INVESTING IN BIODIESEL AFRICAN PALM OIL FOR ALUMINIUM RECYCLING PLANT IN CABINDA ANGOLA

David Muto Lubota
School of Economic Studies
Universidad 11 de Noviembre
Cabinda, Angola
marciodeivy@yahoo.com.br

Erenio González Suárez
School of Chemistry and Pharmacy
Universidad Central de las Villas
Santa Clara, Villa Clara, Cuba
erenio@uclv.edu.cu

Gilberto Dionisio Hernández Pérez
Schoo of Industrial Engineering
Universidad Central de Las Villas
Santa Clara, Villa Clara, Cuba
ghdez@uclv.edu.cu

Juan Esteban Miño Valdés
School of Engineering
Universidad Nacional de Misiones
Oberá, Misiones, Argentina
minio@fio.unam.edu.ar

Inti González Herrera
LaboratoireBordelais de Recherche en Informatique
UniversitéBordeaux I
Bordeaux, Francia
inti.glez@gmail.com

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ABSTRACT

The study of the possibilities that the efficient use of the raw oil of African Palm has is exposed in this work, for production of bioenergetics that guarantees the operations of an aluminium waste recycling plant. A conceptual model and the procedures for the assimilation of technologies of bioenergetics production reported in previous works to Lubota et at., (2016) is proved in the study. Owing to their importance, it is considered the uncertainty to the future changes with emphasis on the growth of the demand of capacities of urban solid waste processing and the material availability. The investment capacity values are established for the first six-year phase with a forward-looking vision, for the second phase, that these capacity values will increase in relation to the first phase. Through this work, dynamic indicators of economic analysis were established, whose results were US$1,832,409 for the net present value, 22% for the internal rate of return and 3 years for payback period of investment at present value.

KEY WORDS: Aluminum; Biodiesel; Investments; Oil; Recycling.

INTRODUCTION

Considering that, in the province of Cabinda Angola, the need to strengthen the energy matrix through the assimilation of technologies for the production of bioenergy is recognized, and at the same time it is planned to introduce the recycling of Urban Solid Waste (USW) which increasingly will demand energy carriers; therefore, it is necessary to study the use of bioenergetics for the USW recycling processes.

It is a characteristic of the USW recycling processes that each waste has specific technologies, which require different forms of energy. For example, paper recycling processes require electricity and steam (González, 1982), the recycling of plastic electricity (Grancho, 2015) and aluminum energy in the form of direct heat for smelting (Sambovo, 2015); For this reason, for energy insurance through biofuels for each type of USW, it is necessary to evaluate technological and logistical aspects, in order to guarantee a stable supply of energy to the industrial process in which it is decided to invest.

An aspect of great importance is the problem of uncertainty in different aspects such as:

• The availability of biomass supply as an energy source for the processes.

• Increasing demand for recycling capacity due to population increase.

• The variation of the volume and type of the different USWs over time.

These problems of uncertainty give rise to the fact that the investment processes must evaluate the alternative of investing in excess productive capacities in the first years of operation, with the aim of meeting the productive capacities when the production capacities grow due to the increase of the production levels of the USW´s different components. This problem was raised by Rudd and Watson (1968) and later the existing problem in the availability of biomass when it is used as a raw material is considered (Oquendo, 2002). The application of these concepts have been included in a procedure specified by Lubota et al. (2016), for the study of the supply chain that allows to determine the initial investment capacity to solve the problem of recycling of the USW and its energy insurance.

DEVELOPMENT

In the municipality of Cabinda, Angola, an appreciable amount of Urban Solid Waste (USW) is generated whose destination is not properly managed (Do Rosario, 2014a) and which includes aluminum, plastic, wood, tires, paper, organic material and others (Do Rosario, 2014b). In parallel with this are available as sources of energy, in addition to wood and sawdust waste generated between the RSU, different forms of biomass that can be sources of bioenergy (Lubota et al., 2014)

For the execution of this work, the conceptual and procedural models proposed by David Muto Lubota in 2015 were used, suitable for the assimilation of technologies according to the article of the bibliographic reference (Lubota et al., 2016).

The procedure used by Lubota et al., (2016), is executed with a set of specific steps, namely:

Step 1. Determination of the product demand and availability of raw material.

Step 2. Surveillance on available and emerging technologies.

Step 3. Diagnosis of alternative raw material availability.

Step 4. Technology scaling.

Step 5. Planning supply chain alternatives. It includes several stages.

Step 6. Technical, economic and environmental evaluation of the new technology.

Step 7. Incorporation of technology.

In the context of a so-called third world country, regarding cost, time and functional operations, a set of actions is required to process all the information and to solve the problems that arise from the uncertainty of technology (Law 2006).

Conceptual Model shows that the assimilation and the technology transfer are interactive because they have the participation of multiple players, which includes technology recipients, suppliers and operators and that goes through a series of phases.

The preparatory phase is where the management draws up the strategic delineation: vision, mission, institutional aim, internal and external analysis, planning of the activities to be carried out and the cooperation within the context of an engineering project is established.

In the second phase, the available resources are assigned, the transition groups are formed, which will constitute the nucleus of the activities to be carried out.

In the execution phase it is where the different processes are progressively adapted, the learned lessons are drawn that serve to review the strategies to proceed to the new adoption of behaviors.

Finally we proceed to the dissemination phase, where technology is institutionalized within the organization, all the processes are created and documented and then they are disseminated to all final users.

Application of the procedures has established, as a methodological axis, the different elements that influence on decision making, among which stand out the price forecasts, the demand/supply balance, the production capacity, the study of technology, the consumption of raw materials and inputs, source supplies, investment and production costs, size and location of the plant, etc. The consideration of uncertainty to future changes has been essential (Rudd and Watson, 1968).

Results and Discussion

According to the presented and based procedures on Lubota et al (2016), the following steps were applied:

Step 1. Determination of the demand for products and availability of raw material

Table 1 shows the processing demand for aluminum contained in the Cabinda USW.

Table N° 1. Presence of Aluminum in the Cabinda USW

	Years			
USW	**0**	**5**	**10**	**15**
	ton/year	**ton/year**	**ton/year**	**ton/year**
Aluminum	**9 836,1**	**11 091,9**	**12 494,6**	**13 743,3**

Source: Own Elaboration

In Table N° 2 we express the energy demand to process the aluminum and plastics present in the Cabinda USW.

Table N° 2. Energy to process Aluminum and Plastics in the Cabinda USW

	Years			
Bioenergetics	0	5	10	15
	ton/year	ton/yea	ton/year	ton/year
Biodiesel	39 855,59	81 239.8	202 771,91	50 5472,99

Source: Own Elaboration

In Table N° 3 we present the demand of raw materials for the production of bioenergetics according to the conversion coefficients for the African Palm Oil.

Table N° 3. Demand of raw material for the production of Bioenergetics

	Years			
Raw Material	0	5	10	15
	ton/year	ton/year	ton/year	ton/year
African Palm Oil	39 855,59	81 239.8	202 771,91	50 5472,99

Source: Own Elaboration

Availability of raw material

The quantification and characterization of the existing energy biomass in a geographical region is the starting point for any project that uses it as a raw material, since it can influence on the industrial site.

The residual biomass that can be used for energy purposes is characterized by its diversity in terms of its origin and characteristics. Therefore, when carrying out territorial studies, this diversity supposes a very high number of possible alternatives in terms of availability, extraction, logistics and biomass consumption, which significantly increases the complexity of them. This complexity is associated with a high degree of uncertainty, due to the multiple interactions between some uses and others and the biomass market itself. That is, depending on the evolution of prices, it will be more or less profitable to extract biomass from the forest.

A first approximation to the territory reveals that the main sources of biomass in the Province of Cabinda are forest stands and agricultural crops. On the one hand, the province of Cabinda has the most productive forest ecosystems in Angola due to its orographic disposition and climatology.

However, despite this potential availability, the absence of technical forest management tools, the atomized structure of the property, the difficult accessibility of the land for its use or the characteristics of the bio mastic resource itself (impurities, humidity, heterogeneity among others) have hindered its use.

Dynamics of forest growth

In the province of Cabinda, 4 types of forest formations are identified in particular:

• Type I: Dense, humid misty forest

Sempervirente, poliestrata, of low altitude (Alto Maiombe), occupies an area of about 431 Km2 of productive forest.

• Type II: Humid dense forest

Semi decidua, poliestrata, of low altitudes, pereguineense (Alto Maiombe), represents around 2676 Km2, being the productive part around 1880 Km^2.

• Type X: Mixed forest mosaic on dry land

It is located in the Sub-littoral savannah, and it has 210 Km^2.

• Without Type: Arboreal mangrove or shrub

They are on the coast (Rhyzophora, Avicennis) and are specific to transitional environments between fresh and salt water, have about 44 Km2 and are not suitable for the production of bioenergetics. Table 4 shows the dynamics of forest growth in m3 / year.

Table N° 4. Dynamics of forest growth

Forest Type	Dynamics m^3 / ha year	Surface Ha	Growth m^3 /year
I	10	43 100	431 000
II	10	188 000	1 880 000
X	15	21 000	315 000
Total		2 626 000	

Source: Own Elaboration

There are two types of palms in Cabinda according to their origins: the planted and spontaneous.

The planted palmar presents greater production capacity during the year, in relation to spontaneous palms.

Table 5 shows the quantities of (palms / ha) and their location.

Table N° 5. Placement of the palm farms

Farm N°	Name	Municipality	Localizaction	ha
1	Sassa-Zau	Cabinda	Sassa-Zau	120
2	Sócoto	Cacongo	Socoto	169
3	Tchuquisi	Cacongo	Massabi	500
4	Pinto da Fonseca	Buco-Zau	Bémbica	208
5	Mpuila	Cacongo	Mpuela	3 000
6	Marco Pinto	Buco-Zau	Melele-Inhuca	100
7	17 de Setiembre	Cabinda	Champuto Rico	2
8	Daniel da Costa	Cabinda	Malembo	15
Total				4 014

Source: Own Elaboration

In Table N° 6 we show the distances between the farm which is of interest for the macro-localization of installations processors of biodiesels.

Table N° 6. Distances between farms in Km

Farms Nº	1	2	3	4	5	6	7	8
1	0	20	34	67	37	57	22	16
2	20	0	34	44	8	43	32	14
3	34	34	0	54	12	54	20	13
4	76	44	54	0	55	36	70	62

5	37	8	12	55	0	40	23	12
6	57	43	38	36	40	0	65	54
7	22	32	20	70	23	65	0	13
8	16	14	13	62	12	54	13	0

Source: Own Elaboration

The spontaneous palm groves are more concentrated in the municipalities of Buco-Zau and Belize, in the communes of (Necuto, Miconge), in Cacongo (Massabi) and in Cabinda (Tando-Zinze). The three mentioned communes present spontaneous palm areas of greater relevance with respect to other regions. Table N ° 7 summarizes the availabilities of palm oil per farm for biodiesel.

Table N° 7. Capacity per farm (in ton/year of palm oil for biodiesel

Farms	Years			
	0	5	10	15
	ton/year	ton/year	ton/year	ton/year
SassaZau	4 134,5	4 134,5	6 278,0	15 246,6
Sócoto	516,8	516,8	784,7	1 905,8
Tchuquisi	68,9	68,9	104,6	254,1
Pinto Fonseca	5 822,7	5 822,7	8 841,5	21 472,3
Mpuila	17 227,2	17 227, 2	26 158,4	63 527,6
Marco Pinto	103 363,2	103 363,2	153 950,6	381 165,9
17 de Setiembre	3 721,0	3 721,0	5 650,2	13 721,9
Daniel da Costa	3 445,4	3 445,4	5 231,6	12 705,5
Totales	138 299,7	138 299,7	206999,6	509999,7

Source: Own Elaboration

Step 2. Surveillance on available and emerging technologies

Relevant internal and external information on technological trends is periodically monitored.

The current socio-economic outlook is marked by the process of globalization of markets, produced mainly by the substantial improvement of communications and transport, in which the development of Information and Communications Technologies (ICT) has been significantly influenced, allowing the exchange of knowledge at any time at a global level.

In the case of the study, a diversity of detected sources was consulted, it is derived that the type of documents to be monitored is very broad; from scientific-technological information (patents, scientific articles, standards, among others.) to information related to news, events, courses, technological supply and demand, research projects, it is also carried out semi-automatically.

According to this search, the technology proposed in Figure N ° 1 was selected.

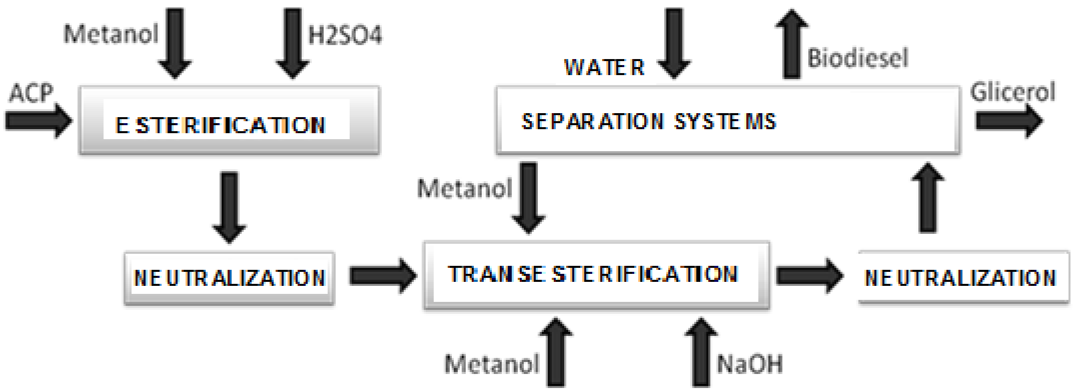

Figure N° 1. Technological Scheme of Biodiesel production using Palm oil
Source: Acevedo Pabón (2012)

Step 3. Diagnosis of raw material availability alternatives

This is another work step that is recommended when the raw material is insufficient or not compatible with existing technologies in the market, which is not the case.

Step 4. Technology scaling

In this work step, due to its specialized nature, partnerships are sought with third parties and, in this case, in particular with universities or research centers.

A group of specialists is formed, in charge of designing, selecting and carrying out the assembly of the generating plant, according to the type of raw material, materials and products.

Some conditions should be taken into account, such as: operational flexibility, productive capacity. The technology that is decided to design must contribute to reduce costs for production, so these plants must be well conceived from the beginning. To prevent pollution and generations of carbon dioxide.

Step 5. Planning supply chain alternatives

The procedure developed for this step includes as a first requirement the planning of the logistics of raw materials supply that has been recommended in previous works (Lubota et al., 2016).

The actual behavior for this case study is outlined below:

Proposed logistics systems

The logistics system includes the collection, transport, storage, handling and pre-treatment of bunches, that is, all activities between the point of origin of the palm and the biodiesel production plant.

The logistic system in the case study, because there are a number of palm farms, has several stages.

Next, the description of each of the stages is made:

Stage 1: Cutting and extraction area

The first phase will be carried out on the farms and will include cutting and extraction. Cutting refers to the operation that is carried out on the palm for palm bunch cuts, then the extraction or removal of the bunches for the treatment centers, and their transport to the collection place.

When the fruit is harvested, the bunches and loose fruits are collected from the ground and deposited in the cargo containers of the transport equipment that finally lead them to the collection point in the farm.

This transport within the lots of the crop is usually known as primary or internal transport, while transport from the collection sites to the treatment plant is known as secondary transport or external transport. In Cabinda, a variety of primary transport systems are used, such as: a) On the shoulder; b) Tractors with the corresponding implement; c) Forklifts; d) Truck pulled by a tractor; e) Cart pulled by a buffalo; f) Pallets.

Stage 2: Bunches treatment center (shatter)

They are special areas where the fruit of several lots or small farms converge. They are located in strategic sites, easily accessible to producers and to the equipment that transports the fruit to the beneficiation plant. This kind of collection treatment centers are frequent in areas where there are productive alliances between small producers and the processing plants.

In these treatment centers, facilities are built that house the scale, the custodian, the office, the patios and hoppers for the discharge of fruit that arrives in the internal transport equipment; these fruits will then be threshed.

Before moving the fruit to the plant, in addition to the daily planning that must exist between the field and the plant, it is important to take into account the following recommendations:

o Minimize the routes for the loading of the fruit.

o Coordinate permanently with the supervisor of harvest the sites or sectors where the harvest personnel travel to make efficient the displacement of transport equipment.

o Maintain the flow of materials to the transportation system.

o Verify that all the harvested fruit is loaded on the day of cutting.

o Verify that there is a minimum of contamination with impurities at the time of loading and prevent such impurities from leaving the transport equipment.

o Check that there are no overloads of the equipment.

o Verify that the personnel use the protection implements.

So that the fruit of the palm arrives at the plant of benefit, where it will be processed, it is necessary to transport it from the sites or collection centers. This work is done with the support of teams described below:

- Double chassis truck: They have capacity for 20 or more tons. This demands roads in very good condition, preferably paved or with good assertion. They are suitable for journeys of 30 to 50 kilometers.

- Livestock trucks: They have a capacity to transport between 12 and 15 tons of fruit. They are very useful for intermediate journeys (from 30 to 50 kilometers), and for uneven terrains as well as for paved roads.

-Tract trucks: They are vehicles for transport at great distances (over 100 kilometers), and have a capacity of up to 35 tons. They are not versatile equipments in uneven terrains or in narrow ways.

- Mixed systems of loading and transport: They are vehicles to which a hydraulic or mechanical system is conditioned to load the fruit from the collection site and unload it in the hopper of the processing plant.

Step 3: Generating Plant

After the unloading of the materials with destination to the central store of the plant, the transesterification process of the palm oil is carried out. The process consists broadly of two stages mainly that are:

- Esterification of the free fatty acids (FFA) present in the oil within the methylestere, followed by,

- Transesterification of the mixture of the neutral glycerides directly into the methylestere.

Stage 4. Determination of the optimum initial capacity of the facility considering the uncertainty of future changes

Based on experience, in previous studies by Rudd and Watson (1968) and similar works for the sugarcane industry developed by Oquendo (2002), Lubota et al., (2016) has proposed a procedure that is represented in Figure No. 2.

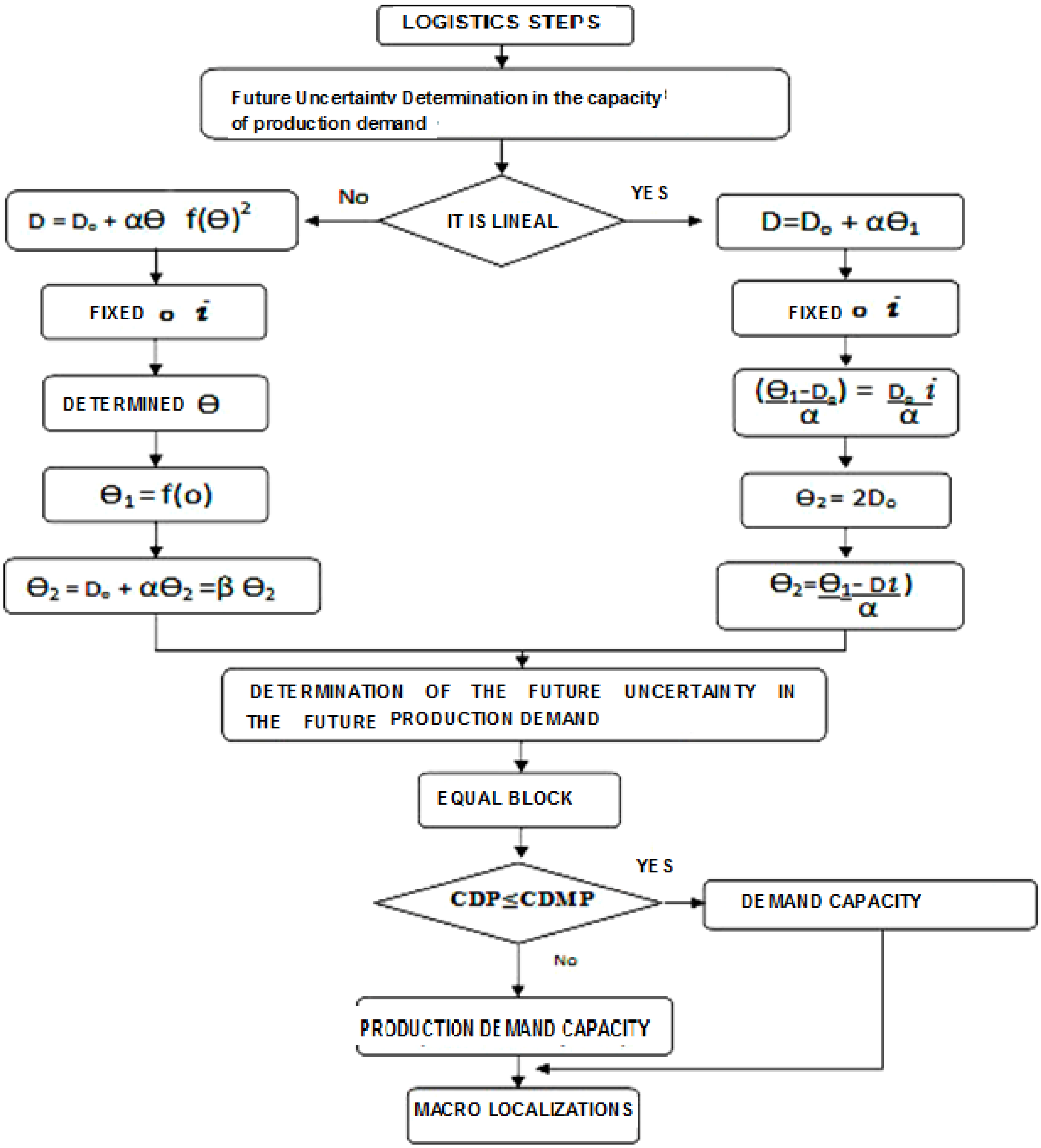

Figure N° 2. Specific procedure to define the initial size of the installation and its macro localization
Source: Lubota et al., (2016)

This procedure includes two stages, one to study the uncertainty in the production demand of the facility and another for uncertainty in the availability of raw materials for bioenergy. The growth required in the production of biodiesel have been estimated starting from the quantities of aluminum to be recycled and electrical energy for the plastic processing are summarized in Table N ° 2 considering the future changes in Table N ° 1.

The first step of the procedure includes the adjustment to an equation of the growth of the demand of bioenergetics and of availability of the raw material. Figure N ° 3.

Demand for Biodiesel

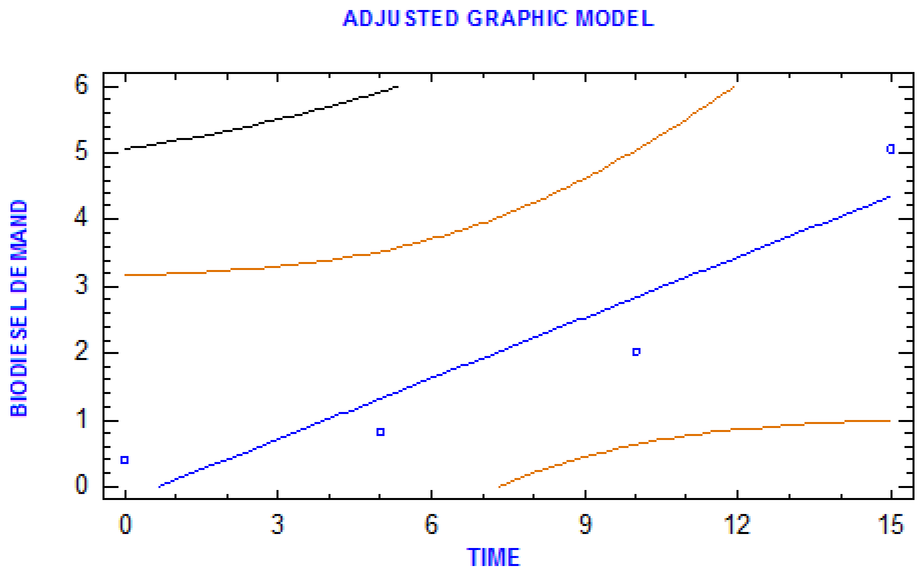

Figure N° 3. Growth of biodiesel demand for the recycling of aluminum with time.
Source: Own Elaboration

The equation of the adjusted model was:

Demand for Biodiesel = -20422.6 + 30367.7 * Time (Equation 1)

Based on this information, applying the methodology proposed in step 5 of the procedure for the determination of the initial investment capacity and also considering the financial uncertainty (Lubota et al., 2016), the results for the biodiesel that is expressed in the Tables 8 and 9, for the case of biodiesel, which also includes the time to carry out the first expansion.

Table N° 8: Initial capacity considering the demand for biodiesel

	Initial demand non nul (without over designing)			FORMULAS
Pending	0,12	0,15	0,18	(without over designing)
	30 367.70	30 367.70	30 367.70	
Initial capacity (Kg/day)	292 919.76	242 306.92	208 565.03	$C^*_i = b_1/i+bo$
First Enlargement (years)	8,33	6,67	5,56	$\theta = (C_1\text{-}bo)/b_1$

Enlargement capacity (kg/day)	253 064.17	202 451.33	168 709.44	$C^{*}=b_1/i$
Total	545 983.17	444 758.35	377 274.47	$C_t = C^{*}_i + C^{*}$

Source: Own Elaboration

The equation of the adjusted model was:

Availability of Palm bunch = 71130 + 23736 * Time (Equation 2)

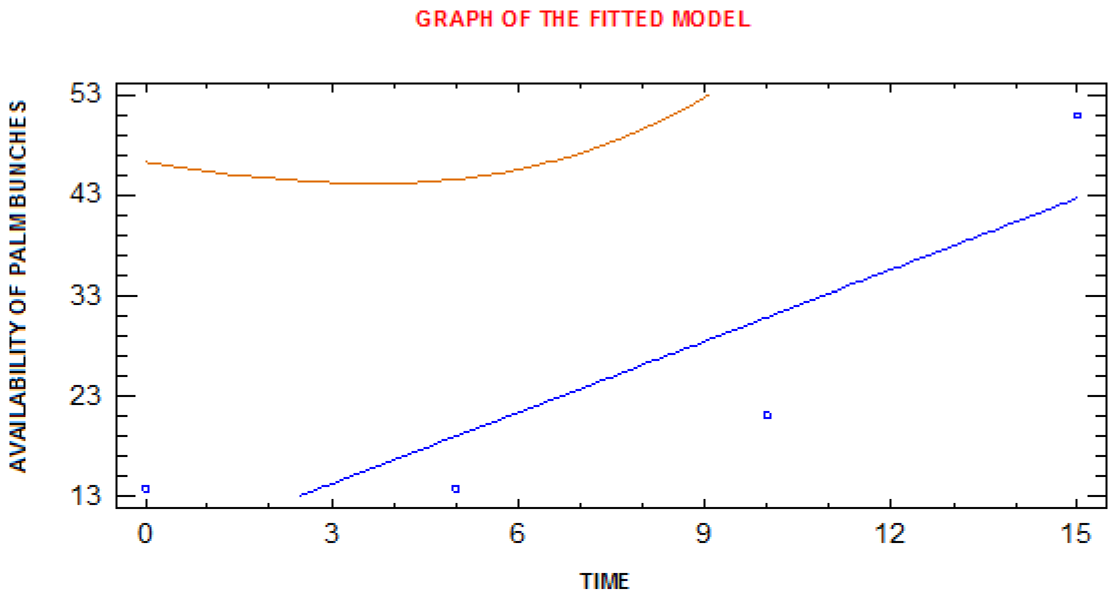

Figure N° 4. Growth of availability of Palm Oil to produce biodiesel for the recycling of aluminum with time

Source: Own Elaboration (2016)

Table N° 9. Initial capacity considering the initial availability of African Palm Oil

	Initial demand non nul (without overdesig)			FORMULAS
	0,12	0,15	0,18	(without overdesign)
Pending	23 736	23 736	23 736	
Initial Capaccty (kg/day)	336 100	296 540	270 166.66	$C^{*}_i = b_1/i+bo$
First Enlargement (years)	8,33	6,67	5,56	$\theta = (C_1\text{-bo})/b_1$
Enlargement capacity (kg/day)	197 800	158 240	131 866.67	$C^{*}=b_1/i$
Total	533 900	454 780	412 033.33	$C_t = C^{*}_i + C^{*}$

Source: Own Elaboration

In Table N° 10 there is a summary of the results, from which analysis one concludes that the limit for the initial and later investment capacity is given by the availability of African Pam Oil (APO).

Table N° 10. Determination of the initial investments conditions for the processing installations of Palm oil for biodiesel

Initial	APO Availability (kg/day)	Demand of Biodiesel (kg/day)	APO requirement According to demand (kg/h)	Possibilities according to availability (kg/h)
$C_{1\,(0.12)}$	336 100,00	292 919,76	507 659,90	193 929.70
$C_{1(0.15)}$	296 540,00	242 306,92	419 942,67	171 103,58
$C_{1(0.18)}$	270 166.66	208 565.03	361 464.52	155 886.16
	Years	years		
$\Theta_{1(0.12)}$	8,33	8,33		
$\Theta_{2(0.15)}$	6,67	6,66		
$\Theta_{3(0.18)}$	5,56	5,55		

Source: Own Elaboration

The results of Table No. 10 allow us to understand that the limiting aspect for the initial investment values is the availability of APO, since, for example, if we consider the highest financial interest rate i = 0.18, we have that while the demand to obtain 208 565.03 Kg / day of biodiesel, demand 361 464.52 kg / day of oil, which is much higher than the 270 166.66 kg / day that is actually available, which barely allow obtaining 155888.16 kg / day of biodiesel. In accordance with these results, we proceeded to estimate the investor values of both facilities and other economic indicators when the plant is producing at full capacity in the sixth year.

Stage 5. Optimization of transportation costs of Palm Oil and Biodiesel for the processing of Aluminum USW

A problem of minimizing costs for transportation is raised in the following way in order to optimize such costs:

Variables of decision

B_i: Binary variable which indicates if a processing plant is installed in the location i. $i = 1 \dots n$

X_{ij}: Quantity of palm tons to be transported between locations i y j. $i = 1 \dots n, j = 1 \dots n$

Y_{ij}: Quantity of biodiesel tons to be transported between locations i y j. $i = 1 \dots n, j = 1 \dots m$

Parameters

L_i: Places involved. Collection centers of palm and other possible places to install a processing center- $i = 1 \dots n$

P_i: Palm production in each location. $i = 1 \dots n$

LD_j : Subset of places where biodiesel is consumed. $LD_j \subset L_i, i = 1 \dots n, j = 1 \dots m$

D_{ij}: Distance between locations i y j. $i = 1 \dots n, j = 1 \dots n$

D_j: Demand of biodiesel in each location. $j = 1 \dots m$

C_{palm}: Cost of transporting a ton of palms a distance of one kilometer

$C_{biodiesel}$ Cost of transporting a ton of biodiesel a distance of one kilometer.

$f: \mathbb{R} \to \mathbb{R}$: Function which indicates how a quantity of palm biomass is transformed into biodiesel.

Objective Function

$$\min Z = C_{palm}\left(\sum_{i,j \in L}(X_{ij} D_{ij})\right) + C_{biodiesel}\left(\sum_{i \in L}\sum_{j \in LD}(Y_{ij} D_{ij})\right)$$ (Equation 3)

Restrictions

In one location one can install a processing plant, but this is not obligatory, this is shown in the binary variable B_i

$$B_i \in \{0,1\} \qquad \forall i \in L$$

To limit the total number of processing plants, one must add a restriction:

$$\sum_{i \in L} B_i = 1$$

The following restriction ensures that each location where palm is produced can only send a maximum amount of this product:

$$\sum_{j \in L}(X_{ij}) \le P_i \qquad \forall i \in L$$

Each place where biodiesel is consumed must receive a minimum amount of biodiesel:

$$\sum_{i \in L}(Y_{ij}) \ge Dem_j \qquad \forall j \in LD$$

The amount of biodiesel that leaves each location is less than the amount of biodiesel produced in that location:

$$\sum_{j \in LD} Y_{ij} \leq B_i f\left(\sum_{k \in L}(X_{ki})\right) \qquad \forall i \in L$$

The conditions of minimum transportation cost, to satisfy the demand that originates the determined initial investment, of 155 886.16, kg of biodiesel / day, were determined for the conditions of Cabinda in 4 743 456.82 USD / year. The macro location of the biodiesel production facility is located in the area of Mpuila, Municipality of Cacongo.

Step 6. Technical, economic and environmental evaluation of the new technology

The aim of the proposal to invest in a renewable energy source is to reduce expenses for fossil fuels and thus make the process profitable and less impact on the environment.

For the analysis, the investment costs and production costs were determined according to the methodology proposed by Peters and Timmerhauss (1981).

The costs of the equipment were sought in the Peters and Timmerhauss (1981) and updated by the current cost index of 2016 predicted as recommended in the scientific literature (González et al., 2012).

Once the fundamental equipment of the plant was dimensioned, the economic analysis of the plant was carried out, based on the calculation of the investment cost, the cost of production, the profit and the profitability indicators.

Determination of the total investment cost and annual production of the palm oil processing plant in biodiesel

The basic studies of the investment were referenced to the study carried out by Sambovo, (2015), according to it for an installation of a capacity of 23 028.16 kg / day being the estimated results, for a production capacity of 430 9l 6.11kg / day :

The CFI values are estimated for the new conditions according to the expression of the rule in point six (Peter and Timmerhauss, 1981).

$$CFI_{cp_n} = CI_{cp_r} \cdot \left(\frac{cp_n}{cp_r}\right)^{0.6} \quad \text{(Equation 4)}$$

being:

CI_{cp_n} : Fixed Capital invested in the new capacity (U$D)

CI_{cp_r} : Fixed Capital Invested in the reference capacity (U$D)

cp_n :New Capacity (Kg/day)

cp_r : Reference Capacity (Kg/day)

CFI = 7 739 736.53 U$D the production of biodiesel with155 886,16 kg palm oil/per day.

To determine investment costs, the methodology proposed by Peters and Timmerhauss (1981) was used, as well as the economic information available to estimate investment costs. Table 11 summarizes the components of Investment Expenditure.

Table No. 11. Components of investment expenses for the transformation of palm oil into biodiesel. Installed capacity: 159 348.16 kg / day

Components		Cost (U$D)
Equipment Costs	100 %	2 668 487.24
Equipment instalation	35%	933 970.53
Instrumentation and control	15%	400 273.08
Tubing	10%	*266 848.72*
Electric Instalation	11%	293 533.59
Buildings	18%	*480 327.70*
Preparation of land	10%	*266 848.72*
Process requirements	40%	1 067 394.89
Land	6%	16 010.92
Engineering and supervision	5%CD	319 684.77
Constuctive expenses	10%CD	639 369.54
Unexpected	5%CFI	0.05 CFI
CFI= CD+CI = 7 352 749.7+0.05 CFI		
Fixed Capital Invested (CFI)		7 739 736.53
Work Capital (CT)	CT = 8%CFI	619 178.92
Total Capital Invested (CTI)	CTI = CFI+CT	8 358 915.45

Source: Own Elaboration

For the determination of Total Production Costs it is necessary to consider all raw material inputs and add the Transportation Costs of Palm Oil to the processing plant and from this to its destination to the Aluminum Recycling Plant. Adding to the Raw Materials the Minimum Cost of Transportation (CTMP) = 19 980 291.927 USD / year is:

Table No. 12. Components of production costs for the transformation of APO. 100% Design capacity 159 348.16 kg / day

Components	%	Costo U$D
1. Fabrication Costs = C. Direct + CF + direction costs		
Raw materials		19 980 291.927
Manual labour	10 % CTP	
Supervisión	15 % CTP	
Requirements	10% CTP	
Maintenance and repair	10% CFI	773 973.65
Supplies	0.015 CFI	116 096.048
Lab. Expenses	0.01% CTP	
Patents and Royalties	1% CTP	
B. Fixed expenses = 928768.38 USD		
Depreciation	0.10 CFI	773 973.65
Taxes	0.01 CFI	77 397.365
Insurance	0.01 CFI	77 397.365
Administrative	0.15 %CTP	
Distribution and sales	0.02% CTP	
Research and development	0.02% CTP	
Financial Interests	0.07 CTI	58 512.40
Product total costs = 0.362 CTP + 21 857 642.41		
Product total costs = 32 142 731.11 U$D/year		

Source: Own Elaboration

The calculation of the Annual Total Production Costs must be made for the different production capacities that may be achieved in the years of operation of the facility, which although they will gradually grow as the installed capacity is used more, they will decrease as unit costs.

For the determination of these Total Annual Production Costs, the percentages of utilization of the capacities obtained with the different possibilities of availability of Palm Oil were selected.

For profitability studies it is necessary to determine the economic conditions in the first 10 years of production in which there will necessarily have to be a period of waste of the installed capacity due to lack of recycled aluminum raw material in the USW that will gradually be covered in the first 5 years

Accordingly, the annual production and cost levels will be as shown in Table No. 13.

Table No. 13. Economic indicators of investments to obtain African palm oil biodiesel

Economic Indicator	Year					
	0	1	2	3	4	5 a 10
% utilization	0	0.44	0.63	0.82	0.85	1.00
Production Cost (MUSD)		16 722.0	22 672.3	30 564.2	32 142.7	32 142.7
Volume of production (ton/day)	0	**70. 05**	100. 39	130. 66	135. 44	159. 35
Production Volume (ton/year)	0	23 160.5	33 128.4	43 119.6	44 697 .1	44 697.1
Production MUSD/year (0.763386 USD/kg)	0	22 624. 1	32 422.8	42 201.1	43 745. 1	43 745. 1
Gain (M USD)	0	5 902. 0	9 750. 5	11 636. 9	11 602. 3	11 602. 3

Through the study, the dynamic indicators were determined, which gave the following values: VAN = 1 832409.66 USD; IRR = 22%; and PRD = 3 years.

Source: Own Elaboration

Step 7. Incorporation of technology

In this step, in accordance with the results obtained in the economic indicators of the investor proposal, the formal proposal of a project for the execution of an installation for the recycling of aluminum and the bioenergy required for this process is adequate, using African Palm Oil.

A proactive attitude is required to increase the availability of African Palm Oil to a future of no more than five years in order to increase the possibilities of aluminum recycling in Cabinda.

CONCLUSION

It is feasible to apply a specific procedure to plan the determination of the initial size of a production facility for African Palm Oil biodiesel and its macro location in the supply chain of the biomass conversion processes in energy carriers.

The initial capacity to be installed for the conversion of African Palm Oil into biodiesel is limited by the availability of that raw material, so future actions must be taken to eliminate this restriction and increase the possibilities of Aluminum Recycling and be able in 5 years the investment to increase the installed capacity for the Production of Biodiesel and Aluminum Recycling.

The initial capacity of the required investments to obtain African Palm Biodiesel and Aluminum Recycling must satisfy values of biodiesel production of 155 886.16 kg / day, with a 3 year investment recovery period.

REFERENCES

Please refer to articles in Spanish Bibliography.

BIBLIOGRAPHCIAL ABSTRACT

Please refer to articles Spanish Biographical abstract.