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CONTENTS

BUILDING BIOFUELS MANUFACTURING PLANTS IN NIGERIA: A FEASIBILITY STUDY APPROACH

By

George C. Ogucjiofor & Uzoma JF Ewurum

Abstract

The efforts at manufacturing biofuels in Nigeria is still at the infancy level. This paper examines the building of biofuels manufacturing plants in Nigeria from feasibility study approach. First, the work examines government subsidy on fuel imports and petroleum-products imports, as justification for biofuels manufacture. Second, the paper reviews the concept of feasibility study from the viewpoints of established scholars, and selects the definition that outlines practicability, suitability and viability of projects as framework for feasibility consideration and assessment. Third, the paper also reviews the technical aspect of feasibility and its analysis as consideration criteria for project practicability. Fourth, the work describes the biofuels-manufacturing processes, namely bioethanol and biodiesel. Fifth, the assessment for practicability, suitability and viability of bioethanol and biodiesel projects are undertaken under specified assessment criteria. The findings suggest that the bioethanol and biodiesel projects in the marketplaces are prevailantly practicable, while feedstocks that would not compete with human food uses, or aggravate the problems of deforestation and desert encroachment are suitable for Nigeria. However, the findings for viability assessment suggest that discounted cashflow (DCF) evaluations, breakeven point (BEP) analyses and time recovery index (TRI) appraisals are required to be undertaken. This provides a new frontier for furthering the work. It is hoped that this work will enhance the appreciation of feasibility consideration and assessment with regard to biofuels manufacture in Nigeria.

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INTRODUCTION

The ongoing plan by the Nigerian National Petroleum Corporation, NNPC under the mandate of the Federal Government of Nigeria, FGN to build biofuels manufacturing plants in Nigeria under the initiative of renewable energy programme is a source of interest to many Nigerians. Accordingly, the NNPC established in August 2005, the Renewable Energy Division (RED), to implement the biofuels programme.

BACKGROUND

RED has since its inception in 2005 conducted several stakeholders

workshops and inter-ministerial committee meetings that have accomplished the biofuels policy, identified potential investors for equity partnerships, and prepared the biofuels infrastructure. According to RED [2008:6] the biofuels policy and incentives document has been approved and gazetted by the FGN (No. 72, Volume 94, pages 180-193 of 20th June, 2007). RED's biofuels programme is predicated on energy crops such as sugarcane, cassava, palmoil and jatropha. To this end, the development of the underlisted projects by RED is in progress.

- Three sugarcane to ethanol projects
- Two cassava to ethanol projects
- Two oil palm to biodiesel projects

STATEMENT OF THE PROBLEM

The petroleum industry has for the past 50 years of operation bequeathed mixed blessings and problems to Nigeria. On one hand, the petroleum industry brought significant economic development and rapid industrialization to Nigeria. On the other hand, the problems induced by the petroleum industry are Nigeria's addiction to petroleum products, gas flaring with its attendant air pollution, oil spills and its environmental contamination, pipeline vandalization and its fatalities, and Niger-Delta crisis which climaxed into armed insurrection, kidnappings and seizure of oil facilities. All these problems no doubt inflicted hardship to both government and the governed.

Example, Nigeria's addiction to petroleum products appears to be a source of government huge expense and subsidy. Appendix A shows the annual subsidies on imported-petroleum products for 2006 2008. While Appendix B shows the quantity of petroleum products importation since 1999 when Nigeria returned to democratic government to 2009. Recently, Reuters [2010:1] reports that NNPC owes fuel suppliers between US$3 US$6 billion for previous imports.

These staggering import bills and quantities have become a source of huge problem for the government and NNPC cash flow. It is because of this problem that Reuters [2010:1] reports that NNPC said it had a healthy cash flow but acknowledged that unpaid government subsidies were putting it under financial strain.

The biofuels initiative dubbed RED was established to tackle the above-written problem. Therefore a good feasibility study for embarking on building biofuels manufacturing plants in Nigeria, will ensure that the biofuels are the actual solution to the problem of the petroleum industry.

CONCEPTUAL FRAMEWORK

The concept of feasibility study has been defined by different scholars in various perspectives. The framework for this study will therefore be drawn from the review of the concept of feasibility study as perceived by

different scholars whose works are available to the researchers.

Imaga [2003:126] defines feasibility analysis as the process of evaluating the future prospects of a project idea in the light of the limitations of the project implementing body and the constraints imposed on the project situation by the environment. From another perspective, Ogbuefi [2002:5] indicates that feasibility study could be regarded as a study to determine if a proposed or given project or investment is achievable, under a specified situation and time, within a given location, and within the context of certain economic and non-economic criteria, as well as client's objectives.

From another dimension, Osara [1994:41] states that a project starts with an idea to achieve an objective and whether the objective is viable as an economic venture is the subject of a feasibility study. Also, from another viewpoint, feasibility study is defined by Nwoko [1988:34] as an indepth examination of the practicability, suitability and viability of a project. This definition made it quite clear that feasibility study seeks to find answers to the underlisted questions:

- Is the project practicable?
- Is the project suitable?
- Is the project viable?

To this end, Nwoko's definition of feasibility study supplies the framework and cornerstone for expanding this work on biofuels feasibility consideration.

Technical Aspect of Feasibility and its Analysis

The results obtained from feasibility study are the prerequisites for pre-investment studies. Imaga [2003:126] highlights that feasibility analysis involves:

- Project identification
- Determination of the internal constraints of the project situation
- Identification of the external constraints inherent in the environment
- Evaluation of the feasibility prospects of the project idea
- Formulation of the project objectives, and
- Feasibility appraisal.

Some basic criteria for selecting manufacturing, or process technologies under the technical aspect of feasibility analysis are described by Imaga [2003:219-226] and the excerpts are highlighted below:

- *That the technology sources may be domestic or foreign*
- *That the technology required for a particular project must first be identified*
- *That the process or manufacturing technology required for a particular project may be patented or unpatented in whole, or in part.*
- *That even when the technology is not patented or patented, the know-how element has to be acquired from those possessing the know-how.*
- *That the means of technology acquisition is by outright purchase from the prospective licensee, or by*

technology licensing, or by joint venture involving participation in ownership by the technology supplier. That the technology must have been fully proven and be utilized in the manufacturing process, preferably in the company from which it came.

- *That new and unproven, or experimental projects should not be considered appropriate.*
- *That obsolescent technologies should be avoided as future supply of spares and tools for plant maintenance will likely pose serious technical problems.*
- *That the raw materials (feedstocks) should determine the technology to be used, given that availability of surplus feed stocks offers a competitive advantage; while non-availability, or restricted availability could be a technological constraint.*
- *That capital-intensive technology may prove uneconomical for a country ridden with excess and cheap labour.*

These criteria of technology selection will function as the framework structure for feasibility consideration and assessment.

FEASIBILITY CONSIDERATIONS AND ASSESSMENT

In this section, an overview of feasibility consideration will be undertaken with regard to the technical aspect. The framework for the consideration will be drawn from Nwoko's [1988:34] concept of feasibility study and Imaga's [2003:219-226] criteria for technology selection and feasibility analysis procedure.

Is the biofuels manufacture practicable for Nigeria?

Biofuels (agrofuels) consists of bioethanol (agroethanol) and biodiesel (agrodiesel). Bioethanol can be produced (see Appendix C) from agro crops containing starch by the processes of:

- Hydrolysis, involving the conversion of starch into sugar.
- Fermentation, which involves the process of conversion of sugar into alcohol (bioethanol), water and carbon dioxide.
- Distillation, involving the process of separation of alcohol (bioethanol) from water (see Appendix C).

Also, biodiesel, an alternative diesel fuel can be made from renewable biological sources such as vegetable oils (palm oil, kernel oil, soybean oil, bennised oil, groundnut oil, cottonseed oil, jatropha seed oil and rubber seed oil), and animal fats (tallow) such as pigs, cow and other poultry fats. However, used cooking oil and animal fats (tallow) are the most economical feedstock for biodiesel production.

Biodiesel is produced (see Appendix D) by the process of transesterification (also called alcoholysis). Thus transesterification is the reaction of a fat or oil with an alcohol (ethanol, or methanol), in the presence of a catalyst such as sodium

hydroxide or potassium hydroxide, to form an ester (biodiesel) and glycerol, as a by-product. The glycerol being denser than biodiesel settles at the reactor bottom and is drawn off, and can be sold as a crude soap. If potassium hydroxide is used as the catalyst, the salt formed can be used as a fertilizer (Appendix D).

The biofuels project idea will be practicable in Nigeria if the existing technology for biofuels manufacture is carefully assessed to ensure that the best choice is made. Appendices E and F show the assessments of practicability of bioethanol and biodiesel projects for a number of process technologies, based on some specified assessment criteria, involving;

- conceptual possibility of project,
- practical achievability of project,
- market-place availability of process technology,
- patent status of process technology,
- state of the technology,
- method of technology acquisition,
- years of technology experience, and
- comment/remark.

The overall result from the assessment criterion in Appendix E is indicative of the embankability and practicability of bioethanol technologies from the Brazilian sugarcane-based process, the Swedish softwood-based process, and the US corn-based process. (See Appendix E). Also, the overall result from the assessment contents of Appendix F is suggestive of the embankability and practicability of biodiesel technologies derived from used cooking oil, tallow and oil seeds. (Refer to Appendix F).

> However, Darroch [2005:1-3] reports that the £15 million plant at Newarthhill, Scotland produces 50 million litres per year of biodiesel, that is 2.9 million litres per month. Owned by Argent Energy and commissioned in 2005, the biodiesel plant is predicated on about 100,000 tonnes of used cooking oil and 230,000 tonnes of tallow collected in the UK each year.

In view of this, a joint venture participation between NNPC and the Scottish Argent Energy will ensure the realisability at commercial scale of biodiesel from used cooking oil and tallow. While an outright purchase of biodiesel production equipment from technology suppliers will ensure the realisability at pilot-plant capacity of biodiesel from oil seeds and virgin oils.

Is biofuels manufacture suitable for Nigeria?

This section assessed the suitability of manufacturing bioethanol and biodiesel in Nigeria, based on the criteria of;

- Project compliance with the provisions of National Agency for Food and Drug Administration and Control (NAFDAC), Standards Organisation of Nigeria (SON), Federal Ministry of Environment (FMEN), which replaced Federal Environmental Protection Agency (FEPA).

- Feedstock constraint
- Substitutability of feedstock
- Feedstock compatibility with process equipment and vessels
- Competition of feedstock with basic human food supplies
- Comment and remark

The assessment sheets for suitability of bioethanol and biodiesel project ideas are shown in Appendices G and H. The assessments in Appendix G are suggestive that on the overall bioethanol manufacture from US corn-based feedstock, Swedish wood-based feedstock, and Brazilian sugarcane-based feedstock are suitable for Nigeria. However, since cassava has over a hundred edible and inedible varieties, local substitution with corn-based feedstock with its associated process plant retrofit is advocated. The cassava variety used as feedstock for Ihiala Starch Mill in Anambra State will no doubt be suitable for the proposed cassava-based bioethanol plant in Nigeria. Incidentally, Nigeria is the second largest producer of cassava in Africa after Congo Democratic Republic (Zaire), and the fifth in the world. About 10 million metric tons of raw cassava is produced in the country annually. Nigeria has the potentials (land and human resources) to produce more than 100 million metric tons per annum of cassava tubers, which can be abundantly produced to meet industrial requirements [Oni, 2010: 34].

On the other hand, the assessments in Appendix H are indicative that biodiesel manufacture from tallow and locally abundant oil seeds like jatropha, rubber, kernel and the likes should pass the suitability assessment. Incidentally, the cheapest approach to biodiesel manufacture is by employing used cooking oil and tallow. In Darroch's [2005:3] view Argent Energy provides an environmentally friendly alternative and its cost structure gives it the edge over rivals using virgin oils. Walker says rapeseed oil can cost up to £373 per tonne to buy, compared to used cooking oil at just £175 per tonne.

Therefore entering into joint venture with Scottish Argent Energy for the building of biodiesel plant in Nigeria for transforming used cooking oil and tallow into biodiesel is the most suitable alternative for Nigeria. Because Nigeria's mobile communication service providers, namely MTN, Glo, Zain, Etisalat and the likes consume over 6 million litres of petroleum diesel per year, they could join the project idea as joint venture partners and stakeholders in the biodiesel project from used cooking oil and tallow.

Is biofuels manufacture viable for Nigeria?

Viability study comes in after it has been established that the project is practicable and also suitable. Viability study examines the costs and benefits expected from the proposed project. In a nutshell viability study is usually undertaken to determine the best choice project out of two or more practicable and suitable projects. The tools of study are usually the payback period analysis and the discounted

cash flow. DCF evaluation often referred to as financial viability appraisal.

However, to understand well in advance the implications of biofuels venture, the underlisted questions must form the viability assessment criteria.

- Can the project sustain itself?
- Can the project payback its cost?
- Does the project need continued subvention, or subsidy from the sponsoring authority?
- How long will it take before the project pays back itself?
- What are the annual cash requirements and flows?
- Will the project be affected by credit crunch in the economy?

These questions are addressed in the viability assessment sheets presented as Appendices I and J. Of course, the viability assessments for bioethanol project (Appendix I) and biodiesel project (Appendix J) as indicated in the assessement sheets are suggestive of the next frontier of the feasibility consideration which will involve detailed viability investigation covering discounted cash flow (DCF) evaluation, time recovery index (TRI) analysis and breakeven point (BEP) analysis. Incidentally, the synonyms for TRI analysis are payback period (PBP) analysis, and risk factor index (RFI) analysis, while the synonym for BEP analysis is the cost volume profit (CVP) analysis. The popular criteria for DCF evaluations are the net positive value (NPV) and the internal rate of return (IRR). These are the tools of viability study and consideration, and subsequently the determinants of bioethanol and biodiesel projects for Nigeria.

CONCLUSION

Feasibility consideration and assessment are undertaken for Nigeria's bioethanol and biodiesel projects under the outline of practicability, suitability and viability advocated by Nwoko [1998:34]. To this end, the practicability and suitability aspects of the feasibility considerations are successfully assessed and the findings obtained from them are promising for biofuels manufacture in Nigeria.

The findings from the practicability assessment show that the bioethanol and biodiesel projects in the marketplaces are predominantly practicable for investment acquisitions. In other words, the biofuels technologies that have been successfully developed in the laboratories, commercialised for industrial usage and are in the marketplaces are considered and assessed to be practicable.

While the findings from the suitability assessment suggest that bioethanol and biodiesel projects with feedstocks that would not compete with human food chain, or compound Nigeria's deforestation and desert encroachment problems are suitable for Nigeria. However, the dependence of Ihiala Starch Mill on a high-starch yielding cassava specie as feedstock indicates the suitability of cassava as

substitute for US corn-based ethanol plant (see Appendix G).

RECOMMENDATION

On the other hand, the findings from the viability assessments are suggestive that the assessment criteria for the bioethanol and biodiesel projects are determinable from DCF evaluations, BEP analysis and TRI appraisals (see Appendices I and J). To this end, the next frontier of the feasibility consideration will be a thorough viability study for Nigeria's biofuels manufacturing projects, to cover DCF evaluations, BEP analyses, and TRI appraisals.

EXPECTATIONS

Energy crops plantation for the purpose of biofuels manufacture has the potential of revolutionising peasant agriculture prevailing in Nigeria, and thereby reducing abject poverty in rural Nigeria.

It is expected that the biofuels projects proposed for Nigeria will ensure:

- That value will be added to agricultural produce and also that profitability will be enhanced for farmers who cultivate energy crops, namely, sugarcane, cassava, palm tree, and of course jatropha.
- That alternative sources of renewable fuels will be created to help minimize the negative economic impact and energy security issues relating to fuel supply disruption by pipeline vandalization and resource control militancy prevailant in the present day petroleum industry.
- That Nigeria will attempt at complying with reduction in carbon dioxide levels implicated for global warming, under the auspices of the 1997 Kyoto Protocol agreement to which Nigeria is a signatory.

To this end, the establishment of RED in August 2005, by NNPC under the mandate of the FGN, to implement the biofuels programme is commendable.

References

Darroch V. (2005), *Argent Energy Turning Chip Fat into Gold: A Lanarkshire-based Biofuel Company is set to add to the biggest operation of its kind with other two plants.* Accessed on August 24, 2010, from http://www.sovereignty.org.uk/features/eco/biofuel3.html

Imaga, E.U.L. (2003), *Groundwork of Project Management and Feasibility Studies,* Owerri: Ibeson Press, p. 126, pp. 219-226.

NNPC (2009), *Annual Statistical Bulletin, Draft Edition,* Abuja: Corporate Planning and Strategy Division (CP&S), p. 42.

Nwoko C. (1988), "Feasibility Studies and the Accountant," in *the Graduate Accountant: The Official Journal of the Association of Accountancy Students, University*

of Nigeria, Enugu, Vol. III, No. 16, p. 34.

Ogbuefi, J. U. (2002), *Aspects of Feasibility and Viability Studies*. Enugu: Institute For Development Studies, University of Nigeria, Enugu Campus, p. 5.

APPENDICES

Appendix A: Government Expenses on Fuel Subsidy

Year	₦ (billion)
2006	255.74
2007	290.47
2008	654.74

Source: Eze and Chiejina [2009:26]

Oni, O. (2010), "Gains in Packaging Fufu Powder for Local, Export Market: The Entrepreneur Today," *BusinessDay*, Vol. 9, No. 200 of Monday, October 25, 2010, p. 34.

Osara, Sylvester I. O. (1994), *Anatomy of Engineering Project Management*, Benin City: Ilupeju Press Limited, p. 41.

Renewable Energy Division (RED) (2008), "Integrating Agro-Sector with the Downstream Petroleum Industry: An NNPC Automotive Biofuels Programme," *Abuja: RED Publication*, June, p.6.

Reuters (2010), "NNPC Owes Fuel Suppliers US$6 billion - Trade Sources," in *BusinessDay*, Vol. 9, No. 169 of September 08, 2010, p.1.

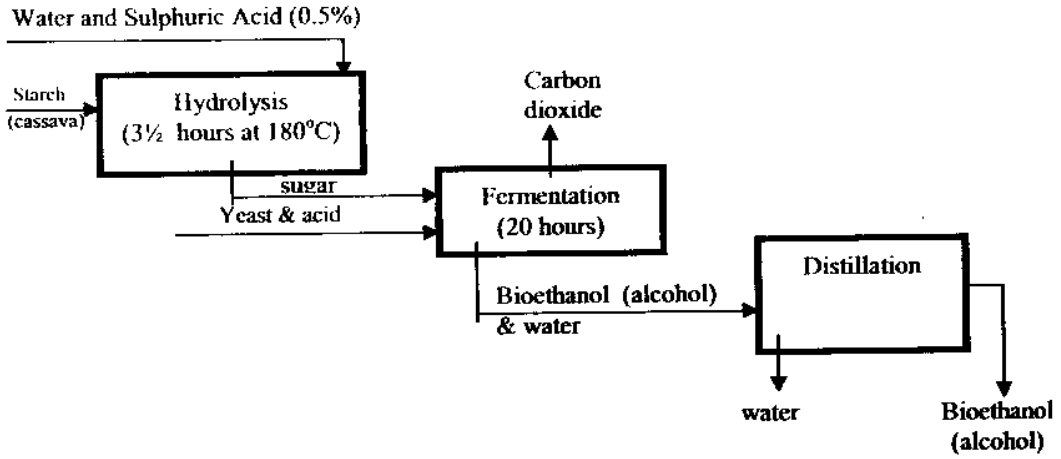
Appendix B: Petroleum-Products Imports (1997 – 2009)

Year	Premium motor spirit, PMS (metric tons)	Automotive gas oil, AGO (metric tons)	Household kerosene, HHK (metric tons)
1999	1,987,474	465,248	171,482
2000	4,144,347	1,952,732	1,155,399
2001	3,857,093	117,156	433,295
2002	4,036,484	404,897	-
2003	5,404,163	1,146,685	637,621
2004	5,696,399	211,471	418,245
2005	5,482,813	N/A	671,939
2006	5,407,634	N/A	1,081,503
2007	5,792,449	N/A	1,335,022
2008	4,596,145	N/A	909,542
2009	5,988,567	N/A	1,170,993

N/A: Not available

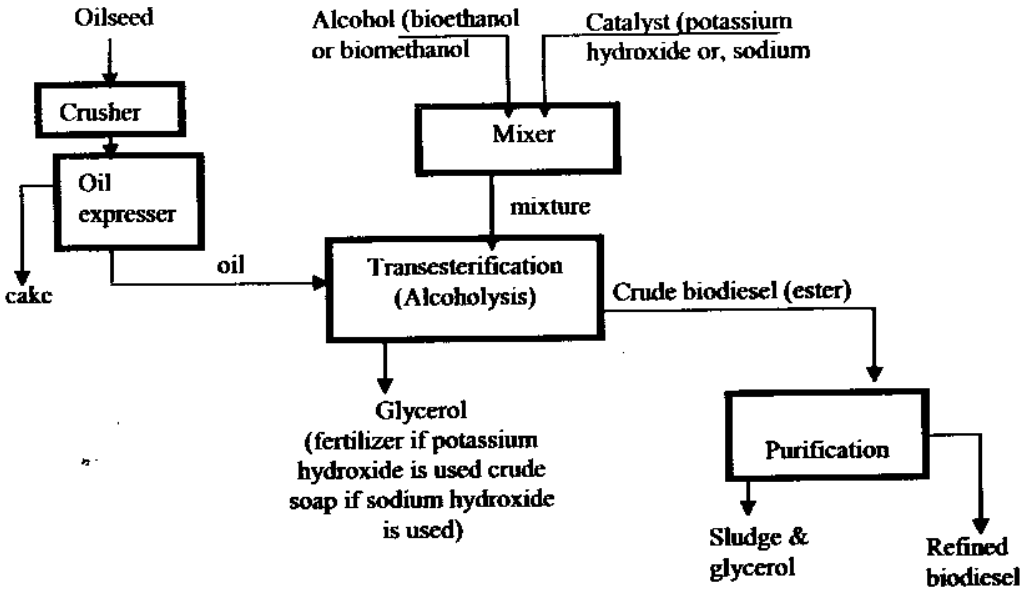
Source: NNPC [2009:42]

Appendix C: Main Process steps in bioethanol manufacture from starch (cassava and the likes) feedstock



Source: Sketched by the authors

Appendix D: Main process steps in biodiesel manufacture from fat or oil feedstock.



Source: Sketched by the authors.

Appendix F: Assessment of Practicability of Biodiesel Project Idea

Assessment Criteria

Biodiesel process technologies	Is the project conceptually possible?	Is the project practically achievable?	Is the process technology in laboratory, or marketplace?	Is the technology patented, or unpatented in whole or part?	Is the technology obsolescent, or state-of-the-art?	Will the technology acquisition be by outright purchase, or joint venture participation with	Years of experience in the process technology

Appendix E: Assessment of Practicability of Bioethanol Project Idea

Assessment Criteria

Bioethanol process technologies	Is the project conceptually possible?	Is the project practically achievable?	Is the process technology in laboratory, or marketplace?	Is the technology patented, or unpatented in whole or part?	Is the technology obsolescent, or state-of-the-art?	Will the technology acquisition be by outright purchase, or joint venture participation with technology suppliers?	Years of experience in the process technology
* US corn-based ethanol plants in Midwestern Region, namely Iowa, Nebraska and Minnesota States.	Yes	Yes	Marketplace	Patented	State-of-the-art	Joint venture participation	(1978-2010) 33 years
* US wood-based ethanol plants in Northeastern Region, namely, Main, New Hampshire, New York and New Jersey States.	Yes	Yes	Marketplace	Patent	State-of-the-art	Joint venture participation	Not available
* US biomass for bioethanol production such as agric post-harvest residues e.g. corn stovers, wheat straw and rice straw.	Yes	Yes	Laboratory	Not Patented	Not applicable	Not applicable	(1999-2010) 11 years
* Swedish softwood-based ethanol plant in North of Sweden	Yes	Yes	Marketplace	Patented	State-of-the-art	Joint venture participation	(2005-2010) 5 years
* Swedish cellulose raw material-based ethanol production in Northern Sweden.	Yes	Yes	Laboratory	Not Applicable	Not applicable	Not applicable	15-20 years
* Brazilian sugarcane-based ethanol plants in the State of Sao Paulo.	Yes	Yes	Marketplace	Patented	State-of-the-art	Joint venture participation	(1975-2010) 35 years
* Brazilian biomass-based feedstock processes such as sugarcane bagasse, eucalyptus, elephant grass, corncob, babacu coconut, municipal cellulosic and solid wastes.	Yes	Yes	Laboratory	Not Applicable	Not applicable	Not applicable	Not available

Source: Analised from the work

Appendix F: Assessment of Practicability of Biodiesel Project Idea

	Assessment Criteria						
Biodiesel process technologies	**Is the project conceptually possible?**	**Is the project practically achievable?**	**Is the process technology in laboratory, or marketplace?**	**Is the technology patented, or unpatented in whole or part?**	**Is the technology obsolescent, or state-of-the-art?**	**Will the technology acquisition be by outright purchase, or joint venture participation with technology suppliers?**	**Years of experience in the process technology**
* Scottish biodiesel plant at Newarthill, Lanarkshire, near Motherwell, turns used cooking oil and tallow (animal fat) into biodiesel.	Yes	Yes	Marketplace	Patented in whole	State-of-the-art	Joint venture participation	(1995-2010) 15 years
* Canadian on-farm biodiesel production in Ontario Province, uses soybeans and canola oilseed as feedstocks	Yes	Yes	Marketplace	Patented in whole	State-of-the-art	Outright purchase	Not available
		Source: Analyzed from the investigation					

Appendix G: Assessment of Suitability of Bioethanol Project Proposal

Assessment Criteria

Biodiesel process technologies	Is the project prohibited in part or whole by NAFDAC, SON & FEPA (FMEN) provisions?	Will the project be constrained by feedstock?	Is the feedstock substitutable with locally available resources?	Will the locally substitutable feedstock be compatible with the process equipment?	Will the locally substitutable feedstock require process innovation?	Will the locally substitutable feedstock compete with basic food suppliers?	Comment/Remark
* US corn-based ethanol plants in Midwestern Region, namely Iowa, Nebraska and Minnesota States.	No	Yes	Yes	No	Yes	Yes	Suitable for Nigeria with plant retrofit if corn a basic food chain is substituted with cassava variety used in Ihiala Starch Mill, Anambra State.
* US wood-based ethanol plants in Northeast Region, namely Main, New Hampshire, New York and New Jersey states.	No	Yes	Yes	No	Yes	No	Suitable for Nigeria if it will not compound existing deforestation problem in tropical zone of Nigeria
* Swedish softwood-based ethanol plant in North of Sweden.	No	Yes	Yes	No	Yes	No	Suitable for Nigeria if it will not compound existing deforestation problem and desert excroachment in Northern Nigeria.
* Brazilian sugarcane-based ethanol plants in the state of Sao Paulo.	No	No	Yes	No	Yes	No	Suitable for Nigeria because sugarcane may not be basic food chain.

Acronyms

NAFDAC: National Agency for Food and Drug Administration and Control

SON: Standards Organization of Nigeria

FEPA: Federal Environmental Protection Agency (now FMEN)

FMEN: Federal Ministry of Environment

Source: Analyzes from the study

Appendix H: Assessment of Suitability of Biodiesel Project Proposal

Assessment Criteria

Biodiesel process technologies	Is the project prohibited in part or whole by NAFDAC, SON & FEPA (FMEN) provisions?	Will the project be constrained by feedstock?	Is the feedstock substitutable with locally available resources?	Will the locally substitutable feedstock be compatible with the process equipment?	Will the locally substitutable feedstock require process innovation?	Will the locally substitutable feedstock compete with basic food suppliers?	Comment/ Remark
* Scottish biodiesel plant at Newarthill, Lanarkshire, near Motherwell, turns used cooking oil and tallow into biodiesel	No	No	Not applicable. Same feedstock does not require local substitute	Same feedstock ensures compatibility	Same feedstock same process equipment	Not applicable	Suitable for Nigeria and is realisable with Argent Energy from Scotland as technical partner.
* Canadian on-farm biodiesel production in Ontario Province, uses soybeans and canola oil seed as feedstock	No	No	Yes	Yes	No	No. Jaropha, kernel, rubber seeds may not compete with basic food chain.	Suitable as on-farm biodiesel manufacturer at pilot-plant capacity for farm settlements and agrarian communities in Nigeria.

Source: Analysed from the work

Appendix I: Assessment of Viability of Biodiesel Project

Biodiesel process technologies	Assessment Criteria: What are the annual cash requirements and flows?	Can the project sustain itself?	Can the project payback its costs?	Does the project need continued subsidy from sponsors?	How long will the project payback itself?	Will the project be affected by credit crunch in the economy?	Comment/Remark
* US corn-based ethanol plants Midwestern Region, namely Iowa, Nebraska and Minnesota States.	Answerable from cash requirements and cashflows estimations.	Answerable from discounted cash-flow (DCF) appraisal	Answerable from discounted cash flow (DCF) evaluation.	Answerable from breakeven point (BEP) analysis.	Answerable from time recovery index (TRI) analysis	Yes	Suggestive that viability aspect of feasibility consideration involves DCF, TRI and BEP analysis
* Brazilian sugarcane-based ethanol plants in the state of Sao Paulo	Answerable from cash requirements and cashflows estimations.	Answerable from DCF appraisal	Answerable from DCF evaluation	Answerable from BEP analysis	Answerable from TRI analysis	Yes	Suggestive that viability aspect of feasibility consideration involves DCF, TRI and BEP analysis

Source: Analyzed from the study

Appendix J: Assessment of Viability of Biodiesel Project

Biodiesel process technologies	Assessment Criteria: What are the annual cash requirements and flows?	Can the project sustain itself?	Can the project payback its costs?	Does the project need continued subsidy from sponsors?	How long will the project payback itself?	Will the project be affected by credit crunch in the economy?	Comment/Remark
* Scottish biodiesel plant at Newarthill, Lanarkshire, near Motherwell, turns used cooking oil and tallow into biodiesel.	Answerable from cash requirements and cash flows estimations	Answerable from discounted cash flow (DCF) appraisal	Answerable from DCF evaluation	Answerable from breakeven point (BEP) analysis	Answerable from payback period (PBP) analysis	Yes	Indicative that viability aspect of feasibility consideration involves DCF, PBP and BEP analysis.
* Canadian on-farm biodiesel production in Ontario Province, uses soybeans and canola oil seed as feedstock.	Answerable from cash requirements and cash flows estimations	Answerable from DCF appraisal	Answerable from DCF evaluation	Answerable from BEP analysis	Answerable from PBP analysis	Yes	Indicative that viability aspect of feasibility consideration involves DCF, PBP and BEP analysis.

Source: Analyzed from the study