Financial assessment of a biodiesel value chain: case study of Chiapas, Mexico

Luz del Carmen Díaz-Peña
Monterrey Institute of Technology and Higher Education, San Andres Cholula, Mexico
Anselmo Salvador Chavez-Capo
Autonomous Popular University of the State of Puebla, Puebla, Mexico
Miguel Angel Tinoco-Castrejón
Monterrey Institute of Technology and Higher Education, San Andres Cholula, Mexico, and
Genoveva Rosano-Ortega and Beatriz Pérez-Armendariz
Autonomous Popular University of the State of Puebla, Puebla, Mexico

Abstract

Purpose – This paper aims to assess the biodiesel value chain produced by the State of Chiapas and, through a financial model, determines its profitability and feasibility as a business.

Design/methodology/approach – The literature review was based on searching in journal databases and in official web sites. To quantify value chain activities, a questionnaire was used to interview project leader. Besley's methodology was used to create the financial model and determine the net present value (NPV). Finally, the SWOT model summarized the analysis based on the results obtained.

Findings – All the costs of the value chain were calculated and the results show that the greatest cost corresponds to the "internal logistical activity," with 74 percent of the total cost/liter. The NPV of the project was positive and the project was thus considered financially feasible.

Practical implications – Biodiesel production plants must know the real costs of raw material (sewing and harvesting the seed) as well as extraction by farmers and regional producers in order to calculate their real profit margin and set competitive prices.

Originality/value – The research responds to a specific demand by the State of Chiapas to assess the feasibility of its value chain by identifying the activities that do not create value.

Keywords Value chain, Biodiesel, Chiapas, Financial model, Renewable energy

Paper type Case study

1. Introduction

This paper focuses on a financial assessment of the biodiesel value chain in the State of Chiapas, Mexico. Michael Porter's model serves as a frame to quantify the value chain because it disaggregates the firm into its relevant activities to understand cost behavior. Our goal was to develop a financial model through a cash flow statement, verifying the feasibility of the process as a business. We also tried to develop a reference document that stakeholders involved in biodiesel production and commercialization can use.

Like most industrialized countries, Mexican industry depends on fossil fuels that transform raw materials into finished products ready for exchange and marketing (Márquez Covarrubias, 2010). Producers are seeking to replace non-renewable energy

Management Research Review
Vol. 36 No. 12, 2013
pp. 1291-1302
© Emerald Group Publishing Limited
2040-8269
DOI 10.1108/MRR-08-2013-0196

that is running out. At the same time, industries and factories generate greenhouse gas emissions (GHG) that have negative and irreversible effects: the rise of sea levels, extreme thunderstorms and droughts are clear examples of the unbalanced ecosystem on the earth (Gago *et al.*, 2003).

Important changes in the fossil fuel world market have occurred in recent years: increasing prices and enormous consumption of energy resources that are almost depleted. The economic benefits of renewable energy sources lie in decreasing prices and the volatility of fossil fuels and diversifying the energy portfolio (SENER, 2006). Emerging economies such as Mexico's are well-positioned to search for renewable energies like biodiesel.

Climate change is another challenge common throughout the world, leading many countries to develop renewable energies from hydraulic, solar, wind and bio-mass (biodiesel) sources to decrease GHG emissions.

This paper focuses on Chiapas, a state located in the southeast of Mexico, bordering the states of Tabasco, Veracruz and Oaxaca, with the Pacific Ocean to the south and Guatemala to the east. It has a territory of 74,415 km^2 (Mexico Reiser, 2012), being the eighth largest state in Mexico. Chiapas is one of 31 states that, along with the Federal District, comprise the 32 Federal Entities of Mexico. It is divided into 118 municipalities, and its capital city is Tuxtla Gutierrez. The state of Chiapas is located in the tropical belt of the planet where hot, semi-hot, temperate and even cold climates may be found. In the north, rainfall can average more than 3,000 mm (120 inches) per year. Chiapas contributes 1.73 percent of Mexico's GDP. Agriculture is the most common activity and produces 15.2 percent of the state's GDP. The industry and energy sectors take a secondary position, producing about 21.8 percent of the state's GDP. The remainder of the state's GDP comes from commerce, services and tourism activities.

The government of Chiapas needs biodiesel to supply local public transportation in the municipalities of Tluxtla Gutierrez and Tapachula. The governor expects that, in the short-term, investors will want to participate in joint projects for sustainable regional development. The raw material used is the *Jatropha Curcas* (Plate 1), a species of flowering plant in the spurge family *Euphorbiaceae*, that is native to the American tropics, most likely in Mexico and Central America (Horticultural Impex, 2011). The *Jatropha Curcas,* cultivated in tropical and subtropical regions around the world, is a poisonous, semi-evergreen shrub or small tree, reaching a height of 6 m (20 ft) and resistant to extreme aridity, allowing it to grow in deserts. The seeds contain from 27 to 40 percent oil (average: 34.4 percent) that can be processed to yield a high-quality biodiesel fuel, usable in a standard diesel engine. The non-edible seeds contain highly poisonous *toxalbumin curcin*. (Horticultural Impex, 2011).

The term "biodiesel" refers here to a synthetic liquid biofuel obtained by natural lipids, such as vegetable oil, through an industrial process known as *transesterification*. Biodiesel applications go from partial to total substitution of petrodiesel (Rojas-González and Girón-Gallego, 2011).

2. Energy consumption and greenhouses emissions

Annual energy consumption globally continues to rise, and the world may soon face a crisis of energy generation. Crude oil occupies first place in the energy portfolio. It is also evident worldwide that global warming caused by greenhouse effects is mainly due to the excess of carbon dioxide in the atmosphere. Results of climate changes such

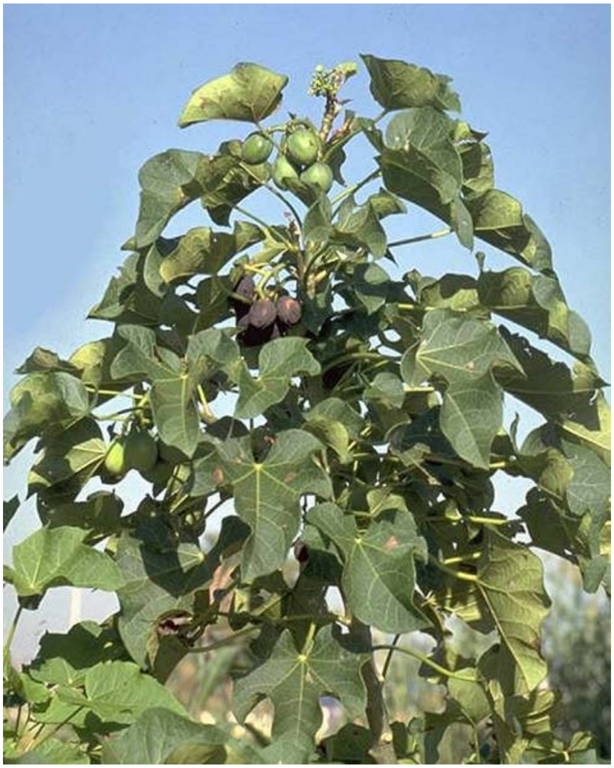


Plate 1.
Jatropha Curcas plant

as rising sea levels, deluges, hurricanes and droughts are already evident (Gago *et al.*, 2003). Carbon dioxide represents more than 50 percent of total emissions of global warming and is the main GHG that contributes to climate change; others are methane, water vapor, and ozone (CMNUCC, 2011). The activities that produce CO_2 include burning of fossil fuel, oil, gas and coal, mainly in the transportation sector.

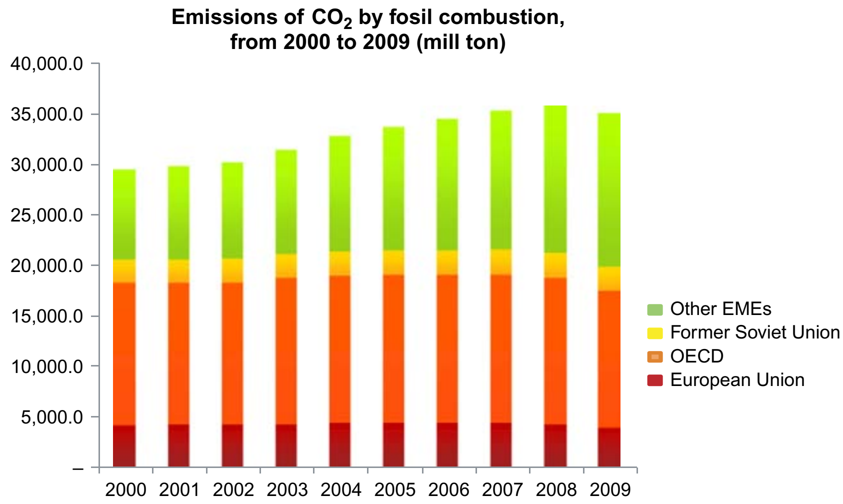
Figure 1 shows the annual amount of CO_2 emitted from 2000 to 2009.

The global trend to reduce GHG has motivated changes in oil company management and has led to new government energy policies (SENER, 2011). Brazil, India, Germany, the USA and Colombia already produce biofuels (bioethanol or biodiesel) made from different consumables, such as corn, soya, sugar cane, biomass and animal flat.

3. Value chain: Michael Porter's model

Firms must define their strategy, markets, mission, values and goals. The value chain is a systemic tool that examines all the activities a firm requires to operate, and it includes interactions. The value chain disaggregates a firm into strategically relevant activities in order to understand costs as well as existing and potential sources of differentiation.

An organizational structure that corresponds to the value chain will improve the firm's ability to create and sustain competitive advantages. The firm may be able to



Source: Peakoil (2011)

Figure 1.
CO_2 emissions from fossil combustion

draw unit boundaries more in line with its sources of competitive advantage and provide for appropriate coordination by relating its organizational structure to the value chain and the linkages within it and with suppliers and channels. There are frequently many linkages within the value chain and organizational structure repeatedly fails to provide mechanisms to coordinate or optimize them. Vertical linkages are often not well established within the organizational structure. Also, managers habitually do not have a clear view of how they contribute to the firm's overall competitive position (Porter, 1985).

The initial level for constructing a value chain is the business unit itself, not the division or corporate level. Products pass through activities of the value chain in a particular order. In principle, each of the activities in the chain adds value to the product. Chains of activities give the product more added value than the sum of the value given independently.

In general, Porter classifies added value activities as primary and support activities. Primary activities correspond to products and markets, such as:

- inbound logistics;
- operations;
- outbound logistics;
- marketing and sales; and
- service.

Support activities assist firms in gaining competitive advantages and include procurement, technology management, human resource management and infrastructure.

4. Methodology

A literature review was carried out to identify definitions and measures for our financial assessment. We examined journal databases on official web sites to quantify each stage of the biodiesel value chain. We conducted fieldwork at the biodiesel production plant to verify processes and we interviewed the project leader. The interview, using Michael Porter's model (1989) as a framework, was designed with a descriptive purpose (Sampieri, 1991). We asked the costs of the value chain for each activity. Current costs were estimated to identify those which could be omitted after analysis.

Post data collection activities in Chiapas were quantified using the Balanced Scoredcard (BSC) and projecting cash flows in an estimated income statement. The BSC defines what management means by "performance" and measures whether management is achieving desired results. It translates the organization's mission and strategy into a comprehensive set of performance measures that provide the framework for strategic measurement and management systems (Kaplan and Norton, 1996). The financial model of Besley and Brigham (2008) was used for calculating a net present value (NPV) and interest return rate (IRR) of the project to evaluate its business profitability and viability. In the last part of this analysis, the strengths, weaknesses, opportunities, threats model (SWOT) summarized results.

5. Biodiesel production from *Jatropha Curcas*: the Porter value chain model

After collecting costs from questionnaires, we analyzed them in terms of the five stages of Porter's value chain model. The costs of support activities were also included.

Inbound logistics

There are about 10,000 hectares of *Jatropha Curcas* crops, pruned twice a year. A *Jatropha Curcas* crop is displayed in Plate 2. The sub-products, obtained by reaping operations, are branches and leaves called biomasses. But they are non-usable and cannot be sold or reused. Once the fruit is reaped, it must be cleaned and its peel and pulp extracted, but no benefits are obtained from its subsequent sale.

Farmers obtain the oil from the seed and extract it with a mechanical process (press machine). The *torta*[1] obtained is only used as compost in the original field. However, with an anaerobic digestion process it could be transformed into biogas and could be sold. 15 percent of the fruit weight corresponds to its three seeds, but only 35 percent of such mass can generate oil extracted from pressing. This means that for each kilogram of *Jatropha* fruit, 52.5 grams of oil result ($0.15^{*}0.35^{*}1{,}000$), i.e. 525 liters/hectare.

Plate 2.
Jatropha Curcas nursery in Chiapas

The government of Chiapas pays the seed oil producers US$0.8239 for each liter. The oil is transported to biodiesel production plants by special tanker trucks or barrels to be transformed by the *transterification* process.

Operations

Two production plants were made operational with full equipment: one in Tapachula and the other in Tuxtla Gutierrez. The total investment came to US$1,850,000, including three production modules, expenses related to importation, installation and training.

Tapachula's plant has a Hindu extractor that extracts up to ten tons of seeds per day, and a reactor with British technology which produce up to 20,000 liters per day. The Tuxtla Gutierrez's plant has Swedish and Mexican technology with a capacity of 10,000 biodiesel liters per day and also serves as an investigation center. The life of the equipment is estimated to reach ten years of constant operation. Therefore, the operation cost was estimated at US$0.2293 per liter, including depreciation (Plates 3 and 4).

Outbound logistics

The government of the State of Chiapas has been given permission given by the Energy Secretary's Office to transport the biodiesel fuel from its production plants to selling locations. Special tanker trucks or plastic containers transport the fuel to Tuxtla Gutierrez, where up to 80,000 liters can be stored. The costs incurred during this stage of the value chain increases the selling price by about $0.0549 per liter of biodiesel. This cost is referred to as the freight cost.

Marketing and sales

The biodiesel sales station (Plate 3) is open to the general public and has two storage tanks of 40,000 liters each. The biodiesel station consists of two high flow dispensers

Plate 3.
Biodiesel reactor PE2000

Source: © Renewable Energy Institute from the State of Chiapas (2012)

Source: © Renewable Energy Institute from the State of Chiapas (2012)

Plate 4.
Biodiesel reactor
FUEL MATIC

capable of managing 200 liters of biodiesel per minute with two hoses per dispenser. The facilities include administrative offices, restrooms, a warehouse and an automatic control room (Plate 5).

The dispenser is the property of the State Government, which pays no rent. The administrative expenses consist of a payroll for seven people in charge of the offices and sales, which represents approximately US$3,844.96 monthly; US$0.0062 per liter. When summing up all costs, Chiapas State can sell the biodiesel for US$1.1699 per liter, on average.

There is a marginal profit on sales of 3.33 percent. However, the biodiesel could be sold as a mixture together with fossil diesel. Some formulas suggest combining 5 or 10 percent of biodiesel with 95 or 90 percent of diesel. The mixture is commercially known as Biodiesel five and Biodiesel ten (B-5 and B-10), respectively. Under such conditions, the price does not significantly increase (about US$1.0514), and the cost-benefit of production is worth the expense.

Service

The main clients for the biodiesel are the Conejo and Tapachulteco buses. They belong to the public transportation departments of Tuxtla Gutierrez and Tapachula, so sales

Plate 5.
Biodiesel dispensary
in Chiapas

come mostly from internal consumption. People in the sales offices provide post-sale service, so no extra cost is attributed to this value chain activity. The service consists in advising clients about usage, how the fuel works in diesel motors and the environmental benefits. However, if the government established by law that all transportation with diesel engines should use biodiesel or at least the B-5 or B-10 mixture, the number of customers would surely increase. For this reason, more appropriate user control should be implemented. Records could be kept of repeat customers, which can be done through the registration of car or truck license plates. It would be helpful to take a customer satisfaction survey to know if customers received good service and to corroborate the quality of the biofuel.

Total balance. Table I shows the costs indicated by the interviewees. The cost distributions were calculated for each of the five Porter's value chain stages.

Sales rise to 7,200,000 biodiesel liters per year at a unit selling price of US$1.1699 for the first year. For estimating cash flow for the next nine years, this price and all related costs increase, about 4.5 percent each year due to Mexico's inflation. There is no tax because it is a government project. The cost of capital was estimated by using the capital asset pricing model, which is 10.31 percent. According to the Besley financial model the project generates a NPV of US$1,377,023.55 with an IRR of 24.37 percent. Under such a scenario, the original investment would be recovered within 7.4 years.

6. Financial analysis and management

We found four vulnerable variables that would cause the NPV to significantly vary if they changed: the sub-products income, the freight cost, the unit sell price and the fix rate.

Sub-products income

One substantial sub-product from the first value chain activity (intern logistics) is the *torta*, with 30,000 tons per year. The price of each ton is US$53.55 and torta can be used as biomass to produce biogas or as compost in planting. In total, this could equal US$1,606,500.00 and is counted as extraordinary income in the cash flow balance statement.

Operations produce another sub-product: glycerin. A 10,000 hectares harvest can generate 538.65 tons of glycerin at a unit sell price of US$112.25, adding extraordinary income of US$60,463.46.

If the income from the *torta* and glycerin are included, the NPV increases to about US$12,463,677.00.

	Amount USD per liter	Percentage (%)
Inbound logistics	0.8239	73.94
Operation	0.2293	20.58
Outbound logistics	0.0549	4.92
Marketing and sales	0.0062	0.56
Service	0.00	0
Total cost	1.1143	100

Source: Author's contribution

Table I. Total cost of biodiesel liter

Freight costs

The government pays US$0.0549 per liter of biodiesel as freight cost. The supplier transports the biodiesel in tanks from the plant in Tapachula to the sales station in Tuxtla Gutierrez. Travel time is approximately three and one-half hours and transport costs are higher than for traditional fuel (SAGARPA -Department of Agriculture, Cattle, Rural Development, Fishing and Feeding-, 2011). If the cost were re-negotiated with the current transport provider to US$0.0343, or if a new supplier were found for this service, the NPV of the project could increase up to US$2,423,150.85.

Unit sell price

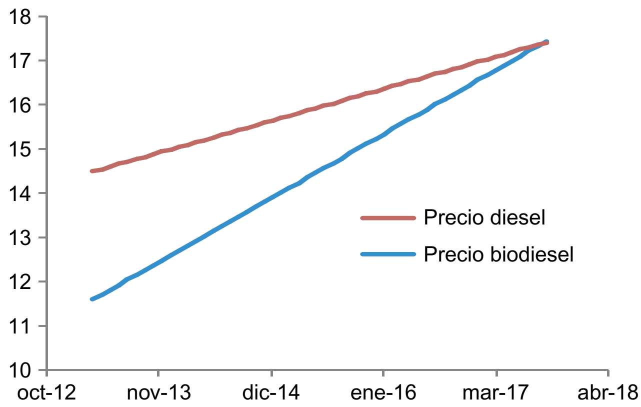
If the unit sell price increased by 5 percent or more, total sales would generate a higher cash flow each year, making the IRR approximately 40 percent. This result would make the project more profitable and consequently more attractive to investors. We correlated biodiesel and historical diesel prices from January 2011 to November 2012. The outcome was a coefficient of −0.35, which shows that in Mexico, if the diesel price increased, the biodiesel price would decrease. The last statement can be justified by the fact that, in Mexico, investments in *Jatropha Curcas* still involve high risk because the plant is not fully commercialized.

Further, we compared increases in biodiesel and diesel prices under the assumption that both prices move equally. The diesel price begins at US$0.6316 with a monthly increase, by government decree, of US$0.0061. Biodiesel starts at US$1.2180, increasing monthly by about US$0.003. The forecast to October, 2017 indicates that the two prices would converge and the client could buy either one for the same price.

Figure 2 shows the convergence of diesel and biodiesel prices.

Estimated fix rate

Since the unit sale price of biodiesel is given in USD, the currency exchange rate plays a determinant role in this analysis. For simplification, the estimated fix rate used corresponds to 14.5645 MXN/USD (data obtained from the Bank of Mexico) but if the fix rate fell to $19.50 MXN/USD, the biodiesel project would lose any chance of generating



Source: Author's contribution

Figure 2. Convergence of biodiesel and diesel prices

economic benefits. Therefore, strong parity of the peso (MXN) against the dollar (USD) is vital for the profitability of this project and we must continuously monitor this variable.

SWOT analysis

Table II shows a SWOT analysis of strengths, weaknesses, opportunities and threats for the biodiesel project.

7. Conclusion

In this research, the main goal was to quantify the activities in the biodiesel value chain and evaluate the profitability of the financial model based on cash flows. According to the project leader, inbound logistic activity represents the highest cost, at 73.94 percent of the total liter cost. We thus conclude that the biodiesel project is financially viable because of its positive NPV.

The best way to evaluate and asses the profitability of the project is to disaggregate its activities and quantify and analyze them individually. Otherwise, relevant cash flows might not be factored in, leading to flawed investment decisions. The value chain analysis helps us make a financial assessment, but it can be improved based on more detailed quantification of the inbound logistic activities. Biodiesel Chiapas does not have specific and detailed costs of the planting and harvesting process that oil producers do. They must calculate and enter the real cost of these activities to better prizing *the Jatropha Curcas's* oil liter. In consequence, the value chain activities which marginal costs could be reduced would contribute to the project profitability, as a whole.

A manager who understands the value chain model can manage all the activities of the process more efficiently to satisfy the needs of the firm. This model can be used in all industries, whatever the size, location or market position of the company.

There are two limitations in our evaluation of the biodiesel process. The first is that only data from the questionnaire are used and the second is that we have no reference point or benchmark with other biodiesel projects in the country as comparisons. We do not know if the VPN obtained is high enough or what the industry average is.

Internal analysis	External analysis
Weaknesses	*Threats*
Installed capacity is underused by 73%	The project lacks sufficient clients
There is no follow up after sales	The price per liter of biodiesel is more than the cost of diesel
The cost of raw material represents 74% of the total cost/liter	No sub product of the process is sold
The production plant is 280 miles away from the dispensary, so the freight cost is high	The cost of the raw material is high
Strength	*Opportunities*
Biodiesel Chiapas has good quality production equipment	There are no competitors in the biodiesel market
The dispenser has enough liter storage capacity	There is enough area for reaping
There are sufficient financial resources to expand the project	The soil and the climate conditions are adequate to reach the installed capacity
The origin of the *Jatropha Curcas* plant is Mexico	

Note: This table needs a better introduction and explanation
Source: Author's contribution

Table II.
SWOT analysis

Future researchers could investigate if biodiesel improved some activities to expand the harvest of the seed. For example, when production installed capacity reached 100 percent or when the local government establishes public policies for using the B-10 or B-20 mixture, the project sales would increase as well as the NPV.

Nowadays, there are 10,000 hectares of *Jatropha Curcas* harvested which supply the two biodiesel production plants with 5,250,000 oil liters per year. However, the installed capacity is to produce 7,200,000 liters, so it is needed to plant and harvest 3,714.3 hectares more for producing the 100 percent of the capacity.

In Tuxtla Gutierrez and Tapachula, Chiapas, the public transportation system already has trucks in operation that use biodiesel, which helps the GHG effect. More local governments need to develop and implement policies that promote the production and use of biodiesel. Renewable energies represent an important response to the widespread demand for a sustainable model that will benefit future generations. Biodiesel production supplies fuel for public transportation. Hence, a profitability analysis of the biodiesel value chain can be a tool to support the decision expanding production.

The most sensitive variables of the project resulting from this analysis were the "unit sell price", the "unit production cost" and the "estimated fix rate MXN/USD". If any of these variables change, the NPV or IRR would vary significantly. The behavior of these variables must be monitored in order to anticipate any decrease of the NPV. We analyzed the fossil diesel and biodiesel prices for the last year and found a lineal correlation between the two fuels of -0.35. This value shows that only a few companies in Mexico could afford to invest in biodiesel projects.

This study has implications for management training and research. Managers need not only labor experience but must have subject knowledge also. The managers of this kind of renewable energy project must pay careful attention to directing and controlling all the processes. They need to document all the changes and corrective actions they make for further research, making it easier for future managers to reach organizational goals.

Note

1. Fruits peel and pulp.

References

ASPO (2011), International Association for the study of Peak Oil&Gas, available at: www.peakoil.net/statistics (accessed 19 November 2011).

Besley, S. and Brigham, F.E. (2008), *Essentials of Managerial Finance*, Cengage, Mexico.

CMNUCC (2011), Convención Marco de la Naciones Unidas sobre el Cambio Climático, available at: http://unfccc.int/portal_espanol/essential_background/items/3336.php (accessed 23 September 2011).

Gago, A., Labandeira, X. and Rodríguez, M. (2003), "Evidencia Empírica internacional sobre los dividendos de la imposición ambiental", Papeles de trabajo sobre medio ambiente y economía. No. 3, pp. 1-61.

Horticultural Impex (2011), *Jatropha Curcas*, Horticultural Impex, available at: www.treeseedsindia.in/jatropha-curcas-1218623.html (accessed 15 November 2012).

Kaplan, R.S. and Norton, D.P. (1996), "Using the balanced scorecard as a strategic management system", *Harvard Business Review*, January/February, pp. 75-85.

Márquez Covarrubias, H. (2010), "La gran crisis del capitalismo neoliberal", *Andiamos*, Vol. 7 No. 13.

Mexico Reiser (2012), available at: http://mexicoreiser.mx/en/destinations/chiapas (accessed 20 June 2013).

Porter, M. (1985), *Competitive Advantage: Creating and Sustaining Superior Performance*, The Free Press, New York, NY.

Rojas-González, A. and Girón-Gallego, E. (2011), "Variables de operación en el proceso de transesterificación de grasas animales: una revisión", *Ingeniería y Universidad*, Vol. 15 No. 1.

SAGARPA (2011), *Biodiesel. Costos de producción*, Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación, available at: www.bioenergeticos.gob.mx/index.php/biodiesel/costos-del-proceso-de-produccion.html (accessed 17 July 2012).

Sampieri, R. *et al.* (1991), *Metodología de la Investigación*, McGraw-Hill, México.

SENER (2006), *Energías renovables para el desarrollo sustentable en México*, Secretaría de Energía, available at: www.energia.gob.mx/res/PE_y_DT/pe/FolletoERenMex-SENER-GTZ_ISBN.pdf (accessed 23 October 2011).

SENER (2011), *Perspectivas de energía renovables 2011-2025*, Secretaría de Energía, available at: www.energia.gob.mx/res/PE_y_DT/pub/2011/Prospectiva_de_ER_2011-2025.pdf (accessed 4 February 2012).

Further reading

Conde, L.A. (2011), "Estimación de las emisiones de CO^2 para el sector de transporte carretero", Taller "Indicadores de Eficiencia Energética en México: 5 Sectores, 5 Retos", Ecology National Institute, available at: www.energia.gob.mx/taller/res/1859/5_Luis_Conde_%28INE%29_Estimacion_de_Emisiones_de_CO2_del_Transporte.pdf (accessed 14 February 2012).

INEGEI (2006), "Estimación de las emisiones de CO^2 para el sector del transporte carretero", available at: www.energia.gob.mx/taller/res/1859/5_Luis_Conde_%28INE%29_Estimacion_de_Emisiones_de_CO2_del_Transporte.pdf (accessed 2 February 2012).

Kaplan, R.S. and Norton, D.P. (1992), "The balanced scorecard measures that drive performance", *Harvard Business Review*, pp. 1-10.

US Department of Energy (2013), *Clean Cities Aliternative Fuel Price Report*, Energy Efficiency and Renewable Energy, available at: www.afdc.energy.gov/uploads/publication/aliternative_fuel_price_report_jan_2013.pdf (accessed 30 April 2013).

Corresponding author

Luz del Carmen Díaz-Peña can be contacted at: carmitadiaz@yahoo.com