

CASE

Bio-ethanol from cassava waste (ETAVEN, Carabobo, Venezuela)

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Supporting case for Business Model 9

Location:	ETAVEN, Carabobo, Venezuela
Waste input type:	Cassava waste
Value offer:	Bio-ethanol (as additive to petrol/ gasoline as transportation fuel)
Organization type:	Private
Status of organization:	Established in 2007, Business operational since 2012
Scale of businesses:	Medium
Major partners:	University of Carabobo, Ministry of Science and Technology, Libertador Municipality Mayor's Office

Executive summary

ETAVEN C.A. (ETAVEN) is a private Venezuelan company established in 2007 that has patented a process for producing ethanol “Yarethanol” using proprietary rights for the strain of bacteria for fermentation from yare, a by-product of cassava processing. Yarethanol is an ecological, non-fossil, non-poisonous, non-polluting and high demand, renewable fuel. It is produced at 50% of the market price through the patented process with a high yield of 50%.

ETAVEN is situated in the cassava-flour-processing region of Venezuela, which allows it to easily and cost-effectively purchase sub-optimal cassava that cannot be used for other commercial purposes, as well as residual plant waste (yare) associated with cassava flour production. By purchasing and using this waste, ETAVEN has had a significant positive impact on both the local community and environment, reducing the pollution associated with high cyanide run-off from improper disposal of cassava into local rivers and lakes, reducing GHG emissions and increasing the incomes of local cassava farmers by up to 50%. It has a very high social impact due to creation of jobs (>1,500 jobs) fostering agriculture. The company began Yarethanol production in the third quarter of 2012, and through franchise model, it seeks to expand its market beyond Venezuela.

KEY PERFORMANCE INDICATORS (AS OF 2012)						
Land use:	5 ha					
Water requirement:	8,000 L monthly (water is reused to wash cassava)					
Capital investment:	USD 2.5 million (Site utilized the existing infrastructure of a former sugar cane refinery)					
Labor:	50 plant employees; and 12 university volunteers to analyze and improve the process					
O&M cost:	Approx. USD 375,000 per annum (forecast 2013)					
Output:	30 tons/ day of Yaretanol					
Potential social and/or environmental impact:	Reduced water pollution previously caused by improper yare waste disposal into local rivers, reducing GHG emissions by substituting petrol used for transportation, creation of jobs, Improved incomes of approx. 300 local cassava farmers					
Financial viability indicators:	Payback period:	< 2 years	Post-tax IRR:	> 50%	Gross margin:	99%

Context and background

The cassava is one of the most drought-tolerant crops, capable of growing on marginal soils. The average yield of cassava crops worldwide was 12.5 t/ha in 2010. The cassava plant gives the third highest yield of carbohydrates per cultivated area among the crop plants, after sugarcane and sugar beets. The plant must undergo processing immediately after harvest (within 48 hrs) to remove compounds that generate cyanide. Yare is a regional name for the milky juice arising from pressing bitter cassava that has a high cyanide content. Venezuela produces 60,000 tons of yare per year which traditionally goes unused and improperly discarded.

Until now, the yare is not used in Venezuela as a source of ethyl alcohol (as bio-fuel). ETAVEN undertook research and laboratory experiments for two years and obtained 50% yield of ethanol from yare. Cassava is one of the richest fermentable substances for the production of alcohol. The fresh roots contain about 30% starch and 5% sugars, and the dried roots contain about 80% fermentable substances which are equivalent to rice as a source of alcohol. ETAVEN uses the sub-optimal cassava that cannot be used for other commercial purposes, as well as residual plant waste (yare) associated with cassava flour production. Cassava processing produces annually big quantity of wastes, and if they are not properly managed, they can cause a serious pollution to the environment and human life.

Ethanol has been known to slightly improve gas mileage. It has a high-octane rating of 113 and improves performance while keeping the engine clean. Ethanol also contains 67% more energy than it takes to produce, so it is efficient for your car and for the environment. An important advantage of biofuels is that they can easily be integrated into the existing transport infrastructure, thus avoiding the significant investment costs associated with other renewable options for the transport sector.

In 2008, ETAVEN patented an engineered yeast strain that efficiently produces Yaretanol or ethanol from yare. In early 2012, ETAVEN completed construction of its pilot ethanol plant and began producing ethanol in Q3 of 2012. It then produced approximately 30 tons of ethanol per day, roughly 1% of Venezuela's national consumption of ethanol. ETAVEN ethanol plant is located in Western Venezuela in the Libertador Municipality, which has a robust cassava processing industry, comprising more than 150 producers and over 300 farmers who supply cassava for bread making. However, small cassava roots or diseased plants cannot be used to produce cassava flour for bread, resulting in approximately 40%

of the local cassava going to waste. Unused cassava was traditionally discarded in local waterways (rivers and streams) where it was left to rot and release toxins. Yare is high in cyanide that can leach into the water supply, while plant decomposition releases methane into the atmosphere. ETAVEN procures yare from either farmers or cassava-flour-making units to produce ethanol, which is sold to oil companies in Venezuela to blend it with gasoline.

Market environment

Ethanol production from yare is dictated by both availability of yare and demand for ethanol. Cassava is the third most common source of food in tropical countries after rice and maize with total production reaching approximately 250 million tons in 2011, according to the UN. Within Latin America, Brazil is the dominant player, accounting for approximately 70% of regional production. Considering the high comparative ethanol yield from yare and that it can be used alongside food production, rather than competing with it, there is a significant opportunity in all cassava-producing countries to increase the potential incomes of cassava farmers.

Global consumption of ethanol has surged during the last 10 years, driven by greater environmental awareness, advances in technology that have made ethanol cost-effective and suitable for fuel and growing national interest in energy independence and security. Furthermore, government subsidies and mandates have driven ethanol's growing popularity. A number of additional countries have begun to require a minimum ethanol blend in gasoline. In addition, there has been significant public investment into the ethanol distribution infrastructure to accommodate this increasing production and demand. Global consumption of ethanol increased during 2002–2012 by approximately 500% reaching 1.4 million barrels per day, led by the U.S. and Brazil who accounted for over 85% of total ethanol production and consumption in 2012.

The two key sources of competition for Yaretanol are: 1) other ethanol producers and 2) the oil industry (for petroleum). Approximately 90% of the ethanol used in Venezuela is imported from Brazil at twice the price of Yaretanol, while 1% is produced by ETAVEN and the remaining 9% by other domestic producers. Other sources used to create ethanol are sugarcane and corn.

Though ethanol is a viable substitution of petroleum in combustion engines, it is used only if mandated by the government. In 2006, Petroleos de Venezuela S.A. (PDVSA), the Venezuelan state-owned oil company, announced their "Ethanol Agro-energy Development Project", a USD 1.3-billion initiative. To increase the production of ethanol, PDVSA plans to build 14 ethanol distilleries by 2012 with an output of 20,000 barrels per day of the biofuel. Venezuela imports ethanol to mix in gasoline. The plan's focus has been to double the amount of land used for sugarcane cultivation over the next five years competing with Brazilian sugarcane imports.

Macro-economic environment

ETAVEN is aware of potential obstacles from vested interests including the PDVSA (with their direct interest in sugarcane ethanol), the Government of Venezuela (due to reduction in tax revenue in dollars), importers of ethanol from Brazil and manufacturers of ethanol from Brazil. Hence, ETAVEN is planning to focus on expanding into Latin America (Costa Rica, Panama, Dominican Republic and Peru) and a number of African countries rather than expansion of their market locally. Many countries are striving for energy independence by way of biofuels that do not come from foodstuffs. Significant research has begun to evaluate the use of cassava as the ethanol biofuel feedstock. On December 22, 2007, the largest cassava ethanol fuel production facility was completed in Beihai in China, with an annual output of 200,000 tons, which would need an average of 1.5 million tons of cassava. In November 2008, China-based Hainan Yedao Group reportedly invested USD 51.5 million (£ 31.8 million) in a new

biofuel facility that is expected to produce 33 million US gallons (120,000 m³) a year of bioethanol from cassava plants (<https://en.wikipedia.org/wiki/Cassava>; accessed 18 January 2018).

Business model

ETAIVEN's key value propositions (Figure 106) is the production of bio-ethanol from yare for blending with petrol, in the process reducing environmental hazard of pollution of water bodies through leaching of cyanide and reducing in methane emission from natural decomposition. ETAIVEN spent initial years in developing technology to process yare to ethanol. Once the technology was ready for commercial production, it formed partnerships to secure procuring of cassava and its by-products from farmers and cassava-processing mills. ETAIVEN does not use any middlemen and takes direct responsibility of delivering ethanol to petroleum companies. There is potential for the business model to create additional value making cassava flour and selling cassava shells as animal feed.

Value chain and position

Yaretanol has higher octane rating than petrol as fuel. It is an octane booster and anti-knocking agent, reducing country's dependence on petroleum, source of non-oil revenue for the producing country, and reducing adverse foreign trade balance. ETAIVEN has patented its technology and process of producing ethanol from cassava and yare (Figure 107). The company buys cassava directly from approximately 300 local farmers, who sell diseased or small roots unsuitable for use in bread making, or it buys yare produced during pressing for flour production from small-scale cassava flour producers. Both supplier groups provide ETAIVEN with waste that cannot be sold or used otherwise; therefore, supplier power is relatively low. Cassava is delivered directly to the plant, while yare is collected by ETAIVEN through its fleet of collection tanker trucks. ETAIVEN also relies on about 12 university volunteers each month, who evaluate and monitor operations, as well as provide staff training and write key operating manuals.

ETAIVEN sells its ethanol to two key clients, Venezuelan petrochemical companies Solven and Inproin. In the context of Venezuela, though the demand for ethanol is high, there is significant buyer power as oil and gas companies can choose whether or not to blend petrol with ethanol. It is yet not mandatory by the Government of Venezuela. If ETAIVEN is able to supply consistently necessary amount to oil companies, the buyer power will remain lower as long as they are willing to blend petrol with ethanol. The primary substitute for Yaretanol is ethanol produced from other products, such as sugar cane or corn. It is unlikely that buyers have a propensity to buy ethanol derived from any particular feedstock; therefore, the threat of substitutes is relatively high. Yaretanol has the lowest production cost of USD 0.18 /L, in comparison to USD 0.35 for corn and USD 0.22 for sugarcane. Therefore, it is very competitive on a cost basis.

The ETAIVEN can also use starch and ethanol as a base for biopolymers and plastic extract as a base for bio-combustibles. The fermentation by-products with other waste streams, including animal manure and human excrement, can further be anaerobically digested to produce biogas and biological fertilizers. The ethanol can also be used as cooking fuel using specially-designed efficient cook stoves. The project is recognized as CDM to generate carbon credits. The cassava peels can be used with livestock manure as inoculum to generate biogas.

Institutional environment

Though Venezuela is the fifth largest oil exporting country in the world and the industry is a significant source of wealth for the country, the Government of Venezuela has promoted ethanol as a substitute for lead additives in gasoline. The Government of Venezuela did express an interest in 2006 to expand ethanol production (from sugar cane). However, it has not as yet made it mandatory to blend for domestic usage. ETAIVEN has patented its proprietary strain of yeast in Panama, since Venezuela exited

FIGURE 106. ETAVEN BUSINESS MODEL CANVAS

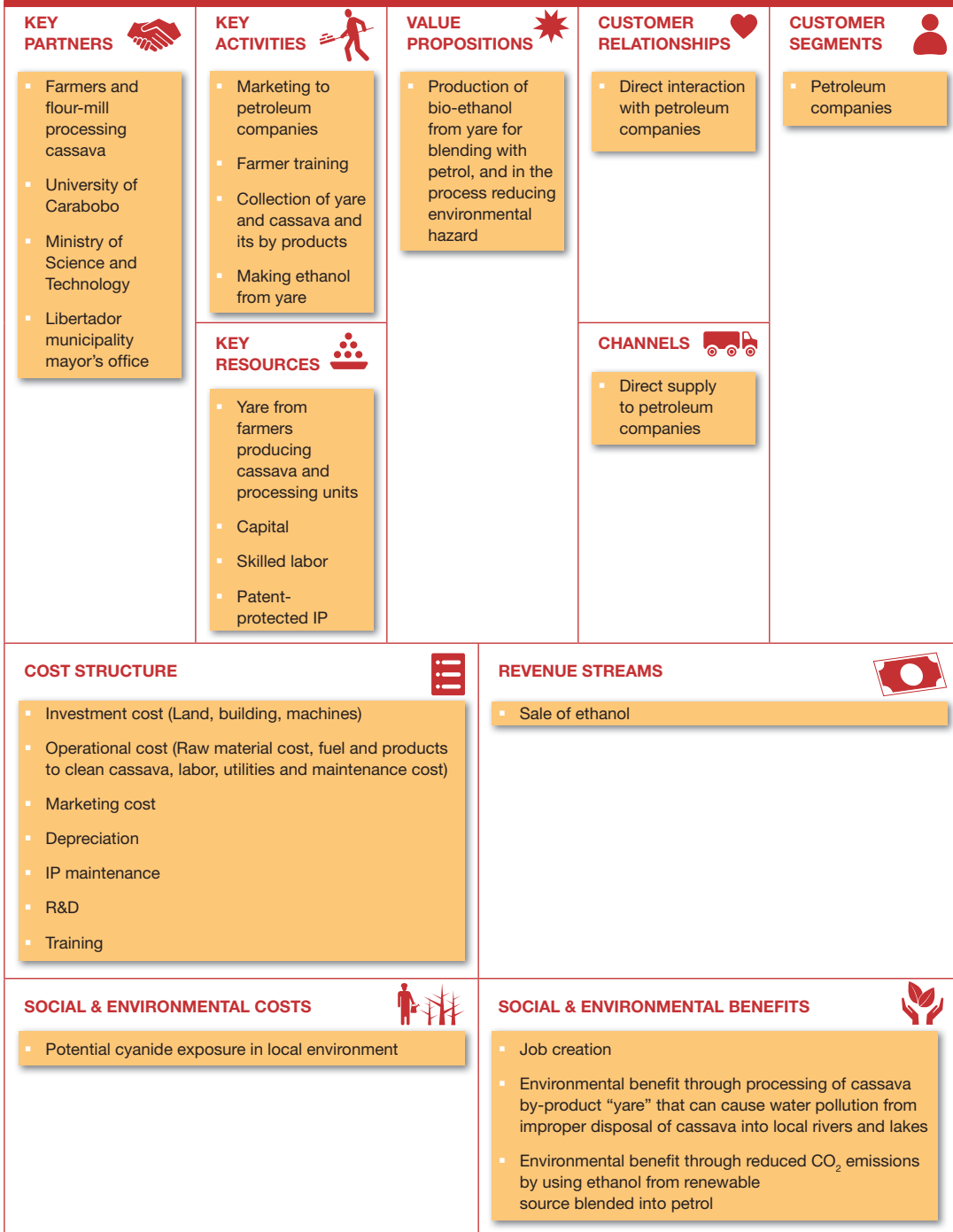
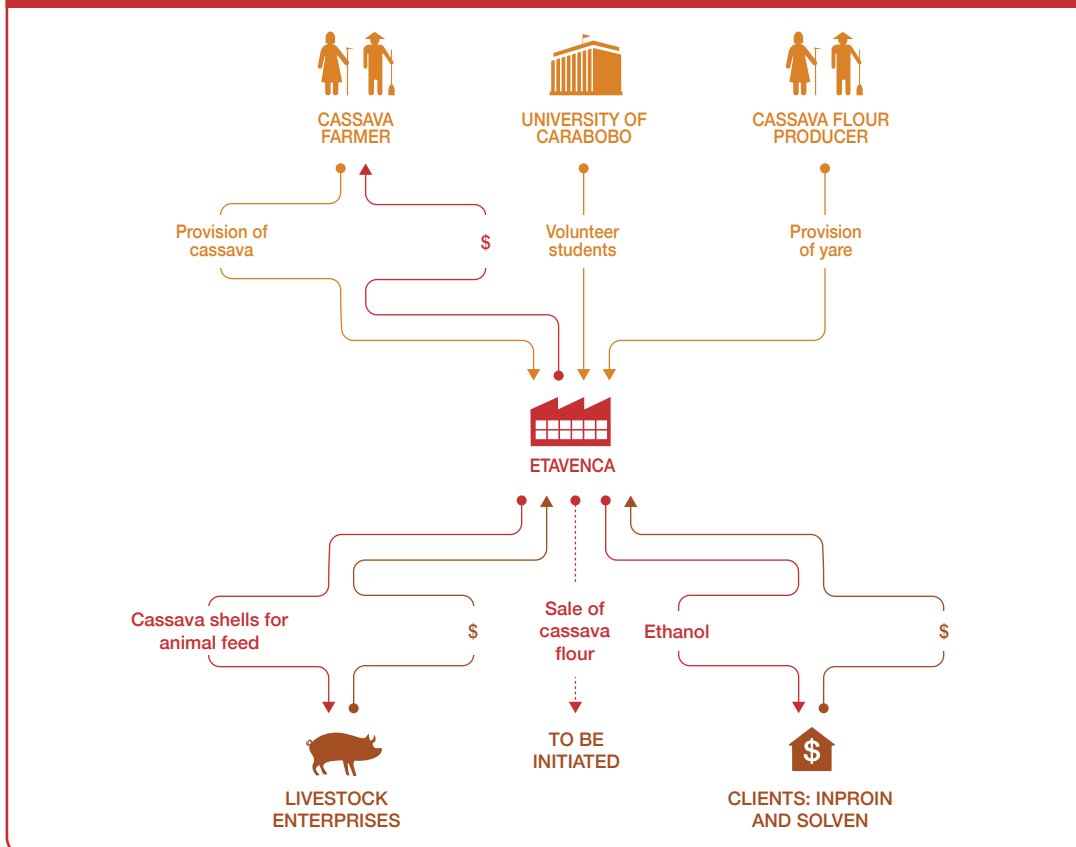


FIGURE 107. ETAVEN VALUE CHAIN

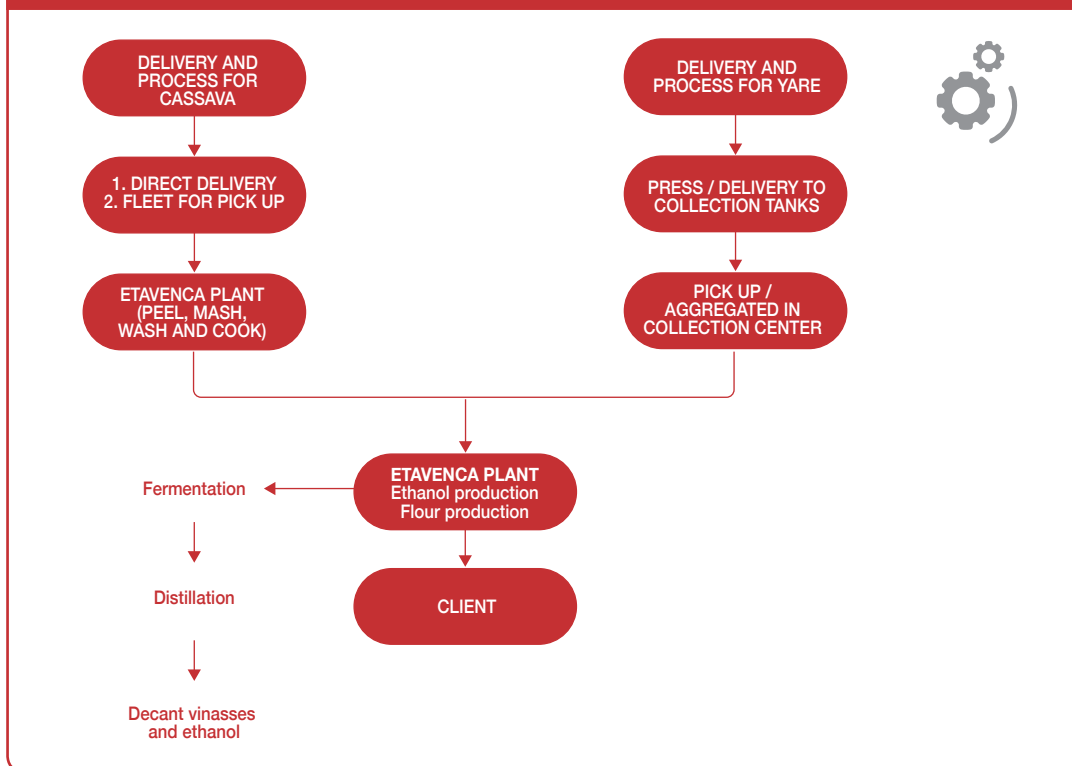


the Andean Community of Nations (CAN) in 2006, and thus, patents established in Venezuela cannot be legally enforced. Blends of E10 (petroleum with 10% ethanol added) or less have been mandated in over 20 countries, spearheaded by the US; however, a required blend has not been implemented yet in Venezuela. The National Council of Scientific and Technological Research (founded in 1967) and the state Ministry of Science and Technology direct and coordinate research activities in Venezuela.

Technology and processes

ETAVEN patented process for producing ethanol from the yare and cassava is as follows (Figure 108): ETAVEN receives two forms of feedstock: 1) yare from the cassava farmers that produce flour and 2) cassava directly from farmers. For cassava farmers that deliver yare, farmers are required to manually press the cassava to extract the liquid and deliver it to nearby collection tanks. ETAVEN owns a fleet of approximately 15 vehicles used to collect yare from each of its collection tanks that are situated near the farms and deliver to a collection center whereby it is aggregated and fed into the plant. In the case of cassava received directly from the farmers, ETAVEN receives the cassava through two different methods; 1) directly from the farmers delivering it to deposits at the plant or 2) utilizing their fleet of vehicles to pick it up directly from farms. For the collected cassava, it is peeled, mashed and then heated up with water to help with the conversion of the starch molecules into sugar, then strained. The cassava skin from peeling process is given away to be used for animal feed. The process of ethanol fuel production involves yeast fermentation of sugars, distillation and dehydration.

FIGURE 108. PROCESS DIAGRAM OF ETAIVEN



The liquids extracted from cassava is fermented with the ETAVENCA strain of yeast in fermentation tanks and undergo distillation process which results in both ethanol and vinasses (residual waste left after distillation) being separated out. The resulting ethanol is then ready to be sold to clients, and the vinasses is treated and disposed. The yield of conversion is about 70–110 L of absolute alcohol per ton of cassava roots depending on the variety and method of manufacture.

There are other optional technologies available for treating cassava-processing waste (from small and large factories). These options include: landfilling, use as animal feed, ensiling of solid residue, fermentation of cassava peel, use of wastewater for irrigation, infiltration of wastewater into the soil, storage in aerobic or anaerobic lagoons and anaerobic digesters. One way is to build anaerobic and aerobic lagoons (ponds) to treat the waste before its disposal. In the condition of anaerobic digestion of cassava waste, cyanide is released in the form of liquor and then liberated by enzymatic and non-enzymatic reactions. This system is very effective and environmental sound but requires a large area of land and large capital investment and therefore is suitable only for the large processing plant. In case cassava processing is of small to medium scale, wastewater can be treated through channelling the waste into shallow seepage areas. The areas, however, should be situated away from natural water sources. Cassava-processing wastewater can also be effectively utilized as a liquid fertilizer, if it is well treated. However, if the waste is not properly treated resulting in its high HCN content that can have a negative effect on plant growth, the use of wastewater for irrigation or as a source of fertilizer should be restricted.

Funding and financial outlook

ETAVEN was established in 2007 by four founding partners who each invested approximately USD 650,000 for a total investment of USD 2.5 million (Table 30) to convert a former sugarcane refinery into the ETAVEN ethanol plant. Total cost was lower than the cost to purchase and restore a brown-field site, in part, because a number of the pre-existing fittings and equipment could be re-used. The most significant capital expenditure items after the land and sugar cane refinery were the four distillation towers, costing approximately USD 75,000 each.

The key production costs for ETAVEN are electricity and raw materials; however, both are low, allowing the company to achieve operating margins in excess of 85%. The feedstock is bought at nominal value (USD 0.02 /L) as it cannot be used for any other purpose, and ETAVEN effectively serves as a waste collection service improving conditions for surrounding farms. The most significant operational cost (approximately 45% in 2012) is for staff wages as the firm employs a substantial workforce of 50 employees. However, only 19 of those employees are officially recorded because the remaining 31 are considered temporary for legal purposes (both are included in the numbers below). From the remaining operational costs, the most significant line items are for fuel (approximately 14% in 2012) and products used to clean the cassava and disinfect equipment (approximately 17%). In addition, ETAVEN runs a significant education budget used to train the *cassaveros* (cassava farmers) in farming best practices and to train staff (approximately 12%).

Production began in June 2012 with monthly sales starting at USD 300,000 and increasing steadily throughout the year to USD 350,000 in December. ETAVEN is forecasting sales to continue growing strongly for the medium term, averaging about 50% growth per annum for the next three years. Due to the low cost of sales, ETAVEN achieved strong operating margins of 99% for the first six months of operation. The net profit margin is forecast to remain stable at about 56% over the forecast period as costs grow in line with revenues.

Socio-economic, health and environmental impact

ETAVEN estimates that their operations have improved the incomes of local cassava farmers and small-scale flour producers by up to 50%. The actual payments to farmers from ETAVEN for cassava and yare are minimal (USD 0.02/L). Therefore, their positive social impact has been primarily through

TABLE 30. ETAVEN FINANCIALS

SUMMARY FORECAST P&L						
USD	2010	2011	2012	2013	2014	2015
Initial Investment	(1,000,000)	(1,000,000)	(500,000)			
Sales			2,287,161	4,190,891	5,573,885	8,249,350
Cost of Sales			(8,922)	(36,786)	(48,925)	(72,409)
Gross Profit			2,278,239	4,154,105	5,524,960	8,176,941
Operating and Financing Costs			(230,219)	(450,515)	(601,462)	(847,430)
Human Resources			(107,350)	(216,285)	(216,285)	(216,285)
Profit Before Tax			1,940,669	3,487,306	4,707,213	7,113,227
Tax			(659,828)	(1,185,684)	(1,600,452)	(2,418,497)
Net Profit			1,280,842	2,301,622	3,106,761	4,694,730
Payback Period from Yr 1 Revenues:	<2 years					
IRR:	50%					

indirect channels. By improving the disposal of waste, local farming operations are perceived as more sanitary by larger cassava buyers, who are now willing to purchase cassava from small holder farmers previously viewed as unsuitable suppliers. In addition, through ETAVEN's educational programs for local farmers, small holders have learned to bypass intermediaries to sell their goods directly to buyers who offer higher prices. Finally, the collection and use of waste cassava (approximately 40% of total yield) and yare diverts substantial (approximately 60 tons per day) cyanide-rich waste from local water sources and reduces methane emission that results from the slow rot of cassava in public spaces.

Scalability and replicability considerations

The key drivers for the success of this business are:

- Patented technology and process for making ethanol from cassava and its by-products.
- Lower production cost of ethanol from cassava in comparison to other feedstock such as sugar cane and corn.
- Ease of access to cassava waste and no value or competition for procuring this waste.
- Underdeveloped national ethanol production, inviting price leadership.

ETAVEN's ethanol production process and sourcing model is highly scalable to developing markets where cassava is grown. Yareanol production technology is relatively simple and cost-effective to implement, requiring only three key steps: extraction, fermentation and distillation before decanting the ethanol and vinasses. Furthermore, cassava is a hardy crop suitable for growth in arid, nutrient-deficient soil, making it popular in sub-Saharan Africa, where there is already a developed cassava industry. ETAVEN intends to franchise its process, targeting Central and South American countries in phase one and further rolling out to Africa and Asia in phase two. The largest potential untapped reserves of cassava are in Nigeria, Thailand, Brazil and Indonesia.

Cassava-to-ethanol plants have already been established in several countries, such as NDZiLO in Mozambique and TMO Renewables in China proving feasibility of the technology. In England, TMO Renewables announced they have advanced to demonstration scale on cassava stalk feedstock with major Chinese fuel and food producers. TMO is now processing an initial shipment of cassava stalk delivered from China, an inexpensive, abundant feedstock underutilized in 2G bio-ethanol. Improved efficiencies at TMO's 0.1-ha demonstration facility are projected to produce ethanol for less than USD 2 per gallon, marking a crucial step toward commercialization. Utilizing cassava stalk, TMO's conversion process will yield 70 to 80 gallons of 2G ethanol per ton of feedstock. The ETAVEN's business is capable of being reproduced at the international scale in tropical climates on the arid soils that are poor in nutrients.

Summary assessment – SWOT analysis

The key strength of ETAVEN is its simple process, low production cost and use of a feedstock that has hardly any other strong alternative uses (Figure 109). The weaknesses of ETAVEN are its unfavourable business environment and limited awareness on ethanol from cassava among policy makers. Due to the limited awareness, there is strong potential for policy makers to give priority for ethanol from sugarcane and corn. Therefore, ETAVEN has significant threat from other established producers of ethanol in its market shed. ETAVEN has strong opportunities to expand its market to other regions in developing countries where cassava is the staple food. In addition, it can further stabilize its business and increase its profitability by vertically scaling its business to capture value from both upstream and downstream parts of its value chain by getting into cassava-flour processing and selling of cassava shells as animal feedstock.

FIGURE 109. ETAVEN SWOT ANALYSIS

	HELPFUL TO ACHIEVING THE OBJECTIVES	HARMFUL TO ACHIEVING THE OBJECTIVES
INTERNAL ORIGIN ATTRIBUTES OF THE ENTERPRISE	STRENGTHS <ul style="list-style-type: none"> Patented technology and process Relatively simple and cheap process to roll out Higher ethanol yield from cassava than any other commercially-used feedstock Uses sub-optimal feedstock thereby not competing with food production Plant is situated close to a cluster of flour mills and cassava producers helping to reduce operating costs Have achieved extremely high operating margins on pilot plant, therefore allowing considerable flexibility in potential costs for future expansion 	WEAKNESSES <ul style="list-style-type: none"> Business model reliant on nominal value for purchased cassava; cost feasibility for international expansion would need to be assessed based on market prices Patented technology virtually invisible; difficult patent enforcement in case of infringement
EXTERNAL ORIGIN ATTRIBUTES OF THE ENVIRONMENT	OPPORTUNITIES <ul style="list-style-type: none"> Potential of expansion in a number of other cassava-producing countries through franchising Significant potential for domestic expansion in Venezuela, assuming improved government support for all ethanol production (not just sugarcane) Potential for vertical scaling and having additional revenue source by getting into cassava-flour making and sales of cassava shells as animal feed Underdeveloped national ethanol production provides room for maneuver 	THREATS <ul style="list-style-type: none"> Competition or entry into market from other, more established cassava-to-ethanol producers Domestic pressure from incumbent sugar cane refineries in Venezuela, and government bias toward sugarcane-based ethanol Unfavorable business environment in Venezuela for ETAVEN Limited awareness of cassava-to-ethanol opportunity among policy makers and governments who could further benefit from the technology

Contributors

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References and further readings

New Tang Dynasty Television. "YARETANOL: Venezuela pioneers alternative fuel from cassava root.

YouTube video, 2:31. Posted October 2009. Retrieved from www.youtube.com/watch?v=LAE28nIEwtk (accessed November 7, 2017).

Pernalette Ivaneth, S. Interviewed by Cynthia Pajares via email. March 14, 2014.

Case descriptions are based on primary and secondary data provided by case operators, insiders, or other stakeholders, and reflects our best knowledge at the time of the assessments (2015/2016). As business operations are dynamic, data can be subject to change.