MAXIMISING GHANA'S OIL RESOURCE TO BOOST POLYESTER FIBRE PRODUCTION IN GHANA

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ABSTRACT

This paper explores the prospects of polyester fibre production on the back of the current production of oil and gas in Ghana. It also seeks to examine the core benefits of polyester fibre, identify and document its production processes and discusses its commercial benefits that are likely to increase with further technological improvement in its production. The methodology employed was the qualitative approach and the descriptive survey. Observation and interviews were the research instruments used to gather data. The study found that Polyester is the most commonly used fibre in Ghana and accounts for 61% of total textile imports in Ghana. The study concludes that polyester fibre production is commercially viable in Ghana. It recommends among others that the Government of Ghana plays an active and strategic role, intentionally promoting, facilitating and incentivising investment in the textile manufacturing sub-sector through its One District One Factory (1D1F) Policy to set up factories for polyester fibre production.

Keywords: Polyester Fibre; Oil and Gas, Textile industry; Polymer

1.0 INTRODUCTION

Polyester is a synthetic fibre derived from coal, air, water, and petroleum. Developed in a 20th-century laboratory, polyester fibres are formed from a chemical reaction between an acid and alcohol. In this reaction, two or more molecules combine to make a large molecule whose structure repeats throughout its length. Polyester fibres can form very long molecules that are very stable and strong (Nurhan, 2018). This synthetic fibre has become the world's most commonly used fibre. It overtook cotton use in 2002 and, with other synthetic fibres, makes up more than 65 % of fibres used in the textile and apparel industry (Textile Exchange, 2017).

Polyester is used in the manufacture of many products, including clothing, home furnishings, industrial fabrics, computer and recording tapes, and electrical insulation. Polyester has several advantages over traditional fabrics such as cotton. It does not absorb moisture, but does absorb oil; this quality makes polyester the perfect fabric for the application of water-, soil-, and fire-resistant finishes. Its low absorbency also makes it naturally resistant to stains. Polyester clothing can be pre-shrunk in the finishing process, and thereafter the fabric resists shrinking and will not stretch out of shape. The fabric is easily dye-able, and not damaged by mildew. Textured polyester fibres are an effective, non-allergenic insulator, so the material is used for filling pillows, quilting, outerwear, and sleeping bags.

Polyester is light, strong and easily dyed, can be woven or knitted and is easily blended with other fibres. It is easy-to- wash, wrinkle-free nature made it revolutionary when it first emerged in the 1970s. Its relative cheapness has fuelled the growth of fast fashion. Polyester fibre has dominated the Ghana's textile industry for a long time, and has overtaken cotton in terms of its direct application by the Ghanaian consumer. This has sustained the industry which used to be a very vibrant sector of Ghana's economy some four decades ago. However, this cannot be said as same today due to the high cost and frequent importation of polyester and cotton fibres to feed the industry. The total industry output was 130 million yards and employed approximately 25,000 people, accounting for about 27% of all manufacturing employment in 1977 (MOTI 2004). The Industry was a reliable source of employment to many Ghanaians,

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and contributed meaningfully to the Gross Domestic Product (GDP) of Ghana. Textile exports generated $27.2 million in 1992, this increased to $179.7 million in 1994 but revenue from exports declined consistently thereafter, and by 1998 the revenue from exports had fallen to US $3.173 million (Quartey, 2006).

Koomson (2019) contends that, Ghana's total industry output was pecked at 130 million yards in 1977; but unfortunately, the figure plummeted to 44 million yards in 2009 and subsequently, 42million in 2011. As at 2010, the employment level of the textile industry which stood at 25000, had woefully dropped to 3000, with total industry output of 40 million yards (Ahene-Nunoo, 2016). The Industrial and Commercial Workers Union (ICU) (2017) as well as Bruce-Amartey and Acquaye (2017) opine that, Ghana's over-reliance of cotton fibre and other cellulosic materials as the main raw material for textile (i.e., for wax and fancy prints) production in Ghana, has had a negative effect on the textile industry. This stance is buttressed by the coalition of textile workers (CTW) (2018), as they postulate that the time has come for Ghana's Textile Industry to explore alternative sources of textile fibres to harness the growth and sustenance of the industry.

Following the discovery of Oil in Ghana and the consequent production therein, very few advantages have been secured from the rich resource apart from petrol, diesel and gas. However, the resource has the potential of affecting the Textile Industry positively and changing the negative narrative of the once commercially viable manufacturing sub-sector. It is against this background that the researchers find it necessary to examine the opportunities and prospects of Ghana's oil industry reserves as a resource for polyester fabric manufacture.

1.1 An Overview of Polyester Fibre

The American Chemical Society National Historic Chemical Landmarks (2020), state that, in 1926, the United States-based E.I. du Pont de Nemours and Co. began a research into very large molecules and synthetic fibres. This early research, headed by W.H. Carothers, centred on what became nylon, the first synthetic fibre. Soon after, in the years 1939-41, British research chemists took interest in the du Pont studies and

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conducted their own research in the laboratories of Calico Printers Association, Ltd. This work resulted in the creation of the polyester fibre known in England as Terylene. (American Chemical Society National Historic Chemical Landmarks, 2020)

In 1946, du Pont purchased the right to produce this polyester fibre in the United States. The company conducted some further developmental work, and in 1951, began to market the fibre under the name Dacron. During the ensuing years, several companies became interested in polyester fibres and produced their own versions of the product for different uses. Today, there are two primary types of polyester, PET (polyethylene terephthalate) and PCDT (poly-1, 4-cyclohexylene-dimethylene terephthalate). PET, the more popular type, is applicable to a wider variety of uses. It is stronger than PCDT, though PCDT is more elastic and resilient. PCDT is suited to the heavier consumer uses, such as draperies and furniture coverings. PET can be used alone or blended with other fabrics to make clothing that is wrinkle and stain resistant and retains its shape.

Demand for polyester has grown strongly and steadily. In 1980, the volume of global polyester production was 5.2 million tons. By 2014, this reached 46.1 million tons. Across this period, 73.4 per cent of demand growth for all fibres was driven by polyester (Textile Exchange, 2017).

In support of the assertion above, Pulidindi & Prakash (2019) contend that, rising apparel import in the Europe region is likely to positively influence the growth of polyester fibre market across the globe in coming years. They explain further that, expanding fashion industry and rising adoption of polyester fibre in apparel and garments are the major factor propelling the market growth. Digitalization of the value chain, shorter lead times, and changing fashion trends are expected to increase the consumption of polyester fibre. This can be attributed to its excellent resistance to wrinkle, stretching, abrasion, chemicals, and shrinking, which makes it ideal for short turnarounds of clothing (Pulidindi & Prakash, 2019).

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1.2 Petrochemical Origins and Impacts

Polyester is made through a chemical reaction involving coal, petroleum (from crude oil), air and water. In 2015, more than 330 million barrels of oil were used to make polyester and other synthetic textiles – the equivalent of more than 21,000 Olympic swimming pools. Polyester production has a lower environmental impact than natural fibres production in terms of water usage and wastewater. However, the energy required to produce polyester (125 MJ of energy per kilogram produced) and the greenhouse gas emitted (14.2 kg of CO_2 per kilogram produced) make it a high-impact process. In 2015, polyester produced for clothing emitted 282 billion kg of CO_2 – nearly three times more than for cotton.

Pollution is also a problem. Factories producing polyester without wastewater treatment systems can release potentially dangerous substances including antimony, cobalt, manganese salts, sodium bromide and titanium dioxide into the environment. As an oil-based plastic, polyester does not biodegrade like natural fibres. Rather it stays in landfill for several decades at least – and potentially for hundreds of years. When washed, fibres from polyester textiles and clothing are shed and enter waterways and oceans as micro-plastic fibres, according to recent studies. Fish, shellfish and other aquatic creatures ingest the micro-plastics, which accumulate, concentrating toxins up the food chain. These can enter human food chains and pass into the wider environment.

2.0 METHODOLOGY

The design is based on the qualitative paradigm. The descriptive method was employed for the study. This helped in examining and discussing the opportunities and prospects of Polyester fibre production in Ghana amid the growing oil industry. The purposive sampling technique was employed for the study. According to Robinson (2014), purposive sampling is an intentional selection of informants based on their ability to elucidate a specific themes, concepts, or phenomenon. This is buttressed by Andale (2015), who explains that, in purposive sampling, the researcher selects a

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sample based on their knowledge about the study and population. The purposive sampling technique was used to select a population of twenty (20) respondents for the study. They consist of experts from the oil and gas industry, textile importers, textile chemists, operatives in the textile manufacturing (sub-sector) and the Association of Ghana Industry. (AGI). The instrument used for the study was interview.

3.0 FINDINGS AND DISCUSSIONS

This section discusses the data collected, interprets and makes analyses for the study. It provides the necessary basis for the findings and conclusions of the study.

3.1 Polyester Fibre in Ghana

The study revealed that polyester fibre has dominated the textile industry in Ghana for a long time, and has overtaken cotton in terms of its direct application by the Ghanaian consumer. Indeed, Ahene-Nunoo (2017) contends that as at July 2016, polyester alone constituted 67% of total textile fibre imports in Ghana. To buttress the point above, Markit (2020) argues that, synthetic fibres (especially polyester) have dominated the fibre market since the mid-1990s when they overtook cotton volumes. With around 66.6 million mt of synthetic fibres, this fibre category made up approximately 62% of the global fibre production in 2018. Polyester had a market share of around 51.5% of total global fibre production. More than 55.1 million mt of polyester was produced in 2018 (Ahene-Nunoo & Throsaad, 2019).

Markit (2020) notes that Polyester fibre is the single-largest-volume fibre used globally, accounting for over 50% of the overall man-made and natural fibre markets. Markit further explains that, since 2000, the consumption of polyester fibres has grown at a sustained rate because of their low cost of production as well as their versatility and relatively large spectrum of applications (from heavy-duty industrial applications to consumer apparel and home furnishing products). The substitution for other materials has allowed polyester fibre to grow faster than the fibre market itself.

Similarly, Danquah (2017) postulates that due to the tenacity of polyester fibre, most school uniforms used by many schools in Ghana (both primary and secondary as well as public and private) constitutes polyester blends between at least 65% and at most 100%. This revelation is strongly confirmed by some members of the Association of Ghana Industries (AGI) who also doubled as importers of textile raw materials (including polyester) and who were engaged by the researchers.

The interviewees further mentioned that, even neighbouring Nigeria that produces polyester locally, is currently seriously experiencing 'scarcity of polyester' which is threatening the survival of the textile industry in Nigeria. The fibre according to them, has been widely used in applications such as cushioning and insulating materials in pillows, comforters and upholstery padding. They noted that, polyester has high tenacity and durability and can withstand strong and repetitive movements. This implies that the market for polyester fibres is yet to be fully explored, and Ghana has a very unique opportunity to rise up to the occasion.

According to textile the chemists who were interviewed for the study, polyester is the world's most commonly used polymer. They noted that, as a synthetic polymer, polyester is made from petroleum-derived ethylene glycol and terephthalic acid ($C_8H_6O_4$). They are either thermoplastics (thus, substances - especially synthetic resins that become plastic on heating and harden on cooling, and are able to repeat these processes) or thermoset (that is, irreversibly hardening a polymer by curing from a soft solid or viscous liquid prepolymer or resin) based on their chemical composition and structure. Majorly used Polyester polymer is thermoplastics.

Stephenson (2019) reports that, Ghana is a relatively recent and small player in Africa's hydrocarbon sector; however, new discoveries by Norwegian start-up Aker on the Deepwater Tano Cape Three Points block could help production rise from a little less than 200,000 barrels per day (bpd) in 2019 to about 420,000bpd by 2023, according to finance minister Ken Ofori-Atta. Aker Energy submitted its $4.4billion development plans in 2019 for its Pecan field, where it argued that between 600,000 and 1,000,000 barrels of oil can be found. Ghana's oil and gas are helping to position it among the continent's fastest-growing economies, with growth forecast to reach 8.8%

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in 2019 (Stephenson, 2019). The study also revealed that, the government of Ghana is quite hopeful that US supermajor ExxonMobil and its consortium partners will find commercial quantities of oil at its Cape Three Points block. AGM Petroleum, backed by Norwegian businessman Kjell Inge Røkke's TRG Holding, also concluded a deal in the year 2019 for its exploration of the South Deepwater Tano block.

The Ghana Petroleum Commission (2019) states that, based on existing subsurface data from seismic and wells drilled, including an analysis of the Pecan-4A well result, the existing discoveries are estimated to contain gross contingent resources (2C) of 450 – 550 million barrels of oil equivalent (mmboe). Aker Energy estimates that with the next two well targets, the total volume potential is 600 – 1,000 mmboe. This is obviously not only good news for Ghana's Oil and Gas Industry, but for her Textile Industry as well. Indeed, some members of the AGI who were engaged by the researchers strongly argued that, government as a matter of urgency must get the Ministry of Trade and Industry (MoTI) and the Ministry of Energy to work in close collaboration to ensure that the crude oil that is mined in Ghana benefits the textile industry, since it has derivatives that produces polyester fibre(s).

Ghana's seeming over reliance on cotton fibre, and the attendant challenges that come with it, makes it highly imperative to get an alternative fibre to stem the tide. Presently in Ghana, polyester and cotton blends are widely used by the apparel/garment manufacturing industry more than any other fibres. Interactions with Ghanaian textile consumers to find out whether they could easily differentiate between cotton and a blend of cotton and polyester (i.e., 95% Polyester and 5% Cotton). The study revealed that, an overwhelming majority of consumers of textiles could not distinguish between polyester and cotton. It was deduced from this response that, the properties of the 5% cotton, enhanced the handle of the polyester fabric to a large extent. It also pointed to the fact that consumers were mostly attracted by the appearance of the fabric rather than comfort. Textile scientists engaged by the researchers however contended that, the biggest contributor to the appeal of polyester is the discovery of microfibers which give polyester the feel of silk and have rapidly become the choicest of all fabrics

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3.2 Raw Materials Polyester

Polyester is a chemical term which can be broken into poly (many), and ester *(*a basic organic chemical compound). The principal ingredient used in the manufacture of polyester is ethylene, which is derived from petroleum. In this process, ethylene is the polymer, the chemical building block of polyester; and the chemical process that produces the finished polyester is called polymerization. Generally, fibres have specific appearances and exhibit behaviours that distinguish them from one another. Polyester likewise, has the specific qualities that make it different from other fibres. The study looks at the chemical and physical properties of this fibre.

3.3 Chemical Properties

A chemical property is any of a material's properties that becomes evident during a chemical reaction. i.e., any quality that can be established only by changing a substance's chemical identity. Chemical properties be determined only when the substance's internal structure is affected. The study looks at the effect of alkali, acids and solvents and on the polyester fibre. It also provides information on miscellaneous properties. The polyester fibres have good resistance to weak alkalis and high temperatures. It exhibits only moderate resistance to strong alkalis at room temperature and is degraded at elevated temperatures. Weak acids, even at the boiling point, have no effect on polyester fibres unless the fibres are exposed for several days. Nurhan (2018) posits that polyester fibres have good resistance to strong acids at room temperature. Prolonged exposure to boiling hydrochloric acid destroys the fibres, and 96% sulfuric acid and causes disintegration of the fibres. Polyester fibres are generally resistant to organic solvents. Chemicals used in cleaning and stain removal do not damage it, but hot m-cresol destroys the fibres, and certain mixtures of phenol with trichloromethane (chloroform- $CHCl_3$) dissolve polyester fibres. Oxidizing agents and bleachers also do not damage polyester fibres. Polyester fibres exhibit good resistance to sunlight, and it also resists abrasion very well. Soaps, synthetic detergents, and other laundry aids do not damage it. One of the most serious faults with polyester is its oleophilic quality. It absorbs oily materials easily and holds the oil tenaciously.

3.4 Physical Properties

Physical properties of a substance is any characteristic that can be determined without changing the substance chemical identity. The study examined the moisture regain, specific gravity, heat effect and mechanical properties. The moisture regain of polyester is low. It ranges between 0.2 to 0.8 per cent. Although polyesters are non-

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absorbent, they do not have wicking ability. In wicking, moisture can be carried on the surface of the fibre without absorption. The specific gravity 1.38 or 1.22 depending on the type of polyester fibres is moderate. Polyester fibres have a density greater than polyamide fibres and lower than rayon. Fabrics made from polyester fibres are medium in weight. The melting point of polyester is close to that of polyamide, ranging from 250 to 300°C (Bendak, & El-Marsafi**,** 1991). Polyester fibres shrink from flame and melt, leaving a hard-black residue. The fabric burns with a strong, pungent odour. Heat setting of polyester fibres, not only stabilizes size and shape but also enhances wrinkle resistance of the fibres. A wide range of polyester fibres with specific properties mainly depend on the method of manufacture. Generally, as the degree of stretch is increased, which yields higher crystallinity and greater molecular orientation, so are the properties, e.g., tensile strength and initial Young's modulus. At the same time elongation normally decreases. An increase in molecular weight further increases tensile strength, modulus, and extensibility. Shrinkage of the fibres also varies with the mode of treatment. If relaxation of stress and strain in the oriented fibre occurs, shrinkage decreases but the initial modulus may be also reduced. Yarns maintained at a fixed length and constant tension during heat setting are less affected with respect to changes in modulus, and reduced shrinkage values are obtained. Poly (ethylene terephthalate) shows nonlinear and time-dependent elastic behaviour. Creep occurs under load with a subsequent delay in recovery on the removal of the load, but compared to that of other melt-spun fibres, creep is small.

3.5 Manufacturing of Filament Yarn

The manufacturing process of polyester filament fibre begins with polymerization. To form the fibre, dimethyl terephthalate is first reacted with ethylene glycol in the presence of a catalyst at a temperature of 302-410°F (150-210°C). The resulting chemical, a monomer (single, non-repeating molecule) alcohol, is combined with terephthalic acid ($C_8H_6O_4$) and raised to a temperature of 472°F (280°C). Newly-formed polyester, which is clear and molten, is extruded through a slot to form long ribbons. After the polyester emerges from polymerization, the long molten ribbons are allowed to cool until they become brittle. The material is then cut into tiny chips

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and completely dried to prevent irregularities in consistency. This process is known as drying.

3.6 Melt Spinning

The melt spinning process begin with the melting of Polymer chips at 500-518°F (260-270°C) to form a syrup-like solution. The solution is put in a metal container called a spinneret and forced through its tiny holes, which are usually round, but may be pentagonal or any other shape to produce special fibres. The number of holes in the spinneret determines the size of the yarn, as the emerging fibres are brought together to form a single strand.

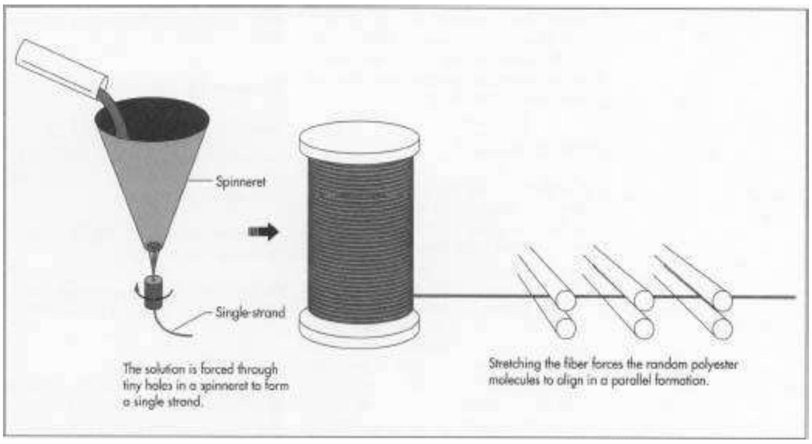

Figure 1: Flow Chart for Melt Spinning
Source: (Ahene-Nunoo, 2018)

At the spinning stage, other chemicals may be added to the solution to make the resulting material flame retardant, antistatic, or easier to dye. When the polyester fibre emerges from the spinneret, it is soft and easily elongated up to five times its original length. The stretching forces the random polyester molecules to align in a parallel formation. This increases the strength, tenacity, and resilience of the fibre. This time, when the filaments dry, the fibres become solid and strong instead of brittle. Drawn fibres may vary greatly in diameter and length, depending on the characteristics desired of the finished material. Also, as the fibres are drawn, they

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may be textured or twisted to create softer or duller fabrics. The process is known as drawing. This is followed by the winding process where the polyester yarn is drawn and wound on large bobbins or flat-wound packages, ready to be woven into material.

3.7 Manufacturing Staple Fibre

In making polyester staple fibre, polymerization, drying, and melt spinning are much the same as in the manufacture of filament yarn. However, in the melt spinning process, the spinneret has many more holes when the product is staple fibre. The rope-like bundles of polyester that emerge are called tow. The newly-formed tow is quickly cooled in cans that gather the thick fibres. Several lengths of tow are gathered and then drawn on heated rollers to three or four times their original length. This process is called towing. The crimping process the follows. Here the drawn tow is then fed into compression boxes, which force the fibres to fold like an accordion, at a rate of 9-15 crimps per inch (3-6 per cm). This process helps the fibre hold together during the latter manufacturing stages. After the tow is crimped, it is heated at 212-302°F (100-150°C) to completely dry the fibres and set the crimp. Some of the crimp will unavoidably be pulled out of the fibres during the processes. This process in known as setting. The cutting process is the next phase. Following the heat setting, tow is cut into shorter lengths. Polyester that will be blended with cotton is cut in 1.25-1.50-inch (3.2-3.8 cm) pieces; for rayon blends, 2-inch (5 cm) lengths are cut. For heavier fabrics, such as carpet, polyester filaments are cut into 6-inch (15 cm) lengths.

3.8 Applications

Polyester is used in the manufacturing of several kinds of clothes and home furnishings like the bedspreads, the sheets, the pillows, the furniture, the carpets, and the curtains. While clothing is the most popular use of polyester, it is also used

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to make the plastic bottles, manufacture high strength ropes, threads, hoses, sails, floppy disk liners, power belting and much more in industries. Polyester is used in the manufacturing of balloons. Such balloons are made of Mylar which is a kind of polyester film. Balloons are made of a composite of Mylar and aluminium foil. Polyester can also be made into thin films that can be used in the food packaging, the audio and videotapes, the electrical insulation and X-ray films. Polyester fibre is used as cushioning and insulating material in pillows, comforters and upholstery padding. They are also used to make bottles, films, tarpaulins, canoes, liquid crystal displays, holograms, filters, dielectric film for capacitors, film insulation for wire and insulating tapes. Polyesters are widely used as a finish on high-quality wood products such as guitars, pianos, and vehicle interiors, industrial polyester fibres are used in yarns and ropes that are used in Tyre reinforcements, fabrics for conveyor belts, safety belts, coated fabrics and plastic reinforcements with high-energy absorption. The fabrics woven or knitted from the polyester thread or yarn are used extensively in the apparel and home furnishings, from the shirts and the pants to the jackets and the hats, the bedsheets, the blankets, the upholstered furniture, and the computer mouse

4. FINDINGS

The study also revealed that:

- **i.** The prospects of a booming polyester manufacturing subsector in Ghana are quite high.
- **ii.** Textile Industry players in Ghana are ready to collaborate with government of Ghana to invest and build a polyester manufacturing sub-sector, and to focus their attention on creating flexible process lines that make it possible to raise the quality, rapidly change the assortment, and manufacture products that satisfy global market requirements.

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iii. The government of Ghana is quite hopeful that US supermajor ExxonMobil and its consortium partners will find commercial quantities of oil at its Cape Three Points block (which connotes an increase in raw materials for polyester fibre production).

iv. Majority of the consumers with whom the researchers interacted could not easily distinguish between polyester and cotton. An indication that polyester is common and acceptable fibre in the Ghanaian textile industry.

v. Polyester fibre has dominated the textile industry in Ghana for a long time, and has overtaken cotton in terms of its direct application by the Ghanaian consumer.

5. CONCLUSION

Owing to the findings of the study, the researchers conclude that:

i. the production of polyester fibre in Ghana is commercially viable. Indeed, Markit (2020) projects that between 2020 and 2024, the market for polyester fibres is expected to grow further, at an average rate of about 4% per year. Given the projected buoyancy of the future of the oil and gas industry in Ghana, there has to be no delays in harnessing the derivatives of this natural resource to the advantage of the county’s economy.

ii. considering the audacious ambition of the Government of Ghana to turn the country into a manufacturing hub for West Africa, there has to be a deliberate focus on working with local textile industry players as well as strategic investors to create markets, support local industries and to create a suitable environment for foreign investment and technology transfer. Indeed, this promises to be one of the biggest avenues of mitigating the unemployment situation in Ghana.

6.0 RECOMMENDATION

Based on the findings and conclusions of the study, it is recommended that:

i. Government of Ghana as a matter of urgency must task the Ministries of Energy and of Trade and Industry, in partnership with the Private Sector (through the

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Association of Ghana Industries as well as the Textile Manufacturing Sub-sector) to work hand in hand to validate and establish the economic viability of Polyester production in Ghana.

ii. The Government of Ghana must play a much more active and strategic role, intentionally promoting, facilitating and incentivising investment in the textile manufacturing sub-sector through its One District One Factory (1D1F) Policy to set up factories for polyester fibre production.

iii. Major Textile manufacturing companies in Ghana must start considering the use of polyester fibre for some of their products if not all, given its excellent absorbent properties and tensile strength.

iv. Encourage and conscientise the textile industry to be innovative in identifying alternative fibres (raw materials) for local production, in light of the difficulties being faced by local producers of raw materials (especially cotton).

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