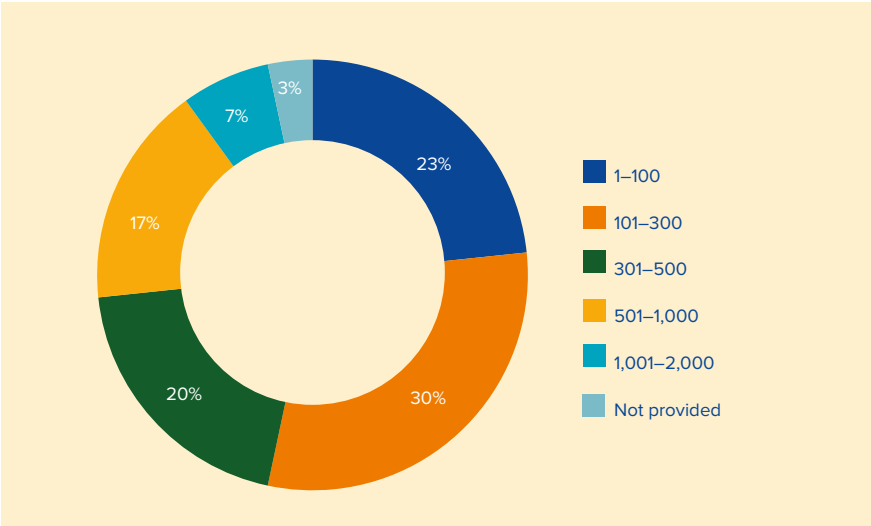


The wide range of the installed capacity highlights the diversity in the scope of operations of the sampled companies.

3.1.4 Staff strength

Staff is another important indicator of operating capacity. The results also showed that the staff strength and the plant operating period widely differed according to the manufacturing scale. Overall, the companies reported staff strength between 25 and 1,670 employees, who, on average, work five days per week. Figure 3 presents the number of staff for the various ranges. Only nine companies have staff strength in the range of 101–300.

Figure 3: Staff strength of the facilities



3.1.5 Product types

The surveyed companies manufacture a wide range of product types. Some of the main products the sampled companies produced include:

Food and oil products

- gari
- hausa koko
- tom brown
- tomato paste
- canned tomato
- kenkey/banku
- fufu/kokonte/banku mix powder
- toffees
- ice cream
- shea butter
- edible oil
- jam

Water and beverages

- soft drinks
- cocoa powder
- cocoa liquor
- fruit juice
- palm wine
- soya milk
- bottled water
- beer

3.1.6 Waste and waste management practices

In the manufacturing of the finished products listed above, the companies generate different types of waste. The sampled companies indicated the following as the dominant waste from their operations:

- cocoa husk
- boiler ash
- plastic waste
- spent oil
- wood waste
- metal scrap
- pet bottles
- paper
- fish waste
- dust
- jute sacks
- plastic/metal containers
- fibre
- empty fruit bunches/spikelets
- palm nuts

In the same vein, the predominant waste management practices in the sampled companies also showed wide variations. The dominant waste management options the respondents mentioned are as follows:

- Recycling of plastic and metal wastes by third parties
- Use of waste vegetable oil from tank cleaning for soap production by third parties
- Use of wood waste as firewood and for construction work by third parties
- Disposal of boiler ash and spent earth to local landfill sites
- Use of dry press cake from palm fruit as boiler fuel
- Use of cocoa waste as boiler fuel and compost and for soap production
- Fish waste processed into fish meals
- Biohazards incinerated in hospitals
- Use of tomato paste waste in biogas production by a third party
- Use of empty palm fruit bunches and fibres as fuel for the boiler
- Unrecyclable solid waste stored in bins and later disposed of by third parties

Regarding wastewater, the survey confirmed that the waste generated by companies is either disposed with or without treatment.

3.1.7 Machinery and equipment

The plants have different types of machinery depending on production activities. The key equipment that is typically connected to the boilers for steam uptake include:

- alkalizer
- debacterizer
- roaster
- pasteurizer
- retort steam kettle
- bottle-washing equipment
- evaporator
- sterilizing and filling machine
- cookers
- strippers
- distillation columns
- palm fruit digesters
- deodorizer
- automatic capping machine
- presses and pre-dryers
- solvent extraction plant
- oil milling equipment
- air compressor
- heat exchangers
- heating cabinets
- refinery plant
- reactor

3.1.8 Boiler technology and fuel management

3.1.8.1 Types of boiler technology

The survey covered 56 boilers in 30 companies. The boiler technology, age, type and operational management influence the performance and efficiency level. The surveyed companies reported two main categories of boiler technologies. These are fire tube and water tube boilers, as shown in the photographs below. Most of the surveyed companies (91 percent) operate 51 fire tube steam boilers with average capacities between 0.1 tons per hour to 20 tons per hour. The remaining 9 percent of the companies operate five water tube boilers with average capacities ranging between 6 tons per hour and 25 tons per hour. The survey shows that fire tube boilers used in the surveyed industries are older technologies compared to water tube technologies. The fire tube boilers had an average age of 18 years with the year of manufacture between 1980 and 2019. The average number of operating hours for the fire tube boilers is 432 hours per month.

On the other hand, water tube boilers are a relatively new technology. Their average age is nine years, and manufactured between 2006 and 2017. The average number of operating hours for the water tube boilers is 509 hours per month.

Steam boilers encountered in industries

3.1.8.2 Fuel use in boilers

The companies reported four main types of fuels used in the boilers, namely biomass, diesel, fuel oils (RFO, a blend of RFO and diesel) and LPG. Table 2 shows boiler categorization and fuel management in the companies. Depending on the fuel burners, the companies either use single or dual fire and water tube boilers. The majority of the single-fuel fire tube boilers run on diesel, biomass, RFO and LPG, whereas the single-fuel water tube mainly uses biomass and LPG.

Table 2: Boiler categories and fuel management

Fuel use	Technology type	Fuel type	No. of boilers	No. of companies	Average consumption (t) Storage Source of fuel
Single	Fire tube	Diesel	13	8	32,833 Underground storage tank/surface tanks Tema Oil Refinery, PUMA Ghana, GOIL
		Biomass	10	7	Firewood: 3 Palm kernel shells and wood chips: 1,200 Cocoa shell: 234 Cashew shell oil: 13 The surface of the land or open-air space, silos Companies' production processes, local and industrial palm processors, villages
		RFO	9	5	46,116 Underground storage tank/surface tanks Tema Oil Refinery, Mahoney
		LPG	1	1	20 Gas tanks Tema Oil Refinery
	Water tube	Biomass	2	2	47.5 The surface of the land or open-air space, silos Local and industrial palm kernel producers, villages
		LPG	1	1	60 Gas tanks Tema Oil Refinery
Dual	Fire tube	RFO and diesel	6	4	6,687.5 Underground storage tank/surface land Tema Oil Refinery, Mahoney
		Biomass and RFO	1	1	27,000 Open-air, storage tanks Tema Oil Refinery, Mahoney
		Biomass and LPG	1	1	2 Open-air, gas tanks Total, local and industrial palm kernel producers, villages

The dual-fuel boiler is mainly fire tube and uses RFO/diesel, biomass/RFO and biomass/LPG as the primary fuels. The companies reported multiple sources of the fuels depending on the types. Tema Oil Refinery and some oil marketing companies (GOIL Company Limited, Total Ghana Limited, Mahoney) supply a higher percentage of the secondary petroleum products used by the surveyed companies. Biomass is sourced from the companies' production processes and local producers. Fuel storage differs depending on the type. There were five main types of fuel storage practices reported. Biomass is stored in silos or in open-air spaces (see photograph below), while liquid fuels and LPG are stored in surface and underground storage tanks.

Biomass stored for use as fuel inputs into boilers

3.1.9 Sources of water for boilers

The main sources of water for boiler operations are from mechanized boreholes, water tank distributors, wells, pipe-borne water from Ghana Water Company Limited and steam condensate. The survey found that: 21 companies recover steam condensate for use; two companies rely on boreholes as the main source of water; four companies get water from water tanker distributor services; while 20 companies rely on Ghana Water Company Ltd. Moreover, two companies indicated that they have soft water plants, and 27 companies treat the water before use. Treatment options include reverse osmosis, chemical treatment and use of carbon filters and softeners. There were two companies that do not treat their boiler feed water.

3.1.10 Combustion and thermal efficiencies

Often, combustion and thermal efficiency are determinants of higher boiler performance, fuel use and steam optimization. Therefore, boiler operators ensure that the boilers are in good condition to optimize steam generation and reduce operating cost and emission footprints. Generally, the companies that operate water tube boilers reported relatively higher combustion efficiency, averaging 94 percent compared to 85 percent for the fire tube boilers. Average combustion efficiency for all boilers is 87 percent. Regarding thermal efficiency, many of the companies reported an average efficiency of 84.3 percent for the fire tube boilers and 77.2 percent for the water tube boilers.[4] Variations in efficiencies could be due to factors such as technology, age, fuel type and quality, and operating and maintenance practices.

4 This information is likely to have been taken from the boiler manuals rather than actual measurements.

Another critical variable for measuring steam boiler performance is steam losses. Steam losses of more than 5 percent should be of concern to the operators. Almost half of the companies (47 percent) reported 5 percent or less in steam losses, which suggests better steam optimization in the operations. Another 10 percent of the companies indicated between 6 percent and 10 percent steam losses, while 6.7 percent mentioned unacceptably high steam losses of 20 percent. The remaining 36.7 percent did not provide information on steam losses.

The possible areas of the steam losses in the production line were listed to include faulty steam traps, damaged steam tracers, leaking steam coils, steam pipe leakage, weak steam pipes, steam valves, pipelines not lagged, leaking joints in overhead leaking pipes, process lines, etc. These findings suggest that with regular monitoring and maintenance of the identified source of the losses, there is the potential to reduce steam losses and improve the overall steam management and minimize air pollution and GHG emissions from the companies' operations.

3.1.11 Pollutants and pollution control systems

Boiler operations generate various types of pollutants and GHG emissions. Pollutants emitted that have negative impacts on the environment include smoke and fumes, dust, black carbon, particulate matter, sulphur dioxide, nitrogen oxides and carbon monoxide. The boiler stacks emit pollutants depending on the combustion efficiency, type of fuel used and the treatment of the fuel before use. Boiler emissions can be managed through various treatment options, including pollution control systems. The survey showed that 11 out of the 30 companies apply end-of-pipe treatment options to control emissions. Some of the treatment options used in the surveyed companies include:

- cyclones (3-stage cyclone separators, Multi-Cyclones, etc.);
- ee-dusters; and
- scrubber systems to absorb black smoke before going to chimney.

While three companies use combustion controls to improve combustion, 10 do not have any pollution control systems in place, and six did not provide the required information.

3.1.12 Boiler maintenance

Fault detection and a regular maintenance regime enable higher boiler performance. The companies that have resources to maintain their boilers tend to have improved operations and lower impacts on the environment, and thus they contribute less to climate change. The companies reported that routine maintenance is carried out in all the industries either weekly, monthly, or annually, consistent with the manufacturer's specifications and their operational practices. Table 3 lists the boiler parts that are frequently replaced or maintained.

Table 3: Boiler parts frequently maintained

Feed water system	Steam system	Fuel system	Others
Sight glass and water chamber	Tubes	Blowers	Electricals parts, including motors
Boiler water level probes	Valves	Burner units	Boiler peripherals
Pumps	Gauges	Fuel and air filters	
	Flanges and pipes	Fuel line strainers	
	Fibre blankets (insulation)	Furnace/combustion chambers	
	Steam traps	Igniter	
	Economizer	Furnace	
		Brickwork and grill (furnace chamber)	
		Burner rotary caps	
		Rodding of fire tubes	
		Photocell	
		Stacks	
		Nozzles	
		Electrode dumpers	
		Fans	
		Multi-Cyclones	
		Refractory	

The different types of maintenance activities the companies reported have been broadly categorized as follows:

- manual and automatic blowdowns
- cleaning of tubes, nozzles and igniter
- manual maintenance using valve handle extension bar
- foot press level and activator auto-switch
- treatment of water to minimize scaling
- lagging and aluminium cladding
- repairs and replacements of boiler parts
- cleaning and scrubbing of boiler parts (e.g. nozzles, tubes, pipes, grates, or stove grill)
- checking and sealing leakages in pipes, pumps, flanges, valves and tubes
- overhauling and combustion tuning of burners
- refractory work
- electrical maintenance of pumps, motors and various measuring instruments
- servicing and use of quality fuel

Annual statutory inspections are conducted on most of the boilers and include the following:

- Pressure vessels and air receivers are tested to ascertain the working condition level.
- All vital equipment like valves, steam traps, alarm switches and air vents are checked and maintained.

The companies indicated varied costs of maintenance, depending on the type of maintenance to be carried out. The maximum cost identified is Ghana cedi (GH¢) 104,000 (i.e. $ 17,744), while the minimum cost is GH¢ 6,000 (i.e. $ 1,024) per annum.

3.1.13 Strategy for boiler improvements

About 53 percent (16 companies) have plans to improve their boilers to achieve high performance. The summary of the boiler improvement options is reported in Table 4.

Table 4: List of improvement options for steam boilers

Improvement options	Number of facilities
Upgrade[5] only	3
Refurbishment[6] only	3
Replacement[7] only	1
New installation[8] only	4
Upgrade and new installation	1
Refurbishment and replacement	1
Refurbishment and new installation	1
Replacement and new installation	1
Upgrade, refurbishment and new installation	1
Not indicated	14

Specific improvement activities to be carried out include the following:

Upgrade

- replacement and servicing of burner units or upgrading of burners that can support dual-fuel use
- replacement of induced draught fans
- re-tubing
- insulation of steam pipes
- use of variable frequency drives

Refurbishment

- repair of refractory material in the firebox
- extension of boiler chimneys
- cleaning and descaling of fire tubes

Replacement

- installation of an additional new boiler

5 Increase capacity while improving efficiency of an existing boiler.
6 Retooling/overhaul/parts replacement/redesign/repairs for efficiency improvement.
7 Change an existing boiler or replacement/installation of a boiler.
8 Acquisition or installation of new systems.

New installations

- installation of an economizer to the boiler
- installation of pollution control system
- programme for monitoring all steam traps, condensate return system and treatment from a retort
- redesigning the steam distribution system
- fuel switch (LPG instead of RFO and diesel)

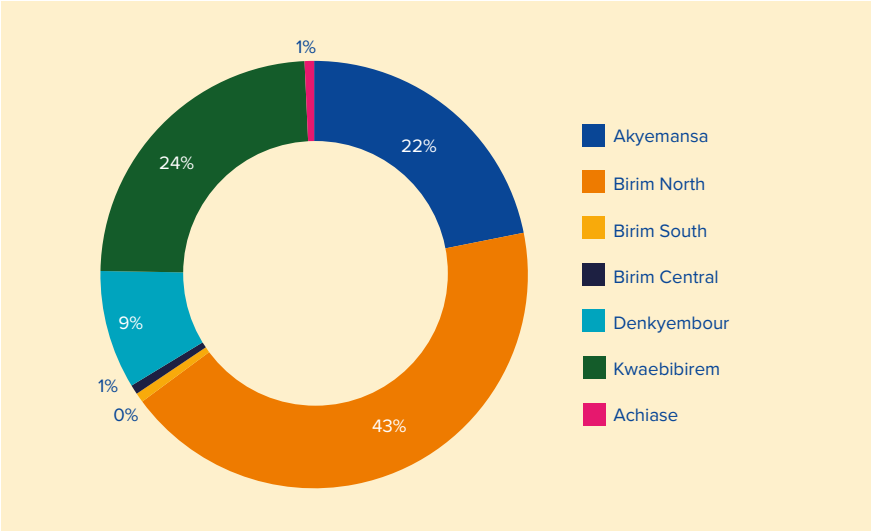
The cost of improvement varies from the lowest amount of GH¢ 30,000 ($ 5,118) to the highest cost of GH¢ 3,495,934 ($ 596,472). The expected sources of funding are bank loans (two companies), internally generated funds (10 companies) and foreign partners (three companies). Only one company did not indicate the source of funding.

3.2 Artisanal palm oil processing

3.2.1 Coverage area

The inventory covered a total of 279 APO processing facilities in seven districts in the Eastern Region. Figure 4 presents the breakdown of facilities the survey covered in each district.

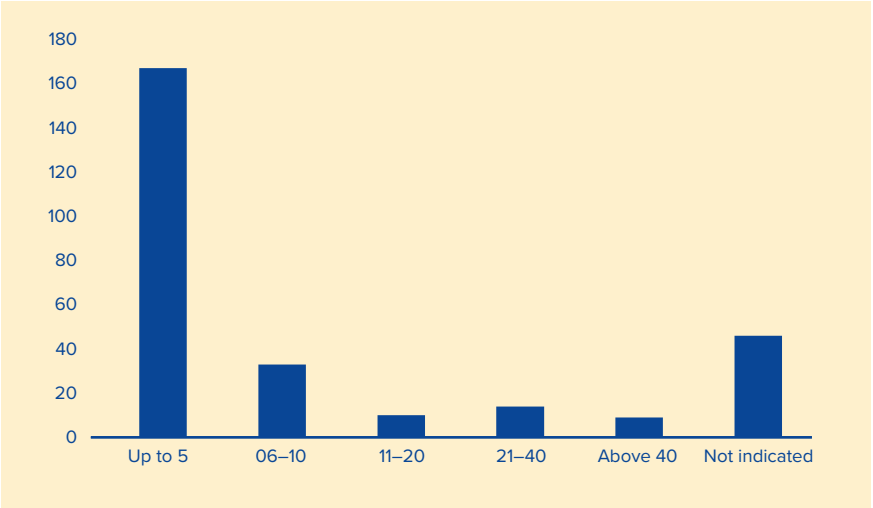
Figure 4: District distribution of facilities



3.2.2 Production capacities of artisanal palm oil millers

The capacities of the facilities as reported in the questionnaire are based on raw material consumption or production levels. They range from raw material consumption of between 1 to 80 tons per day of fresh fruit bunches and production levels of 40 to 10,000 litres per day of palm oil (Figure 5).

Figure 5: Distribution of production capacities



The facilities do not have scales to measure the actual tonnage. Experts however estimate the actual capacities as between 3 to 8 tons per day of fresh fruit bunches with an extraction rate of 9–11%.[9] Data presented in Figure 5 are estimates and indicate that APO processing activities in the survey area are carried out at varying capacities. Analysis of the data indicates that almost 60 percent of the facilities are operating at the small-scale level, processing up to 5 tons of palm fruits per day. A remarkable proportion of about 17 percent did not indicate their capacities probably because they do not keep records.

3.2.3 Staff strength

Information gathered from the survey facilities indicates that they operate in clusters and tolling systems. The staff strength is a critical determinant of the production output of the artisanal millers. While the staffing levels for these clusters and facilities (including casual labourers) range from one to 60 persons, they all operate a one-shift system of eight to 12 hours daily and two to seven days in a week. About 78 percent of the facilities employ up to 10 people, while the rest employ between 11 and 60 (Table 5).

Table 5: Overview of staff strength of typical APO facilities

Staff strength	Number of facilities	Percent (%)
1–10	217	77.7
11–20	35	12.5
21–30	14	5.0
31–40	6	2.3
41–60	5	1.7
Above 60	1	0.4
Not indicated	1	0.4

9 Osei-Amponsah C., Agbotse P., Swanzy F. and Stomph T. J. (2018), 'Role of small-scale enterprises in agricultural development agendas: insights from oil palm processing enterprises in the Kwaebibirem District of Ghana', Ghana Journal of Agric. Sci. 52, 131–144.

3.2.4 Types of machinery

Several types of machinery are used at the various stages in the APO milling facilities. Some of the major machinery and the approximate quantities in the facilities surveyed are presented in Table 6.

Table 6: Types of machinery

Machine type (as given by facilities)	Industrial name	Quantity
Expeller machine	Screw press	30
Grinding machine	Mechanical digester	71
Pressing machine	Manual spindle press	126
Combined oil processing machine	Screw press	13
Palm oil digester	Mechanical digester	30
Palm oil milling machine	Manual spindle press	124
Blower	Fibre-nut separator	13
Cooker tanks	Steamer/cooker	32
Pounder machine	Mechanical digester	11
Palm kernel mill	Palm kernel expeller	15
Palm kernel cracker	Palm nut cracker	52
Cake breaker	Fibre-nut separator	20
Boiler	Cookers/steamers	5

The key types of milling machinery the artisanal responders reported using in the palm oil processing are the grinder, expeller, screw and filter press, digester, blower and cooking tanks, while the kernel cracker, mill and cake breaker are used for processing palm kernel. The photographs below show selected examples of presses used at the mills.

Examples of manual spindle presses

Most of the machines are manually operated, but a few are powered by electricity or diesel. Only five facilities use boilers. The other equipment used includes the oven, fibre and nut separator and decanter machine.

Typical example of oil mill/expeller in APO facility (left) A blower machine in an APO facility (right)

Cracker and winnower machines

3.2.5 Raw materials, processing and product types

The main raw material used at these facilities is palm fruit, which is processed into crude palm oil. Additionally, four facilities further process the palm kernel nuts into crude palm kernel oil. Palm fruits are obtained from independent farmers and aggregators. The fruit is kept in the open or under a shed before processing (see photographs below).

Fresh fruit bunches

Loose palm fruits stored under a shed

Processing involves hacking and manual removal of the fresh fruits from the bunches. The palm fruits that are mixed with husks are separated using a locally made sieve (see photographs below).

Sieve for loose fruits and chaff separation

The fruits are cooked in tanks and other locally made cooking pots. Fibre, firewood, used vehicle tyres and bamboo are the main fuel used in the cooking process. The cooked palm fruits are processed using the expeller or a digester and manual screw press to extract the crude oil. The crude oil is then collected in drums to separate the oil from any accompanying slurry. The slurry is further cooked to recover more oil. The recovery of oil from the sludge involves the addition of water and cooking (see photographs below).

Cooking tank (left) and oily sludge being poured into a clarification tank (right)

The oil is stored in jerry cans and barrels of capacities ranging from 25 to 250 litres (see photographs below) and sold locally or exported to neighbouring countries, including Togo, for soap making. In a few cases, 1-ton capacity containers are used.

Jerry cans (left) and barrels (right) for oil storage

The processing of palm fruits into oil meant for consumption follows the same approach. However, the fruits are processed within a day or two, and the oil is further treated to enhance the quality.

3.2.6 Wastes types and management practices

Generated waste exists in both liquid and solid forms. Solid wastes include palm fibre, empty fruit bunches, palm nut (where it is not processed), palm kernel shells (where palm nut is processed), palm kernel cake, ash and sludge, which are normally dumped in the open. Solid generated waste is not quantified; hence, actual volumes generated are not available. Part of the wastes (kernel cake, fibre and kernel shells) is used as fuel for cooking the palm fruits. The palm waste used as fuel represents just a small fraction of the quantities generated. Some of the palm nuts are processed into palm kernel oil on and off-site. The unused portions are dumped around the facility and occasionally burnt to reduce the volumes. This is the normal practice in almost all the facilities surveyed (see photographs below).

Ash dumped at one facility (left), ash dumped at the cooking area (middle) and ash dumped near a stream (right)

The current waste management practice of burning unused palm waste, including palm kernel, generates air emissions, which could have serious implications for the environment, the workplace and public health. It could also be a source of bush fires during the dry season. However, these wastes are a potential resource that could serve the entire energy needs of the facilities if properly harnessed. Also, the waste could be an energy resource for other industries, in the form of electricity generation and processing into briquettes and pellets.

Of particular concern is the disposal of ash generated from the cooking process. This is normally dumped around the cooking area and poses a serious workplace hazard to workers. It was reported in one of the facilities that a male worker mistakenly stepped into smouldering ash and was badly injured.

Liquid waste is mainly generated from residual cook water and slurry and sludge from the production and other processing activities such as cleaning of the cooking systems and processing equipment. These are discharged without treatment into the environment (see photographs below). This practice could have a

Solid waste from palm bunch (left) and slurry discharged into a wetland (right)

detrimental effect on waterbodies and human health, particularly in areas where the communities depend on streams for their water needs. Moreover, the fact that most facilities are located close to wetlands coupled with their waste management practices poses a serious threat to the ecosystem.

3.2.7 Fuel type, fuel uses and storage

Biomass is the source of fuel for cooking activities in all the facilities surveyed. These are generated as by-products from production activities and are mostly not quantified. They are dumped at the periphery of the production area and collected for use when required. In some of the facilities, other biomass types such as firewood (see photographs at bottom of page), bamboo, raffia plant and used tyres are added to the fuel to improve combustion. It should be noted that the biomass types are not used in isolation but are normally combined. Table 7 provides the fuel types and the number of facilities using them as revealed by the data gathered.

Table 7: Types of fuels used in the APO facilities

Fuel type	Process stage used	Number of facilities
Fibre	Cooking	96
Fibre cake	Cooking	103
Firewood	Cooking	86
Palm nuts	Cooking	10
Palm kernel shells	Cooking	15
Empty fruit bunches	Cooking	58
Palm branches	Cooking	12
Spikes	Cooking	7
Tyres	Cooking	1
Raffia plant	Cooking	2
Diesel	Milling and extraction processes	71
Petrol	Milling and extraction processes	3

The use of vehicle tyres for cooking in one of the facilities is not a desirable practice due to its negative implications, especially on human health and the environment. The practice could be discouraged if the use of other biomass types is optimized. Palm kernel shells are known to have high calorific value and could replace the use of the vehicle tyres. The shells could also be a major source of fuel for some industrial processes.

Firewood for use as fuel (left) and fibre from blowers (right)

Other energy sources include electricity, diesel, petrol, engine oil, dirty oil and grease, which are used in the milling and oil extraction operations. The petrochemicals are purchased in small quantities on demand in gallons using motorbikes. Electricity is obtained from the national grid.

3.2.8 Cooking systems

Cooking systems used by these facilities are mainly the traditional metal cooking pots and steel tanks.

These are loaded with the loose fruits and set on the traditional cooking stove using an open fire. Most respondents acknowledged that this cooking system is inefficient. The facilities indicated that the cooking operation is optimized using more fuel and large volumes of water. The pots are covered during cooking, and regular attention is given to the fire to ensure the flames are sustained. The biomass is dried before use to facilitate combustion. However, the cooking pots and tanks are covered with fabric, which is intended for steam retention in the tanks. This is, however, not achieved as the fabric is unable to prevent the steam from escaping because the tanks are open. The cooking operation, which is optimized by the use of more fuel, is not best practice and could be improved. Improvement measures may include the use of more efficient pots and improved stoves (see photographs below).

Cooking tank (left), cooking pot (middle) and traditional tripod and cooker (right)

3.2.9 Sources of water

Water is one of the input materials and is mainly used for the cooking and sterilization process and cleaning. Water used by the facilities is mostly from boreholes (community boreholes and individual ones, some of which are mechanized), wells, pipe-borne water from Ghana Water Company Limited, streams, rivers and ponds (see photographs below). The water is largely untreated except in a few facilities that add alum before use.

Standpipe (left) and well (right)

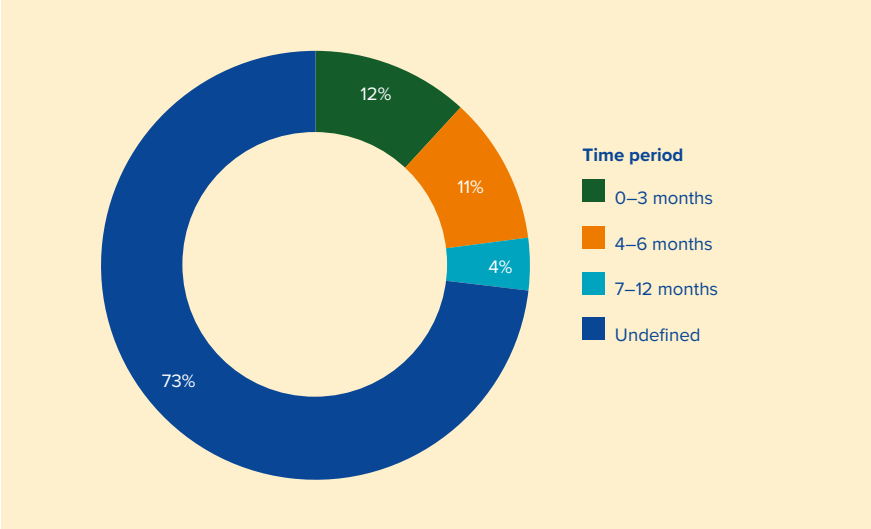
3.2.10 Maintenance activities

Repairs and maintenance carried out on machinery relate to the following:

- Broken down cake breaker
- Leakage of cooking and clarification pots and tanks
- Breakage of the cooking stove
- Replacement of damaged boiling pans
- Repair of oil expeller, i.e. pulley, miller (auger), bearings
- Oil change
- Repairs and maintenance of cooking tanks. The oil mill digester machine has components such as a belt, motor, engine, shaft, bearings, etc.
- Fan belt, bolts and nuts, nozzle and totting of miller are replaced regularly

Though these systems do not undergo any statutory inspection or maintenance, maintenance is done on the machinery to ensure efficiency and reduce interruptions in their operations. The frequency of maintenance conducted by the facilities is presented in Figure 6.

Figure 6: Frequency of maintenance



Of the 279 facilities surveyed, 11.8 percent have a maintenance frequency of 1–3 months, 11.1 percent within 3–6 months, 3.9 percent within 6–12 months and 73 percent did not indicate the frequency of their scheduled maintenance (Figure 6).

3.2.11 Cost of maintenance

The cost of maintenance ranges from GH¢ 100–23,000, depending on the part being serviced. Table 8 gives the breakdown of the cost of maintenance in the 279 facilities surveyed.

Table 8: Range of cost of maintenance

Cost of maintenance (GH¢)	Cost of maintenance ($)[10]	Number of facilities
100–1,000	17.06–170.62	181
1,001–3,000	170.79–511.86	66
3,001–5000	512.03–853.09	13
5,001–10,000	853.26–1,706.19	8
Above 10,000	Above 1,706.19	7
Undefined		4

The results also showed that 64.8 percent of the facilities spend between GH¢ 100–1,000 on maintenance, while 23.6 percent spend between GH¢ 1,001–3,000, 4.7 percent spend GH¢ 3,001–5,000, 2.9 percent spend GH¢ 5,001–10,000, 2.5 percent spend above GH¢ 10,000 and 1.4 percent did not define the cost of maintenance. Maintenance cost, which ranges between GH¢ 100 and 3,000 for the majority of facilities, is geared towards fixing the cooking systems and machinery for grinding and extraction. Most of the facilities do not have a scheduled maintenance regime, which results in frequent breakdowns leading to the increased operations cost.

3.2.12 Pollution, health and environmental impact, and control measures

Pollutants from these facilities include smoke, particulate emissions, heat, noise and steam or vapour. All the facilities admitted these pollutants affect their health and the environment as well as contribute to climate change. Health effects on the workers include difficulty in breathing, especially for asthmatic patients, eye irritation, impaired vision from smoke, skin irritation and burns, respiratory and lung infections, and hearing difficulties due to noise. There are no pollution control systems in these facilities to control these releases, and the level of air emissions have not been measured to assess the impact on their health and the environment. The respondents, however, admitted the emissions have environmental and health effects, which eventually affect the facilities' finances. Exposure to smoke and heat from fires and steam in the cooking activities is a major occupational hazard and could harm workers' health.

10 Exchange rate US$ 1 = GH¢ 5.86 (as at September 2020).

3.2.13 Improvement options

Table 9 lists the improvement options the facilities reported in the survey. About 61 percent (169) of the facilities surveyed indicated the need for an upgrade of their processing machinery and operations, including proper drying of biomass before use.

Table 9: List of steam production machinery improvement options

Improvement option	Number of facilities
Upgrade only	32
Refurbishment only	6
Replacement only	27
New installation only	37
Upgrade and refurbishment	2
Upgrade and replacement	23
Upgrade and new installation	41
Refurbishment and replacement	4
Refurbishment and new installation	2
Replacement and new installation	22
Upgrade, refurbishment and replacement	2
Upgrade, refurbishment and new installation	3
Upgrade, replacement and new installation	8
Upgrade, refurbishment, replacement and new installation	58
Not indicated	12

Among the surveyed facilities, 12 percent (32) of the facilities indicated their preference to upgrade only while the remaining 81 percent preferred a combination of improvement options including refurbishment, replacement and new installation in addition to upgrading.

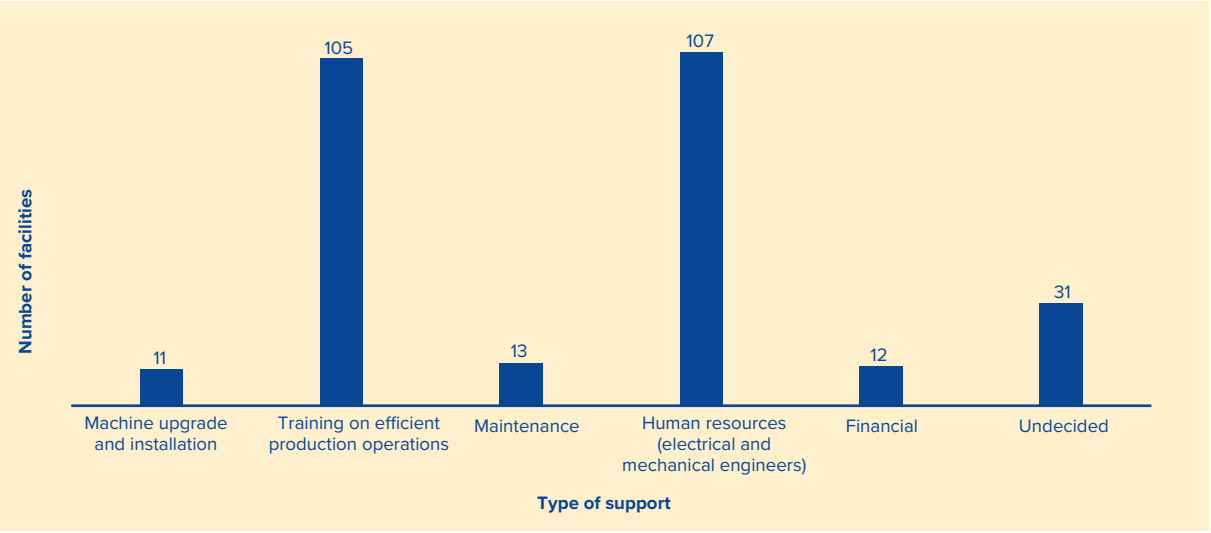
In the same vein, 61 percent (171) of the facilities opted for new installations such as the installation of boilers, efficient cooking systems, modern cooking and clarification tanks, stoves and installation of chimneys. Out of this number, 21.6 percent proposed to install new equipment and machinery while the remaining (78.4 percent) opted for a combination of the other improvement options.

Furthermore, 52 percent (144 facilities) expressed interest in replacing worn out parts, inefficient and malfunctioning machinery and equipment. Among these 144 facilities, 18.8 percent (27) are interested in a replacement only. An estimated 28 percent (77) of the facilities desire to refurbish their equipment and machinery. About 20.1 percent of the facilities surveyed indicated the need for all the improvement options – upgrade, refurbishment, replacement and new installation – while 4.3 percent did not indicate any improvement option.

3.2.14 Technical and financial support

Most of the facilities expressed their desire to install improved cooking systems that will reduce emissions and associated health effects. Proposed support is listed in Figure 7.

Figure 7: Required technical support



About 43.1 percent of the facilities require engineering support for installation, operations and servicing and maintenance of machinery and equipment. Specifically, the facilities require the services of electrical and mechanical engineers to facilitate improvement in operations. About 38 percent of the facilities require technical training for their staff to improve operational performance, and 11.1 percent were undecided or did not indicate the type of support they require, while 4.3 percent of the facilities indicated the need for financial support to implement the improvement options identified. The cost of implementation of the improvement options identified was estimated between GH¢ 2,000–2,000,000 ($ 341.20–341,237). Table 10 presents the distribution of improvement costs among the surveyed facilities.

Table 10: Range of improvements costs

Cost of upgrade (GH¢)	Cost of upgrade ($)	Number of facilities	Percent (%)
2,000–10,000	341.24–1,706.19	166	59.5
10,001–30,000	1,706.36–5,118.56	66	23.7
30,001–50,000	5,118.73–8,530.94	15	5.4
50,001–100,000	8,531.11–17,061.88	12	4.3
100,001–300,000	17,062.05–51,185.63	10	3.6
300,001–2,000,000	51,185.80–341,237.53	1	0.4
Undecided		9	2.2

3.2.14.1 Source of funding

The source of funding for the improvement options identified from the survey and the breakdown is presented in Table 11.

Table 11: Source of funding

Source	Number of facilities	Percent (%)
Self-finance	14	5.0
Bank	208	74.5
Non-governmental organizations	18	6.5
Government funding	11	3.9
International support	6	2.2
Undecided	22	7.9

Only 5 percent of the facilities are in the position to self-finance the implementation of the improvement options. The majority of them (74.5 percent) stated that they require funding from banks to finance the proposed improvement options. A few (3.9 percent) of the facilities expect the government to provide the funding they require while 2.2 percent anticipate support from international sources.

4 Chapter Four:

KEY ISSUES, RECOMMENDATIONS AND CONCLUSIONS

4.1 Highlight of key issues from the inventory

4.1.1 Identified issues in the formal food and beverage industry

- Four companies reported steam losses between 10 and 20 percent, which can be improved. Areas of steam losses are faulty steam traps, damaged steam tracers, leaking steam coils, steam pipe leakage, weak steam pipes, steam valves, pipelines not lagged or cladded, leaking joints in overhead leaking pipes, process lines, etc.
- Ten companies using biomass and 13 using RFO and other low-quality fuels such as a blend of waste oil and diesel are more likely to generate emissions if the appropriate pollution control systems are not installed. Twelve companies use cleaner fuels: nine are using diesel, three are using LPG.
- Partial adherence to appropriate health, safety and environmental practices, e.g., spillages from handling of fuel lead to poor housekeeping and the associated environmental and workplace health hazards.
- Use of old boilers and technology can result in inefficiencies, high emissions and industrial accidents.
- Lack of treatment of boiler feedwater may result in scaling and thus reduce the efficiency of the boiler.
- No system is in place to measure or monitor boiler efficiency (regular monitoring is key to determine the combustion efficiency of the boilers).
- Only six out of the 30 companies surveyed are using dual-fuel boilers, which are all using the fire tube technology.
- Storage of biomass in the open during the wet season is an issue that needs attention to reduce the absorption of moisture. Companies using high moisture biomass may generate high levels of pollution.

4.1.2 Key issues identified in the artisanal palm oil facilities

- The survey revealed that most of the workers are women who work for long hours and are exposed to work-related illnesses and hazards such as heat, emissions and stress. These workers have minimal or no formal training in the activities of the sector nor in the required environmental, occupational health and safety standards.
- The technologies employed in the production operations (milling method, low-level mechanization) are outdated, leading to a low oil extraction rate and increase in waste generation.
- The cooking systems, especially the traditional tripod stoves, the cooking tanks and pots and fuel use practices are inefficient and result in heat losses into the working environment and contribute to work-related illness and hazards, air emissions and GHG emissions and endanger public health.
- The dumping and burning of wastes result in emissions that affect the climate and public health.
- Discharge of wastewater (palm oil mill effluent) from the production operations could have a detrimental effect on waterbodies.
- Limited expertise in operational activities, including plant maintenance, leads to low productivity and high operational cost.

- Due to the low quality of the oil produced by these facilities and the addition of Sudan IV dye by some facilities, they are unable to sell at the world market price.
- Lack of proper documentation and record-keeping resulted in gaps in the information provided by the facilities, leading to significant discrepancies when compared to known industry data.
- Limited information on sources of and access to funding.
- Poorly scheduled maintenance regimes increase the frequency of breakdown.
- Lack of guidelines and procedures for managing the sector.
- Lack of equipment (scales) and capacity to measure quantities of raw materials and product.

4.2 Recommendations

4.2.1 Recommendations for the formal sector

Policy

- Develop a training and certification programme for boiler attendants and operators.

Technical

- Develop and implement a system to measure and monitor boiler efficiency. Regular monitoring and maintenance of the identified source of the losses will reduce steam loss and improve the overall steam management and minimize air pollution and GHG emissions from company operations.
- Ensure companies using RFO and low-quality fuel pretreat fuel to improve upon the quality before use or purchase of high-quality fuel to reduce air emissions.
- Ensure companies using biomass institute measures to reduce exposure of the fuel to moisture, especially during the wet season.
- Treat boiler feedwater before use to improve the boiler's performance.
- Develop a replacement plan to procure new efficient boilers, preferably dual-fuel boilers.
- Consider fuel switch from RFO to LPG or biomass, especially in those facilities that generate biomass as waste.
- Promote the need for condensate recovery for reuse to reduce freshwater use.
- Conduct an annual energy audit on boilers.

Environment and occupational health and safety

- Install the appropriate end-of-pipe systems to reduce and control emissions to meet set standards.
- Create awareness on operation and maintenance of boilers to improve performance and improve on health, safety and environmental practices.

4.2.2 Recommendations for the artisanal palm oil facilities

For the informal sector, the project may assist in the following to improve the facilities' operational performance:

Policy

- Developing guidelines for managing the sector's operations.
- Developing policy on standards for quality and packaging of the product.

Cross cutting

- Providing access to improved and efficient cookstoves, cooking systems and technologies.
- Ensuring stakeholder consultation and involvement in any support to the sector.
- Collaborating with relevant institutions such as the IIR and GRATIS Foundation to design and fabricate improved and efficient cooking and milling equipment.
- Providing logistic, financial and technical support to strengthen the work of APOMOAG.

Technical

- Promoting the development of a scheduled maintenance regime.
- Training of workers in best practices in palm oil processing including resource use efficiency, pollution control and waste management, equipment setting and maintenance documentation and record-keeping, sources of funds and how to access them.
- Exploring the feasibility of installing communal boilers for clusters of APO processing.
- Exploring the feasibility of collecting process wastewater (palm oil mill effluent) to generate additional energy.
- Retooling of the sector in terms of equipment to improve productivity.
- Considering piloting best practices in selected facilities to serve as a demonstration to drive uptake.
- Developing a structured system to implement technical support.

Economic

- Providing information on sources and access to funding.
- Providing a flexible interest and repayment system for any financial mechanism for the sector.
- Engaging the banks on the possibility of providing loan schemes to improve the performance and productivity of the APO processors to reduce pollution and GHG emissions.
- Developing a structured system to implement financial support.
- Providing financial support to strengthen the work of APOMOAG.

Environment and occupational health and safety

- Training workers on best practices to reduce work-related illnesses and hazards.
- Developing an environmental management system to monitor the operation of APO facilities.

4.3 Conclusions

The boiler inventory conducted in the FAB industries in Accra-Tema and palm oil processing facilities in the Eastern Region sought to assess the performance of industrial boilers in the FAB and APO processing industries and identify improvement options. The assessment revealed that there is room for improvement in boiler performance and cooking systems in the two areas considered. The implementation of all the recommendations identified for the two sectors will greatly contribute to improving operational efficiency and reducing GHG emissions.

Key improvements

Retooling

- Install a heat exchanger as an improved version of the cookstoves or small biomass steam boilers (1-ton capacity).
- Move from the use of the spindle press to mechanized screw presses.
- Use measuring tools for weighing and quantifying raw materials and products and testing quality of products.

Capacity-building

- Training of the workers in best practices in palm oil processing including resource use efficiency, pollution control and waste management, equipment setting and maintenance, documentation, management skills and record-keeping, housekeeping, sources of funds and how to access them.
- Sensitization on the need for regular maintenance.
- Develop best management practices in APO processing sector.

Flexible financial scheme

- Concessional loan facility
- Matching fund model
- Zero interest loans

Annexes

ANNEX 1: QUESTIONNAIRE FOR FOOD AND BEVERAGE INDUSTRIES

Environmental Protection Agency

Industrial boiler inventory form for the formal sector

Preamble

The Environmental Protection Agency is implementing a boiler efficiency project in collaboration with the United Nations Development Programme. This questionnaire is to take inventory of boilers used and identify challenges with the operation of boilers. Outcome of the inventory will serve as input for the improvement of boiler efficiency, reduce greenhouse gas emissions as well as inform the design of the technical and financial package for the project. The information provided in this form will be protected, and confidentiality of information will be kept.

Section A: Company information		
Name and address of company		
Name		
Address for correspondence		
Location:		
Town		
District		
Region		
Digital address		
Email address of company		
Contact person's details:		
Name		
Telephone number		
Email		
Capacity (plant and staff):		
Production/plant capacity	**Operating capacity:**	**Installed capacity:**
Staff strength		

No. of working days	
Working hours per day	
No. of shifts	
No. of boilers	
List of major machinery connected to the boiler use	

Section B: Production information

	Type	Average quantity per month
Raw materials used		
Products		
Wastes generated		
By-products		

Section C: Management practices

Source(s) of waste	
Discuss how waste is managed	

Section D: Boiler information (complete for each boiler)

	Boiler 1	Boiler 2	Boiler 3
Type of boiler			
Make and model			
Capacity (tons)			
Combustion efficiency			

Thermal efficiency			
Operating pressure (bars)			
Year of manufacture			
Hours of operation per month			

Fuel use:

Single			
Dual			
Type of fuel			
Fuel treatment prior to use (e.g. fuel blending, dewatering)			
Average steam production (tons/hr)			
Boiler stack temperature (°C)			
Use(s) of steam			
Condition of boiler*			

* State any defects materially affecting the maximum permissible working pressure.

Section E: Fuel options

	Source	Quantity	Cost (GH₵)	Mode of transportation	Storage practices
Other potential fuel(s) for use					

Section F: Water

Source of boiler feed water	
Type of treatment	
Boiler feed water consumption (m^3/month)	
Boiler make up water (m^3/month)	
Feed water tank capacity	
Feed water deaerators	
Condensate return (%)	

Section G: Steam pipe/lines

Total length of steam pipes/lines	
Percentage of pipe lagged	
Type of lagging material	
Nature of lagging	

Section H: Management and maintenance

Boiler blowdown operations:

Process/procedure	
Frequency	
Discuss how boiler operation is optimized	
% of steam loss	
Possible areas of steam losses	
Frequency of maintenance (as per manufacturer's requirement)	
Frequency of maintenance (as being practiced)	
Components frequently maintained	
Cost of maintenance	
Frequency of statutory inspection	
Recommendations from statutory inspection	
Name(s) of additive(s) to fuel (if any)	
Sources of additives	
Quantities used	
Purpose of addition of fuel additive	

Section I: Emissions

Is there a filter or pollution control system installed on the boiler?	
If yes, indicate the name and discuss its operation	
Type of pollutants emitted from the boiler stack	
Maximum emission levels from the last two times of emission monitoring	

Section J: Improvement

Plans for improvement	Upgrade*	Refurbishment**	Replacement***	New installation****
Details of improvement/ replacement				
Estimated cost				
Proposed source of funding				
Proposed date for upgrade/ refurbishment				
Type of technical support required				

* Increase capacity while improving efficiency of an existing boiler.
** Retooling/overhaul/parts replacement/redesign/repairs for efficiency improvement.
*** Change an existing boiler or replacement/installation of a boiler.
**** Acquisition or installation of new systems.

Thank you for the completion of the questionnaire!

ANNEX 2: QUESTIONNAIRE FOR ARTISANAL PALM OIL FACILITIES

Environmental Protection Agency

Industrial boiler and cooker inventory form for the informal sector

Preamble

The Environmental Protection Agency is implementing a boiler efficiency project in collaboration with the United Nations Development Programme. This questionnaire is to take inventory of boilers and cookers used and will also identify challenges with the operation of boilers and cookers. Outcome of the inventory will serve as input for the improvement of boiler and cooker efficiency, reduce greenhouse gas emissions as well as inform the design of the technical and financial package for the project. The information provided in this form will be protected, and confidentiality of information will be kept.

Section A: Company information

Name and address cooperative/group:	
Name	
Address for correspondence	
Name of owner	
Telephone number	
Email address	
Location:	
Town	
District	
Region	
Digital address	
Email address	
Contact person's details:	
Name of contact person	
Telephone number	
Email	
Capacity (plant and staff):	
Plant capacity	
Staff strength	
No. of working days	

Working hours per day	
No. of shifts	
List of major machinery connected to the boiler use	

Section B: Production information

	Type	Average quantity per month
Raw materials used		
Products		
Wastes generated		
By-products		

Section C: Waste management practices

Source(s) of waste	
Discuss how waste is managed	

Section D: Energy information

	1	2	3
System(s) for cooking			
Volume of cooker (tons)			
Efficiency of the system			
Hours of operation			

Section E: Fuel

	Source	Quantity	Cost	Mode of transportation	Storage
Type(s) of fuel used					
Other potential fuel(s)					

Section F: Water

Source of cooker feed water	
Type of treatment	
Cooker feed water consumption (m^3/month)	
Cooker make up water (m^3/month)	
Feed water tank capacity	

Section G: Management and maintenance

Discuss how cooking operation is optimized	
Nature of maintenance including specific components frequently maintained	
Cost of maintenance	
Frequency of statutory inspection	
Recommendations from statutory inspection	

Section H: Emissions

Type of pollutants emitted from the cooking operations	
Measures to minimize emissions	
Effect of emission on workers and the environment	

Section I: Improvement

Plans for improvement	Upgrade*	Refurbishment**	Replacement***	New installation****
Details of improvement				
Estimated cost				
Proposed source of funding				
Proposed date for improvement				
Type of technical support required				

* Increase capacity while improving efficiency of an existing cooking system.
** Retooling/overhaul/parts replacement/redesign/repairs for efficiency improvement.
*** Change an existing cooking system or replacement/installation of a boiler.
**** Acquisition or installation of new systems.

Thank you for the completion of the questionnaire!

ANNEX 3: LIST OF FOOD AND BEVERAGE COMPANIES

No	Company	Location
1	3F Ghana Limited	Tema
2	Accra Breweries Limited	Accra
3	Afrotropic Cocoa Processing Limited	Spintex Road
4	Aquafresh Limited	Spintex Road
5	Avnash Industries Ghana Limited	Tema
6	Barry Callebaut Ghana Limited	Tema
7	Bunge Loders Croklaan Industries Limited	Tema
8	Cargill Ghana Limited	Tema
9	Chocomac Ghana Limited	Tema
10	Coca Cola Company of Ghana Limited	Spintex Road
11	Conserveria Africana Ghana Limited	Tema
12	Cosmo Seafoods Company Limited	Tema
13	Cocoa Processing Company	Tema
14	Dada Food Company Limited	Tema
16	DU Fresh Company Limited	Spintex Road
17	Emigoh Ghana Limited	Pantang
19	Fan Milk Ghana Limited	Accra
21	Food Processors International Ghana Limited	Tema
22	Ghana Specialty Fats Limited	Tema
23	GIHOC Distilleries Limited	Accra
24	Guinness Ghana Breweries Limited	Accra
25	HealthiLife Ghana Limited	Spintex Road
26	Ignis Industries Limited	Tema
27	Kasapreko Company Limited	Spintex Road
28	Multipac Limited	Tema
29	Nestle Ghana Limited	Tema
30	Niche Cocoa Industry Limited	Tema

No	Company	Location
31	Niche Confectionery	Tema
32	Nurevas Food Ghana Limited	Spintex Road
34	Nutrifoods Ghana Limited-Tomato Factory	Tema
35	Pioneer Food Cannery	Tema
36	Praise Exports Service Limited	Pokuase
38	Raanan Fishfeed West Africa Limited	Tema
39	Royal Sweets Limited	Accra
41	SBC Beverages Ghana Limited	Accra
42	SKD Monarch Limited	Tema
43	Usibras Ghana Limited	Tema
44	Wilmar Africa Limited	Tema
45	Special Ice Company Limited	Oyarifa
46	Nkulenu Industries Limited	Madina
47	Cocoa Touton Processing Company Limited	Tema
48	McBells Distilleries Limited	Accra
49	Promasidor Ghana Limited	Accra
50	Equator Foods Ghana Ltd	Spintex Road

ANNEX 4: LIST OF ARTISANAL PALM OIL FACILITIES

No	Name of company	Location
1	Alfus Ghana Limited	Kusi
2	Okanta Noah Farms	Nkwateng
3	Alex Aboagye	Chia
4	Afrifa George Dompreh	Anyinase
5	Kwasi Antwi	Adwafo
6	Emmanuel K. Agoha	Chia
7	Kwame Kyere	Kofi Anto
8	Diana Anotria	Yaw Nkrah
9	Janet Prah	Akim Ofoase
10	Esi Nana	Odumase
11	Towoboase	Towoboase
12	Enso Nyame Y3 Oil Mill	Nkwarteng, near Centre
13	Jacob Sakyi Oil Mill	Nkwarteng, near Mamanmu River
14	God is My Judge Oil Mill	Dudiase
15	Nhyira Processing Machinery	Ntronany, close to Dodowaso
16	Amanie Ankrah Oil Milling	Dodowaruso
17	Duah Eric Oil Processing	Dodowurso
18	Akosu Soghe Oil Processing	Zongo Ntronang
19	Abigail Enterprise	Akoase
20	Nyame Adom Oil Palm Company	Akoase
21	Opoku Akobrah Enterprise	Akoase
22	Eric Nyarko Oil Milling	Akoase
23	Nyame Akwan Oil Mill	Mamanso, near MTN mast
24	Nyame ne Boafo Oil Mill	Mamanso Zongo
25	Jevi Avornyo Oil Processing	Akrofonso-Nkrankwam
26	Ayendenabu Nicolas Oil Processing	Old Abirem
27	Halidu Madina Oil Processing	Old Abirem
28	Fati Abdul Rahman Oil Milling	Nkwateng, near Centre

No	Name of company	Location
29	Atsu Avornyo Oil Mill	Akrofonso Ayigbe Town
30	J. O. Mensah Enterprise	Akoase
31	Adjei Enterprise	Mamanso
32	Parade Emmanuel Oil Mill	Nkwarteng
33	Kwame Asamoah Oil Processing	New Abirem
34	Asiedu Enterprise	Dodoworaso
35	Ali Mohammed Oil Mill	Nyafoman
36	Patience Akutey	Afosu
37	Patience Sarfoa Oil Processing	Nkwarteng
38	Nyame Tease Oil Mill	Ntronang, Mentukwa
39	Kumi Emma Oil Mill	Nkwarteng
40	Margaret Asumah	Obia Bedneja
41	Kate Asumang Oil Processing	Old Abirem
42	Lubepu Ventures	Hweakwai
43	Patience Adjarko Oil Mill	Akoase
44	Geetily Field Works	Akronfonso
45	Nyame Na Ay3 Oil Milling	Ntronang, Dadease
46	Anthony Andoh Oil Processing	Adwafo, Techiman
47	Nyame Beye Processing Mill	Adausena
48	Akoragyim Enterprise	Adausena
49	Teye Noah Oil Mill	New Abirem
50	Teye Koodi Oil Mill	New Abirem
51	Onyame Adomarakwa	Kusi
52	Geshon Crammer	Akim-Takorase
53	Peace Crammer	Akim-Takorase
54	Yehowa Adom Crammer	Akim-Suabe
55	KOBBOA Farms	Akim-Wenchi
56	Mr. Isaac Akomaning	Akim-Wenchi
57	Saved By Grace Enterprise	Wenchi

No	Name of company	Location
58	GT Investment	Akim-Kusi
59	Subinsa Oil Mill	Akim-Takorase
60	Seth Amuzu Agbozo	Adu gyem
61	Appiah Veronica	Akyemanso
62	Asomaning Christiana	Akyem Adubease
63	True Love Ent. (Nana Appiah)	Adiwafo
64	Elizabeth Boafo	Akyemanso
65	Boateng Joseph	Kofi Nimo
66	Emmanuel Amoako Yaw	Besease
67	Zariatu Alhassan	Ayirebi
68	Michael Kofi Kwakye	Akyemansa
69	Yaw Boakye	Ayirebi
70	Robert Arhin	Kyiri Mankani
71	Baah Moses	Akye-krom
72	Kwame Sefa	Akokoaso
73	Awudu Dawuda Yaw	Adwafo
74	Robert Nkrumah	Odumase
75	Samuel Amankwah	Otwereso
76	Christiana Boatemaa	Adwafo
77	Alfred Ampong Gyesei	Aduafo
78	Frimpong Emmanuel	Ayirebi
79	Kofi Asare	Adwoafo
80	Kwabena Appiah	Akokuaso
81	Nartey Jonathan	Sukurang
82	Opare Desmond Samuel	Mukijia
83	SendRich Oil Mill	Offoase-Depo
84	Joseph Kugbor	Paawudu
85	Joseph Bolahene Amponsah	Ayirebi Halfassini
86	Faustina Baah	Akim Ayirebi

No	Name of company	Location
87	Alex Gyimah	Adwafo
88	Kwame Sefa	Akokoaso
89	Amma Gyankomaa	Ayirebi
90	Asaboro Richard	Ayirebi
91	Kwame Sefa	Akokoaso
92	Hon. George Tettey Addison	Mukyia
93	Quayson Isaac	Otabil
94	Teye Angmortey	Munkyia
95	Akyerem Foster	Abenase
96	Gifty Amoh	Akokoaso
97	Kwaku Nkrumah	Akokoaso
98	Emmanuel Bonsu	Boso Villa
99	Margaret Autwumwaa	Adwafo
100	Hlordzi Mensah	Ofoase-Kuma
101	Beatrice Tackie	Ayirebi
102	Akotey William	Boso villa
103	Nyame Bekyere Crammer	Akim-Abaam
104	Armah Crammer	Akim-Asuom Amanfrom
105	Kwasi Bempah Crammer	Akim-Asikam
106	David Oil Mill	Kwae (Miracle top)
107	Autie Donkor Oil Mill	Akim Subi
108	Diana Anotria	Yaw Nkrah
109	Hajia Krama	Akim Wenchi
110	Muta Nakilu Salifu Oil Processing	Nkwateng, Near Center
111	Collins Kesse Oil Processing	Akatashie (Afosu)
112	Francis Ofosu Oil Processing	Old Abirem
113	Fasmo Ventures	Akokoeso
114	Martha Afful Oil Mills	Ofoase
115	Christian Dutror Oil Processing	Ngyafoman adjacent Awo Afi Pipe Ano

No	Name of company	Location
116	Ama Kissiwa oil processing	Afosu
117	Yankofa Oil Processing Enterprise	Akweitey
118	Nyame Ne Hene	New Abirem
119	Esi Nana Oil Processing	Afosu
120	Eda Wo Anim Oil Mill	Nkwarteng
121	Peokli Sonhwe Oil Processing	Old Abirem
122	Gbalepkor Kwame Oil Processing	Old Abirem
123	Anthony Mensah Oil Mills	Ofoase
124	Yakubu A. Rahman Oil Processing	Old Abirem
125	Kwabena Danso Oil Mill	Asuabena
126	Boadu Trading Enterprise	Akim Chia, Zongo
127	Agya Osei Oil Processing Enterprise	Nkwarteng, Along Major Road to Abirem
128	Tulianu Nurkuor Company Limited	New Abirem After the Hospital, Close to the River
129	Glory Be to God Enterprise	Afosu near Cocoa Research Inst. of Gh.
130	Otoo Enterprise	New Abirem
131	Faustina Korang	Akrofonso
132	Asomaning Boadu Oil Mill	Akim Afosu, Old Zongo
133	Felicia Amoakoa Oil Mill	Afosu
134	Medimafo Tease Oil Mill	James Town (Abenaso)
135	Emmanuel Ofosu Oil Processing	Oil Abirem
136	Wona Kyim (Elder James) Oil Mill	Birim North District
137	Kofi Frimpong Oil Milling	Hweakwaw
138	Ansah K.T Benjamin Oil Processing	Old Abirem
139	Goka Daniel	Hweakwae
140	Sulley Seidu Oil Processing	Old Abirem
141	Solomon Boadu Oil Mill	Hweakwae, Beposo
142	Peter Yeboah Oil Processing	Old Abirem
143	Asomdwe Hia Oil Milling	Afosu
144	CMA Association Oil Processing Enterprise	Tweapease, behind the Roman School

No	Name of company	Location
145	Joe Cremer Company Limited	Tweapease, Kwaebibrem District
146	Wenchi Gate Cremer Limited	Kordadwin, Denkyembour District
147	K.O Oil Mill	Akim Abaam, Kwaebibirem District
148	Atteh Oil Mill Company	Akim Subi, Kwaebibirem District
149	Hannah Cremer Limited	Bontediase-Abaam, Kwaebibrem District
150	Mr. Essel Oil Mill Company	Abenasu, Kwaebibirem District
151	Mr. Awusi Oil Mills	Kade, Kwaebiberim District
152	Hwe Nea Awurade Ay3 Limited	Asuom, Kwaebibirem District
153	Onyame Tease	Akim Asoum, Kwaebibirem District
154	Appiah Joseph Krama	James Town, Kwaebibirem District
155	Agya Kwam Oil Mill Limited	Otumi, Kwaebibirem District
156	Kwame Botwe Limited	Subi, Kwaebibirem District
157	Yaw Asumeng Oil Mill	Subi, Kwaebibirem District
158	Amoa Kwo	Damang, Kwaebibirem District
159	Agyei Krama	Aweam Nkwanta, Kwaebibirem District
160	Alhaji Majid Ooil Mill Limited	Nkwantanang
161	Odo Kuo Oil Mill Co. Ltd	Ayem Nkwantanang, Kwaebibirem District
162	David BA Krama	James Town, Kwaebibirem District
163	Emmanuel Aburam Krama	James Town, Kwaebibirem District
164	Nyame Na Aye	James Town, Kwaebibirem District
165	Kwasi Boso Krama	Akyem Tachiman, Kwaebibirem District
166	Emmanuel Incoom Krama	Kwae, Kwaebibirem District
167	Nicholas Oil Mill Company	Akim Abenaso, Kwaebibirem District
168	Nhyira Mma Oil Mill Company	Otumi-Asikam, Kwaebibirem District
169	Ato Kwamena Budu Amoako (Budu Consult)	Akyem Abodom, Kwaebibirem District
170	Joe Farms Enterprise	Pramkese, Kwaebibirem District
171	D-Drinks Company Limited	James Town, Kwaebibirem District
172	Kingsley Kofi Agyei Oil Mills	Kade, Kwaebiberim District
173	Koms Logistics Company Limited	Nkwantanang, Kwaebibirem District

No	Name of company	Location
174	Quality Oil Mill	Kade, Kwaebiberim District
175	John Adu Gyamfi	Akim Asoum, Kwaebibirem District
176	Tetteh Ignatius	Akim Bomso, Kwaebibirem District
177	Janet Ayim	Akim Asoum, Kwaebibirem District
178	Rose Okyere Krama	James Town, Kwaebibirem District
179	Rosemond Krama	Otumi-Asikam, Kwaebibirem District
180	Kwabena Ankaa Farms	Abompe, Kwaebibirem District
181	Nyamebekyere Krama	Nkwantanang, Kwaebibirem District
182	Constance Krama	Akim-Subi, Kwaebibirem District
183	Yehowah Berhwe Krama	James Town, Kwaebibirem District
184	Bendam Company Limited	Nkwantanang, Kwaebibirem District
185	Adu Cremer Company Limited	Odrokrom, Kwaebibirem District
186	Alhaji Cremer Company Limited	Nkwantanang, Kwaebibirem District
187	Light Cremer Company Limited	Abekrum, Kwaebibirem District
188	Fresh Oil Palm Company	Kade-Daman, Kwaebibirem District
189	Bisa Yeboah Krama	Subi, Kwaebibirem District
190	Richard Kofi Adzibolo	Akim-Kusi, Denkyembour District
191	J.B Morgan Mills	Takorasi (new site), Denkyembour District
192	Kofi Oduro Krama	Akim Wenchi (new site), Denkyembour District
193	Kofi Owusu Krama	Akim Wenchi, Denkyembour District
194	Abenavi Krama	Akim-Kusi, Denkyembour District
195	Adugu Krama	Akim Takorase, Denkyembour District
196	Richard Krama	Akim Takorase, Denkyembour District
197	Ebenezer Oil Mill	Akyem Suabe, Dekyembour District
198	Grace Pomaah Krama	Akim Wenchi, Denkyembour District
199	Akporhor Lawson (Aunty Donkor)	Takorasi Zongo, Denkyembour District
200	Maame Krobo	Towoboase, Denkyembour District
201	Mantse Corn Mill	Mamanso, Birim North District
202	Victor Okob	Okaikrom, Birim North District
203	M.S.O. Oil Processing Enterprise	Mamanso- Zongo, Birim North

No	Name of company	Location
204	Kwame Sakyi Oil Mill	Mamanso, Birim North District
205	Ama Nyarkoa Oil Mill Processing Enterprise	Mamanso, Birim North District
206	Doris Ofosua Asiamah Oil Processing	Afosu, along Larbikrom Road, Birim North
207	Onwona Enterprise	Mamanso, Birim North District
208	Eric Asamoah Oil Processing	Nwateng, Birim North
209	Nyame Bekyere Oil Mill	Afosu, along Larbikrom Road, Birim North
210	Osuani Enterprise	Afosu, Birim North
211	Frimpomaa Rosemond Oil Mill	Afosu, Ahenbronoso, Birim North
212	Dadie3 so Aba Oil Mill	Afosu, Obrapa Kwanso, Keggase, Birim North
213	Cyndan Oil Mill	Mamanso, Birim North District
214	Abu's Company	Nkwarteng behind the Roman church, Birim North
215	P-nels Enterprise Pres.	New Town, Akim Oda District
216	Joel Ohemeng	Akim Gyadam, Birim Control District
217	Biakoye Oil Mill	Achiase, Achiase District
218	Odo Kuo Crammer	Akim Achiase, Achiase District
219	Imalid Cremer Limited	Akim Swedru-Sakune, Birim South District
220	Twum Barima	Praso Kumu, Birim North District
221	Gyimah Boateng Oil Mill	Amana Praso near Methodist Church, Birim North
222	Auntie Ama Oil Processing	Pankese near Sakant warehouse, Birim North
223	Ernestina Kesse Oil Mill	Okaikrom, Birim North District
224	Enoch Awugya	Kontenase, Birim North
225	Bismark Amuzu Oil Processing	Kontenase, Birim North
226	Emmanuel Kofi Gyan Oil Milling	Kontenase, Birim North
227	Sogah Stephen Oil Mill	Kontenase, Birim North
228	Jonathan Atiemo Larbi Oil Mill	Abohema, Birim North
229	Edward Amoh Oil Processing	Asuabena, Birim North
230	Moore Gyan Oil Processing	Praso Kuma, Birim North District
231	Rebecca Owusu Oil Processing	Abodom, Birim North
232	Akwesi Amebletor Oil Mill	Praso Kuma, Birim North District

No	Name of company	Location
233	Yembelembe Moses Oil Milling	Abodom, Birim North
234	Korkor Regina Oil Mill	Dodoworaso, Birim North
235	Konadu Oil Mill	Amenam behind the SDA Church, Birim North
236	Patricia Anima Oil Processing Enterprise	Amenam Kwanta, Birim North
237	Kwadwo Offei Oil Mill	Adadekrom, Birim North
238	Mary Duodu Oil Mill	Adadekrom, Birim North
239	Philip Yekple Oil Mill	Nyafoman, Birim North
240	Daniel Ofosu Oil Processing	Nyafoman, Birim North
241	Digester Oil Mill	Adadekrom, Birim North
242	Andrews Opoku Oil Processing	Anwana Praso, Birim North
243	Obenso Crammer	Akim-Kwae, Kwaebibirem District
244	Philip Crammer	Akim James Town, Kwaebibirem District
245	Agyesco Palm Kernel Oil Refinery Enterprise	Akim-Pranke, Kwaebibirem District
246	Christian Mothers	Akim-Abodom, Kwaebibirem District
247	Agoe Crammer	Akim-Bomso Kwaebibirem District
248	Dawuda Cremer Company Limited	Pramkese, Kwaebibirem District
249	Okai Abraham Oil Mill Company	Twum Wusu, Kwaebibirem District
250	Auntie Ama Oil Mill Company	Akim Abodom, Kwaebibirem District
251	Francis Quaye Oil Processing	Afosu, Birim North
252	Musayuba Enterprise	Mamanso, Birim North District
253	Rosemond Mensah Oil Mill	Otumi, Kwaebibirem District
254	Samuel Hornu Oil Mill	New Abirem, Birim North
255	God's Time is the Best	Kofi Nimo, Akyemansa District
256	Pastor Shadrack Opoku Gyamfi	Ayirebi, Akyemansa District
257	Asare Seth Company Limited	Kade-Amompe, Kwaebibirem District
258	Akoloni Enterprise	Abaam-Agyekrum, Kwaebibirem District
259	Lantei Crammer	Akim-Asikam, Kwaebibirem District
260	Francis Crammer	Akim-Twumwusu, Kwaebibirem District
261	Asiedu Amoako Oil Processing Enterprise	Amenam, behind the SDA church, Birim North

No	Name of company	Location
262	Doris Owusu Oil Mill	Amenam behind the Pentecost church, Birim North
263	Kasum Oil Processing Enterprise	Praso Kuma, Birim North District
264	Yedewe Stephen Oil Mill	Amenam, opposite CMB, Birim North District
265	AttahGuy Company Limited	Mamanso, Birim North District
266	Yaw Kesse Oil Processing	Praso Kuma, Birim North District
267	N Boadu Palm Oil processing	Hweakwea, Birim North
268	Rose Okyere Oil Processing	James Town, Birim North District
269	Zenabu Mutakilu Oil Processing	Afosu, Birim North
270	Gye Nyame Enterprise	Afosu, Birim North
271	Adom Oil Processing Ltd	Birim North
272	Ama Kwatemaa	Adobrease, Akyemansa
273	Aninkorah Festus	Ayirebi, Akyemansa
274	Benjamin Nortey	Nkwantang, Birim North
275	Evergreen Palm and Kernel	Akim Kade, Kwaebibirem
276	Fawsa Issaka Oil Mill Company	Akim Pramkese, Kwaebibirem
277	Gladys Addo Oil Processing	Dodo Warso, Nkwateng, Birim North
278	Naa Oil	Nkwantang, Kwaebibirem
279	Nyame ne boafo Crammer	Akim-Nkwanta, Birim Central

ANNEX 5: REFERENCE TABLES

Table A: Staff strength

Range	Number of facilities
1–100	7
101–300	9
301–500	6
501–1,000	5
1,001–2,000	2
Not provided	1

Table B: Districts covered by the inventory

District	Number of facilities
Akyemansa	61
Birim North	120
Birim South	2
Birim Central	2
Denkyembour	25
Kwaebibirem	67
Achiase	2
Total	**279**

Table C: Production capacities of the artisanal palm oil millers

Plant capacity (tons per day)	Number of facilities	Percent (%)
Up to 5	167	59.8
6–10	33	11.8
11–20	10	3.6
21–40	14	5.0
Above 40	9	3.3
Not indicated	46	16.5

Table D: Type of support needed by the artisanal millers

Type of support	Number of facilities	Percent (%)
Machine upgrade and installation	11	3.9
Training on efficient production operations	105	37.6
Maintenance	13	4.7
Human resources (electrical and mechanical engineers)	107	38.4
Financial	12	4.3
Undecided	31	11.1

Table E: Frequency of maintenance

Frequency of maintenance (months)	Number of facilities
0–3	33
4–6	31
7–12	11
Undefined	204

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